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ENVIRONMENTAL FACTORS AFFECTING GREASY WOOL YIELD TRAITS OF BUCHI SHEEP IN PAKISTAN

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ABSTRACT

Data on Buchi sheep collected from 1986 to 2010 maintained at the Livestock Experiment Station Jugaitpir, Pakistan were analyzed to study the environmental factors considered to be sources of variation for greasy wool traits in Buchi sheep.The average values and standard errors were 1.88 ± 0.11 kg for greasy wool yield at 1st shearing, 1.84 ± 0.01 kg for greasy wool yield at 2nd shearing and 3.21 ± 0.02 kg for annual grassy wool yield. Statistical analysis was performed by using the mixed procedure of the SAS statistical package. The model included year and season of birth, sex, type of birth, parity, age and weight of dam at lambing, and two-way interactions between these factors as fixed effects and residual as a random effect. Analysis revealed that all wool yield traits were significantly ($P < 0.05$) affected by year of birth, sex of lamb, interaction between year and season, and interaction between year and sex of lamb. In addition, wool yield at 1st shearing was also affected ($P < 0.05$) by age of dam at lambing. Season, type of birth, parity, and weight of dam were not important for any greasy wool yield trait in this Buchi flock. Significant effects of different environmental factors on all wool yield traits found here suggested that an effective action plan would be required to face any severe climate and feed scarcity situations on the farm.

Key words: Buchi sheep, environmental factors, interaction, wool.

INTRODUCTION

Sheep holds prime importance in the livestock set up and is the major source of livelihood of thousands of people in Pakistan. Sheep are mainly kept for meat and wool whereas milk and skin are regarded as secondary by-products. Pakistan possesses about 28.4 million heads of sheep which supply annually 23 % of the total meat produced and 43 thousand tons of carpet wool in the country (Anonymous, 2012). Hasnain (1985) recounted 28 indigenous breeds of sheep in Pakistan. Wool is used as a raw material for producing the high quality hand and machine-knitted carpets. Export of hand-knitted carpets alone is a source for substantial foreign exchange earnings. However, the production of wool is comparatively low which renders the sheep industry uneconomical. Buchi sheep are considered a good source of increased wool yield in Pakistan. A nucleus flock of Buchi sheep is being maintained at the Livestock Experimental Station in Jugaitpir since 1986. In addition, a considerable population is found in the hot desert area of Cholistan in Pakistan.

The quantity and quality of wool and other products can be improved through selective breeding. However, wool production phenotypes are influenced by environment and genotype. Appropriate estimation of environmental factors affecting wool traits is essential to assess the actual genetic worth of animals to make effective breeding plans for genetic improvement of sheep in Pakistan. Thus, the objective of this research was to estimate the effect of various environmental factors on greasy wool yield at first shearing, greasy wool yield at second shearing and annual greasy wool yield in Buchi sheep from the nucleus herd at the Livestock Experimental Station in Jugaitpir.

MATERIALS AND METHODS

Animals and data: Greasy wool yield records of Buchi sheep maintained at the Livestock Experiment Station, Jugaitpir, Bahawlpur District, Punjab, Pakistan between 1986 and 2010 were used for this study. Normal and complete records were included in the study. The dataset included identification of the lamb, ewe and sire, lamb date of birth, birth type, birth weight of the lamb, sex of lamb, age and weight of dam at lambing, wool yield at 1st shearing and wool yield at 2nd shearing. Sex of lamb, type of birth and seasons were coded as follows: for sex of lamb: 1 = female and 2 = male; for type of birth: 1 = single and 2 = twin; and for season of birth: 1 = spring, and 2 = autumn. Dams were grouped into three sets each for parity, age at lambing, and weight at lambing. Dam parity groups were 1 = first and second parity, 2 = third andfourth parity, and 3 = 5 and more parities.Age of dam at lambing were grouped as 1 = young (< 4 years), 2 = mature (4 to 6 years), and 3 = old (> 6 years). Dam weights at lambing were classified as 1 = low (< 32 kg), 2 = medium (32 to 34 kg), and 3 = heavy (> 34 kg). Data were entered and edited in Microsoft Excel.

Farm location, climate and type of soil: The Livestock Experiment Station at Jugaitpir, Bahawalpur District, is working under the Directorate of Livestock Farms, Livestock and Dairy Development Department Punjab, Lahore, Pakistan. It was established in 1983-84 on 5,200 acres land in Cholistan (desert area). The farm is located at 50 km on Bahawalpur-Hasalpur road (District Bahawalpur) near Asrani railway station on the south-western side of Punjab, Pakistan. The overall objective of the farm was to conserve and improve the indigenous breeds of Cholistani (cattle) and Buchi (sheep). Types of soils in this farm are either sandy or sandy loam. The average rainfall is approximately 120 mm per year, predominantly in the months of July to September (monsoon season). Temperatures vary from 28^{o}C to 50^{o}C in summer and 9^{o}C to 26^{o}C in winter.

