PREVALENCE OF REPEAT BREEDING IN GOATS AND THE IMPACT OF AGE AND SEASON IN RAWALAKOT AZAD JAMMU AND KASHMIR: AN ULTRASONOGRAPHIC STUDY

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ABSTRACT: Repeat breeding is a serious reproductive malady in goats that negatively impacts productivity and economic returns in Pakistani smallholder systems, which have more than 95 million goats and depend on goats as the primary source of their livelihood through meat, milk, and hides. Multifactorial etiologies, including nutritional deficits, parasitism, climatic stress, and suboptimal management, are well documented. Still, knowledge of age-season interactions in a subtropical highland environment is lacking, making it difficult to devise effective strategies. In this retrospective ultrasonographic study, the prevalence of repeat breeding and the effects of age and season in 