General management and feeding practices: The conditions regarding feeding, management and disease control of the animals more or less remained similar during the study period.Twice a year shearing was the normal practice since the establishment of the flock. Flushing of breeding ewes was practiced during breeding seasons (spring and autumn) and lambs were received during the respective seasons. Open barns and covered areas were provided to adult animals for protection against harsh weather. Lambs were weaned at the age of fourth months. Weaned lambs were then transferred to isolated pens for post-weaning rearing. Animals feeding mainly comprised of grazing of available seasonal fodder. Concentrate was offered as supplement during fodder scarcity periods. During summer and autumn seasons (May to October) animals were fed Green Jowar (*Andropogon sorghum*), Guara (*Cyamposis psoraliodes*), Moth (*Phaseolus aconitiflovis*), Maize (*Zea mays*) and Cow peas (*Vigna sinensis*). Berseem and Lucern were major fodder crops for grazing during winter and spring seasons (November to April). Lumps of common salt (Sodium Chloride) were offered in mangers for free choice licking. A vaccination schedule against common diseases like foot and mouth disease, sheep pox, enterotoxaemia and pleuro-pneumonia were regularly observed. Animals were protected against internal and external parasites through drenching (every four months) and dipping (twice a year) throughout the study period.

Statistical analysis: Greasy wool records collected from 1986 to 2010 were used to estimate the effects of year of birth, season of birth, sex of lamb, type of birth, parity of dam, age of dam at lambing, weight of dam at lambing and two way interactions between these factors on greasy wool yield traits. Traits were greasy wool yield at first shearing, greasy wool yield at second shearing and annual greasy wool yield.The following mathematical model was used to analyze the 3wool yield traits:

$Y_{ijklmnp} = \mu + yob_i + sob_j + sex_k + tob_l + dalc_m + dwlc_n + parity_p + (yob^*sob)_{ij} + (yob^*sex)_{ik} + (sob^*sex)_{jk} + (sob^*tob)_{jl} + (sex^*tob)$

Where

$Y_{ijklmnp}$= observation on a trait
μ = population mean
yob_i=year of birth
sob_j= season of birth
sex_k= sex of lamb
tob_l= type of birth
$dalc_m$= age of dam at lambing
$dwlc_n$= weight of dam at lambing
$Parity_p$= dam parity group
$(yob^*sob)_{ij}$= interaction between year and season of birth
$(yob^*sex)_{ik}$= interaction between year of birth and sex of lamb
$(sob^*sex)_{jk}$ = interaction between season of birth and sex of lamb
$(sob^*tob)_{jl}$ = interaction between season and type of birth
$(sex^*tob)_{kl}$ = interaction between sex of lamb and type of birth
$e_{ijklmnp}$ = random residualassumed to benormally and independently distributed with mean zero and variance σ^2.

Data were analyzed with the mixed procedure of the Statistical Analysis System (SAS, 2011).

RESULTS AND DISCUSSION

Data description: Descriptive statistics for greasy wool traits are presented in Table 1. Means and standard errors were 1.88 ± 0.11 kg for greasy wool yield at 1st shearing, 1.84 ± 0.01 kg for greasy wool yield at 2nd shearing and 3.21 ± 0.02 kg for annual greasy wool yield.

Environmental factors affecting greasy wool yieldtraits

Greasy wool yield at 1st shearing: The analysis of variance to estimate the effects of different environmental factors and interactions between these factors on greasywool yield at 1st shearing is presented in the Table 2. The effects of year of birth (P < 0.0001), sex of lamb (P < 0.0001) and age of damat lambing (P <0.0484) were all important factors for this trait. The interactions between year and season of birth (P< 0.0001), and between year and sex of lamb (P < 0.0001) were also significant. However, the effects of season, type of birth, parity, and weight of the dam at lambing on this trait were non-significant. Differences in management, feed availability, diseases, conditions of climate and raising systems in different years, were probably reasons for the significance of year of birth for this trait. Male lambs generally attained higher weights and were likely to be heavier and of larger size than females at preweaning ages, thus produced more greasy wool at first shearing. This was supported by a difference in least squares means of 0.062 kg (P < 0.0001) in favor of males for this trait. A significant effect of age of dam at lambing here indicated that this factor was important for this trait. The difference in least squares means between dam age groups 2 and 1 was 0.051 kg ($P < 0.0401$), between dams age groups 3 and 1 is 0.079 kg ($P < 0.0166$), and between dams age groups 3 and 2 were 0.028 kg ($P < 0.0484$) for wool yield at 1st shearing. This suggested that lambs born out of young ewes tended to produce less wool than lambs from mature and older dams. This may have occurred because younger ewes utilized a proportion of the ingested nutrients for their own growth and development and therefore produced lambs of smaller in size than the mature and older ewes. In addition, young ewes may have produced less milk than older ewes, thus providing a less favorable maternal environment compared to older ewes and negatively affecting wool yield of their lambs at 1st shearing.The non-significant effect of birth type on this trait may be because only 4% twinswere produced in this Buchi flock. The majority of dams attained a similar weight at lambing, thus theeffect of weight of dam at lambing was not important for this trait.

The significant effects of year of birth and sex of lamb found here were in agreement with results fromearlier studies at different locations in different breeds of sheep in Pakistan. Akhtar *et al*. (1993) for Awassi, Baber (1994) and Iram (2008) for Lohi and Akhtar (1996) for Hissaredale breeds of sheep reported that year of birth and sex of lamb were the main sources of variation for greasy wool yield at 1st shearing. However, season and type of birthwere not important for this trait.The non-significant effect of age of dam found in those referenced studies was contrary to the result found here. On the other hand, Hussain (2006) reported year of birth as well as sex of lamb and age of dam was significant for Thalli sheep in Pakistan.The significant effect of birth type reported in that study differed from the one in the present study. Ahmad *et al*. (2010) for Kari sheep breed in Pakistan also recounted that sex of lamb was the main source of variation for the greasy wool yield at 1st shearing. Similar results were reported by Mehta *et al.* (2004) for Megra wool sheep breed in India. In that study, the effects of year and sex of lamb were found to be significant, but the effects of season and type of birth were non-significant.

Results here showed significant interactions between years and seasons of birth, and between years and sexes and of lamb forwool yield at 1st shearing. This specified that the effects of those factors were not independent and that the combined effects of these factors produced variation for this trait. None of the referenced studies above estimated interactions between these factors. Thus, it was not possible to compareresults found here with the referenced studies.Least squares means for year-season interactionfor this trait ranged from 1.13 ± 0.053 kg to 2.70 ± 0.078 kg in the autumn of years 2000 and 2009. The minimum and maximum values estimated for least squares means by year-sex combinations were1.076 ± 0.063 kg and 2.99 ± 0.063 kg for males born in 2001 and 2009.The variation in values of least squares means of wool yield at 1st shearing for the interactions between years and seasons (spring and autumn) is shown in Figure 1. The highest values of wool at 1st shearing (i.e., ≥ 2.5 kg) were observed in the spring of 1986, 1996, and 2009, and in the autumn of 1986, 1993, 1995, 2008, 2009, and 2010). The lowest values of wool at 1st shearing (i.e., ≤ 1.5 kg) were produced in the spring of 1999, 2000, 2001, 2002, 2003, and 2004. Figure 2 showed variation for sexes (males and females) across years that had an almost identical pattern as that observed across year-seasons with high wool production values at 1st shearing (i.e., ≥ 2.5 kg) in 1986, 1987, 1994, 1995, 1996, and 1997 for males, and 1986, 2009 and 2010 for females, and low values in 1991, 1999, and 2000 for males, and from 1999 to 2004, and in 2006, and 2007 for females. Year-seasons and year-sex subclasses with low wool yields at 1st shearing were likely due to a combination of factors including harsh weather conditions, low amounts of feeding available, and differences in maternal milk of Buchi ewes during those periods.

Greasy wool yield at 2nd shearing: F values and levels of significance of different environmental factors and two-way interactions between these factors on greasy wool yield at 2nd shearing are presented in Table 3. The main effects of year of birth ($P < 0.0001$) and sex of lamb ($P < 0.0339$), and the interactions between year and season of birth ($P < 0.0001$), and between year and sex of lamb ($P < 0.0001$) were significant for this trait. Conversely, season, birth type, parity, age and weight of the dam at lambing were unimportant for wool yield at 2nd shearing in this flock. The variation in greasy wool yield at 2nd shearing observed in different years reflected the level of nutrition and management as well as climate conditions affecting ewes during pregnancy. The level of nutrition and management likely varied according tothe ability of the farm manager, his efficiency in the supervision of staff and availability of financial resources.These factors may have influenced the availability of feed and management practices in this herd across years. Temperature and frequency and amount of rain may also have affected animal productivity in different years. Males were likely bigger, attained higher weights and produced more wool than females. The least squares means depicted that females produced 0.058 kg less wool than males at the 2ndshearing. Age of dam was not a significant effect on wool yield at second shearing likely because maternal effects were not important for lamb growth at this age.

The significant effects of year of birth and sex of lamb for greasy wool yield at 2nd shearing obtained here were in agreement with outcomes from previous studies in five breeds of sheep (Awassi, Hissardale, Thalli, Lohi and Kari) kept at various locations in Pakistan (Tahir; *et al.* 1993, Akhtar*;* 1996; Hussain; 2006; Iram; 2008; Ahmad *et al.* 2010). Non-significant effects of age and weight of dam found in all referenced studies were in agreement with the present study. Contrary to here, these authors also observed significant season and type of birth effects on this trait. Mehta *et al.* (2004) for Megra breed of sheep in India also estimated significant effects for year and sex of lamb and non-significant effects of season and type of birthfor greasy wool yield at 2^{nd} shearing in agreement with findings here.

A significant interaction was found here between years and seasons of birth forgreasy wool yield at 2^{nd} shearing. This suggested that seasons (spring and autumn) effects changed across years, thusvariation among different combinations of years and seasons existed for this trait. Least squares means for year-season combinations ranged from 1.54 ± 0.064kg in the spring season of year 1999 to 2.69 ± 0.058kg in the springof year 1995. Similarly, the significant interaction between year of birth and sex of lamb estimated here reflected different effects by different combinations of years and sexes. The values of least squares meansfor the interaction between year and sex ranged from 1.41 ± 0.061 kg for females born of year1991 to 2.38 ± 0.74kg for males born of year 1995.Comparisons of interactions here with those from other studies could not be made because interaction effects were not included in the models of the cited studies above. Least squares meansfor wool production at the 2^{nd} shearing by year-season combinations from year 1986 to 2010 are presented in Figure 3, and by year-sex combinations in Figure 4. Although least squares means for wool production at the 2^{nd} shearing were lower than values for wool production at the 1^{st} shearing, their patterns across year-season and year-sex subclasses were similar. High year-season values were all below 2.5 kg, and low values (i.e., ≤ 1.5 kg) occurred only in the autumn of 1998 and 1999, and in the spring of 2006 (Figure 3). Likewise, high values of year-sex subclasses existed for males in 1987 and from 1995 to 1997, whereas low year-sex values occurred for males in 1998, 1999, and 2006 and for females in 1999 (Figure 4). As indicated for wool production at 1^{st} shearing, year-season and year-sex fluctuations for wool production at 2^{nd} shearing over time may have been due to combinations of climate and feeding conditions over time, and to a lesser degree to remnants of preweaning maternal effects during the postweaning period.

Annual greasy wool yield: Table 4 presents the analysis of variance to evaluate the influences of different environmental factors and interactions between these factors in the model on annual greasy wool yield.Year of birth ($P<0.0001$), sex of lamb ($P<0.0001$) as well as the interactions between year by season of birth ($P < 0.0001$), and between year by sex of lamb ($P<0.0001$) were found to be important sources of variation for this trait. The variation in annual greasy wool yield reflected the level of management, climate factors such as temperature and humidity, and availability of feed across years. In addition, the ability of the farm manager, his system of crop husbandry, his efficiency in the supervision of farm labour and availability of financial resources may have affected sheep performance for this trait. Male lamb gestation period is longer than females (Baber, 1994) and are generally born heavier at birth than females. Further, males normally grow larger in size, are bulkier, and produce more wool than females. Least squares mean annual wool yield indicated that males produced 0.092 kg more annual greasy wool than females. Results obtained here were in agreement withstudies conductedfor different breeds of sheep in Pakistan. Nawaz (1985) for Awassi and Kachhi, Khan *et al.*, (1991) and Akhtar *et al.*, (1994) for Awassi and Akhter (1996) for Hissardale breeds of sheep reported year of birth and sex of lamb to be important factors for annual greasy wool yield. Research in Pakistan with Thalli (Hussain, 2006), Lohi (Iram, 2008) and Kajli breeds of sheep (Qureshi 1996; Farmanullaha, 2011) also found significant influences of those two factors on annual wool yield. Results from several breeds in other countries showed considerable resemblance in levels of significance fordifferent environmental factors with the findings of present study for annual greasy wool yield. Cloete *et al.* (2002) for Dhone Merino and Metabasi *et al.* (2009) for Tygerhoek Merino breeds of sheep in South Africa reported significant effects of year and sex of lamb, and non-significant effects of season, type of birth and age of dam on this trait in agreement with the results obtained here. Similar effects were found for Kermani sheep in Iran and Megra breed of sheep in India by Mokhtari *et al.* (2009) and Mehta *et al.* (2004). However, the outcomes of studies by Baik *et al.* (1983) and Gracia *et al.* (1989) for Corriedale and Suffolk breeds of sheep were slightly different. In those studies, year, season, sex and age of dam were found to be significant factors for this trait. Season of birth was not found important for annual wool yield here. Birth type was not significant here, perhaps due to the low twin rate for Buchi sheep (4%). The age and weight of dam at lambing had no effect for annual greasy wool yield, probably because these factors had no effect on the growth and size of the lamb at the postweaning age (Akhtar *et al*., 2012).

Table 1. Statistical description for greasy wool yield traits in Buchi sheep[1].

Traits	No.	Mean ± SE	SD	Minimum	Maximum
Greasy wool yield at 1st shearing (kg)	3205	1.88 ± 0.11	0.643	0.700	3.800
Greasy wool yield at 2nd shearing (kg)	2299	1.84 ± 0.01	0.469	1.00	3.700
Annual greasy wool yield (kg)	2299	3.21 ± 0.02	1.320	1.40	6.500

[1]SE = Standard error; SD = Standard Deviation.

Table 2. Significance level and F values for greasy wool yield at 1st shearing in Buchi sheep[1]

Effect	DF	F Value	Pr>F
Year of birth (yob)	24	108.32	<0.0001
Season of birth (sob)	1	0.03	0.8695
Sex of lamb (sex)	1	25.72	<0.0001
Type of birth (tob)	1	0.11	0.7459
Dam age at lambing (dalc)	2	0.62	0.0484
Dam weight at lambing (dwlc)	2	0.6	0.7655
Parity	2	3.03	0.5483
yob*sob	23	19.17	<0.0001
yob*sex	23	45.83	<0.0001
sob*sex	1	2.13	0.1448
sob*tob	1	1.03	0.3096
sex*tob	1	0.6	0.4404

[1]DF= degrees of freedom; Minimum significance level = P < 0.05.

Table 3. Significance level and F values for greasy wool yield at 2nd shearing in Buchi sheep[1].

Effect	DF	F Value	Pr > F
Year of birth (yob)	24	51.09	<0.0001
Season of birth (sob)	1	0.1	0.7517
Sex of lamb (sex)	1	4.51	0.0339
Type of birth (tob)	1	3.39	0.0657
Dam age at lambing (dalc)	2	1.23	0.2764
Dam weight at lambing (dwlc)	2	0.15	0.8567
Parity	2	0.57	0.5641
yob*sob	23	3.62	<0.0001
yob*sex	23	35.65	<0.0001
sob*sex	1	0.41	0.5245
sob*tob	1	0	0.9572
sex*tob	1	3.21	0.0733

[1]DF= degrees of freedom; Minimum significance level = P < 0.05.

The significant interaction of years by seasons found here showed the dependency of factors on each other for annual wool yield. This pointed out that seasons effects varied across years for this trait and the different effects were estimated here by the combined effects of year by season of birth. Least squares means for year-season combinations were estimated from 1986 to 2010. The minimum and maximum values of estimates were 2.156 ± 0.091 kg and 4.904 ± 0.112 kg in spring season of the years1999 and 1996.The values of least squares means for the interaction between year and sex ranged from 2.473 ± 0.166 kg for females born of year 1999 to 4.963 ± 0.121 kg for males born of year 1995.The fluctuation in least squares means for annual greasy wool yield by year and season of birth combinations from 1986 to 2010 is shown in Figure 5. The pattern of least squares means for annual wool yield was more similar to wool yield at 2nd shearing than wool yield at 1st shearing with highs and lows in similar sets of years. A similar situation existed for least squares means for year-sex subclasses (Figure 6). The pattern of high and low values of least squares means for annual wool yield of year-sex combinations from 1986 to 2010 (Figure 6) was comparable to that of wool yield at 2nd shearing (Figure 4). Again, a similar explanation could be postulated to explain the lower values of year-season and year-sex least squares means. Harsh climate conditions (rains, temperature, humidity) combined with insufficient feed may have negatively affected annual wool production. [Here is where information on climate conditions (excessive rain, drought) and lack of sufficient feed for the Buchi flock, or perhaps increases in clinical and subclinical diseases may help explain why wool production fell during the low years. Please include citations.]

Table 4. Significance level and F values for annual greasy wool yield in Buchi sheep[1].

Effect	DF	F Value	Pr > F
Year of birth (yob)	24	195.5	<0.0001
Season of birth (sob)	1	0.05	0.8214
Sex of lamb (sex)	1	282.7	<0.0001
Type of birth (tob)	1	0.11	0.7368
Dam age at lambing (dalc)	2	1.12	0.344
Dam weight at lambing (dwlc)	2	0.03	0.9731
Parity	2	0.98	0.3757
yob*sob	23	14.17	<0.0001
yob*sex	23	92.63	<0.0001
sob*sex	1	3.28	0.0704
sob*tob	1	1.08	0.2988
sex*tob	1	0.55	0.4566

[1]DF= degrees of freedom; Minimum significance level = P < 0.05.

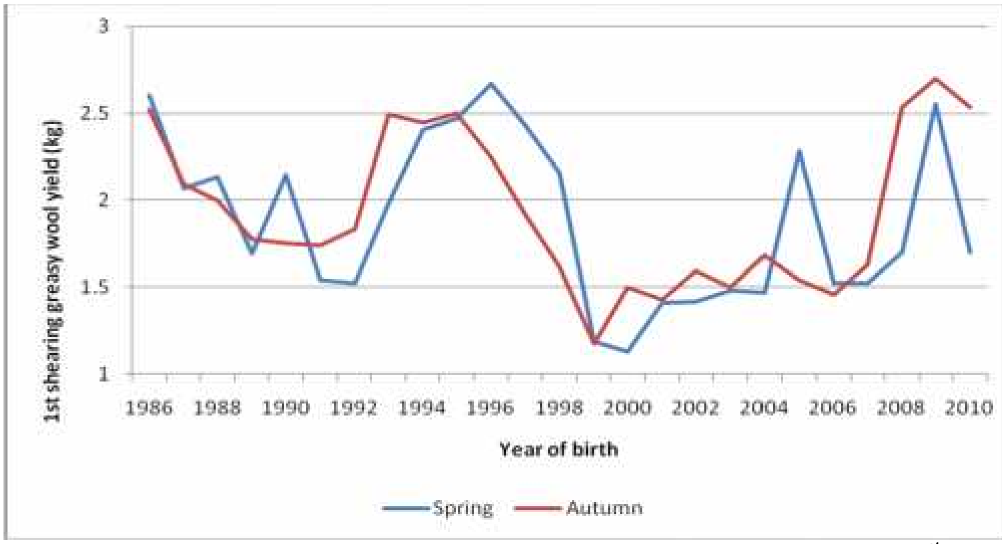

Figure 1. Least squares means by years-seasons interaction for greasy wool yield at 1st shearing.

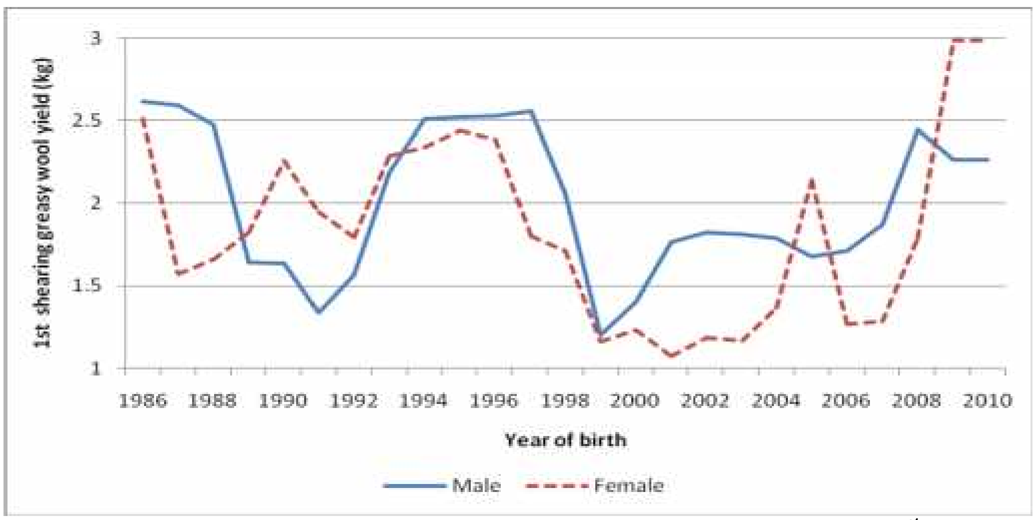

Figure 2. Least squares means by year-sex subclasses for greasy wool yield at 1st shearing

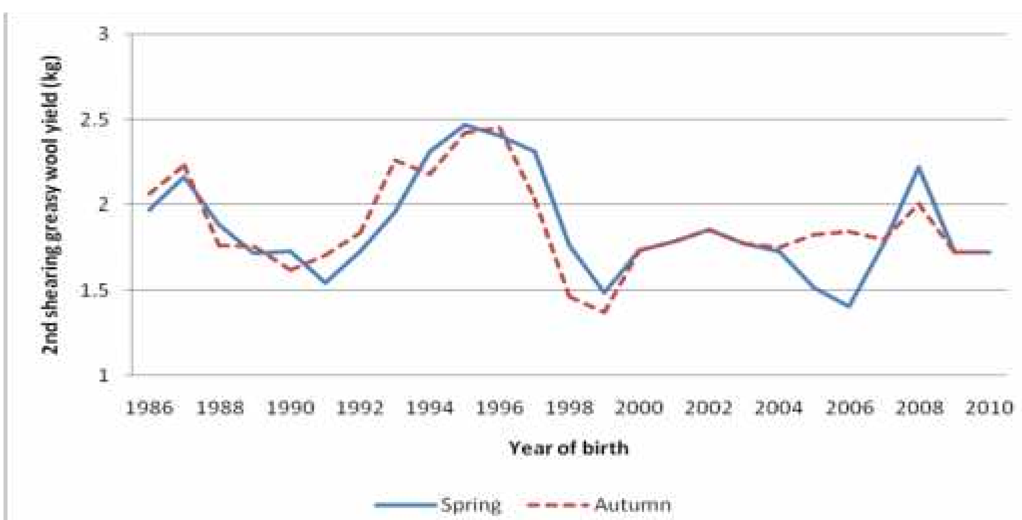

Figure 3. Least squares means by year-season combinations for greasy wool yield at 2ndshearing

Figure 4. Least squares means by year-sex combinations for greasy wool yield at 2nd shearing

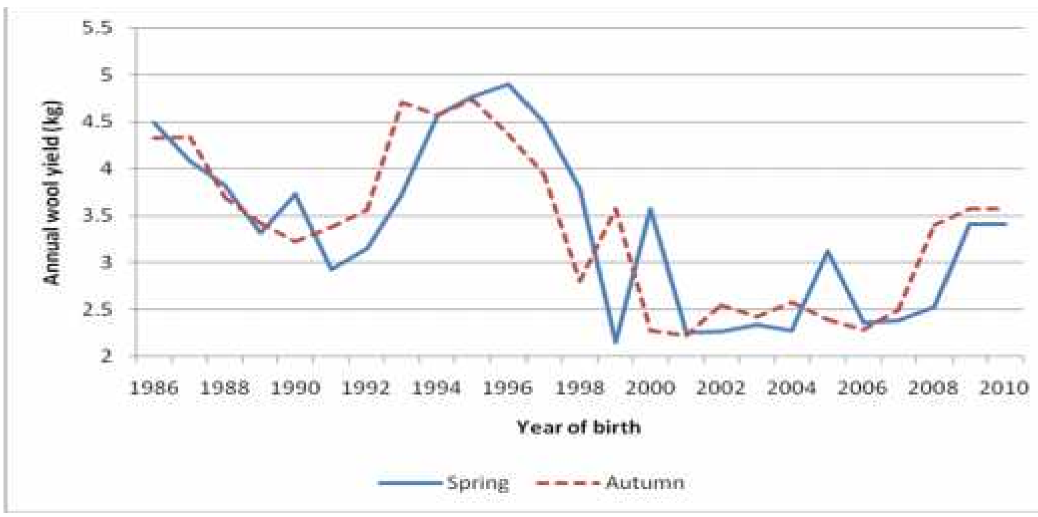

Figure 5. Annual greasy wool yield least squares means by year-season combinations

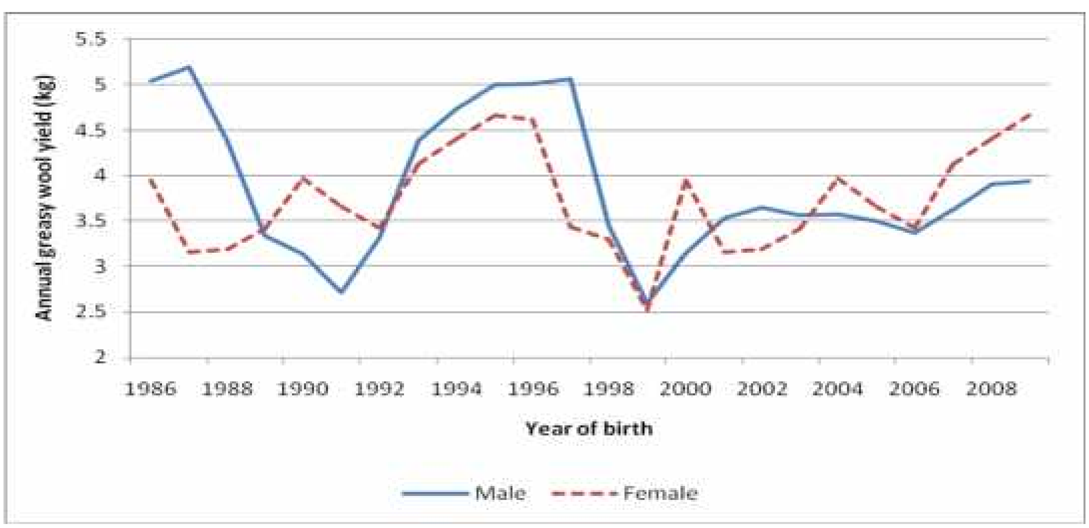

Figure 6. Annual greasy wool yield least squares means for by year-sex combinations.

Conclusions: Results here indicated that the three wool yield traits in this nucleus flock of Buchi sheep were affected by combinations ofenvironmental factors primarily year and season of birth, and year and sex of lamb. Trends of least squares means for the three wool yield traitsshowed a substantial amount of variability for wool yield acrossyear-season and year-sex combinations from 1986 to 2010. Harsh climate conditions (rains, temperature, humidity) combined with insufficient feed may have been contributing factors. It may also reflect insufficient level of preparedness to cope with years of scarcity of feeding resources and harsh weather conditions.Perhaps a strategic plan to counterbalance periods of feed shortagesand protection against unfavorable weather conditions would be advisable. This would help support, improve and sustain wool yield performance during critical periods.

REFERENCES

Ahmad, S., M. S. Khan and M. F. U Khan (2010). Factors affecting wool Characteristics of Kari sheep in Pakistan. Turk. J. Vet. Anim. Sci. 34 (6): 485 – 492.

Akhtar, M., K. Javed, M. Abdullah, N. Ahmad and M.A. Elzo (2012). Environmental factors affecting postweaning traits of Buchi sheep in Pakistan. J. Anim. and Plant Sci. 22(3): 539-536.

Akhtar, M., G. Mohiuddin, M. S. Muhammad and A. Ali (1994). Phenotypic, genetic and environmental correlations between different wool yield traits in Awassi sheep. J. Anim. and Plants Sci., 4(4): 51 –52.

Akhtar, M., M. Tahir, M. Z. Saddiqui and M. S. Muhammad (1993). Repeatability of wool yield in Awassi sheep under local condition of Punjab. Pakistan Vet. J. 13 (4): 188 – 190.

Akhtar, P. (1996). Genetic and phenotypic parameters of some performance characteristics of Hissardale sheep. Ph. D Thesis. University of Agriculture Faisalabad, Pakistan.

Anonymous, (2012). Economic Survey of Pakistan. Economic Advisers Wing, Finance Division, Government of Pakistan, Islamabad.

Babar, M. E. (1994). Genetic and phenotypic parameters of some performance characteristics of Lohi sheep in Pakistan. Ph. D. Thesis. Department of Animal Breeding and Genetics University of Agriculture, Faislabad.

Baik, D. H., W. J. Shin, and S. H. Chee (1983). Effect of environmental factors on the production of greasy wool in Corriedale sheep. Proce. 5th World Conf. Anim. Prod. August 14-19, 2 Tokyo, Japan, Japanese Society of Zootechnical Science. 53- 54. (Anim. Breed. Abst. 53: 2812, 1985).

Cloete, S. W. P., A. J. Olivier, M. A. Snyman and E. du Toit (1998). Genetic parameters and trends in a selection experiment for increased fleece weight involving South African Merino sheep. Australian J. Exp. Agric. 38 (5): 427-432.

Farmnullah, (2011). Genetic and phenotypic trends in some performance traits of Kajli sheep. M. Phil. Thesis. Department of Livestock Production, University of Veterinary and Animal Science Lahore, Pakistan.

Garcia, F. X., R. R. Neira and M. Vega (1998). Non-genetic effects on body weights in Corriedale sheep. Advances en Production Anim. 10 (2): 89 – 100.

Hasnain, H.U. (1985). Sheep and goats in Pakistan. FAO Animal Production and Health paper 56. FAO, Rome.

Hussain, A. (2006). Genetic evaluation of Thalli sheep in Pakistan. Ph. D. Thesis.Department of Animal Breeding and Genetics, Universityof Agriculture Faisalabad, Pakistan.

Iram, A. (2008). Within flock genetic and phenotypic trends for some performance traits in Lohi sheep. M. Phil. Thesis. Department of Livestock Production, University of Veterinary and Animal Science Lahore, Pakistan.

Khan, M. A., L. A. Akhtar, G. Mohiuddin and G. R. Khan (1991). Environmental factors influencing some production traits of Awassi sheep in Pakistan. Sahrad J. Agric. 7 (3): 329-335.

Mehta, S. C., S. K. Chopra, V. K. Singh, M. Ayub and V. Mahrotra (2004). Production and quality of wool in Magra breed of sheep. Indian J. Anim. Sci. 74 (7): 792 – 794.

Mokhtari, M. S., A. Rashidi and Y. Mohammad (2008). Estimation of geneticparameters for post weaning traits of Kermani sheep. Small Ruminant. Res.80: 22–27.

Nawaz, M., M. D. Ahmad, Z. Ahmad, G. R. Khan, and M. A. Khan (1985). Comparative performance of Awassi, Kachhi and crossbred (Kachhi x Awassi) lambs. Pakistan J. Agri. Sci. 22 (3): 181-187.

Qureshi, M. A. (1996). Genetic and environmental components of variation in performance traits of kajli sheep in Pakistan. Ph. D Thesis. Department of Animal Breeding and Genetics University of AgricultureFaislabad, Pakistan.

SAS, 1995. SAS/STAT User's Guide (Version 9.3). SAS Inst. Inc. 2011, Cary, NC.

Tahir, M., F. Ahmad., M. Akhtar and M. Latif. (1993). Estimation of heritability of wool yield of Awassi sheep in Pakistan. Pakistan J. Agri. Sci. 30 (3): 249-251.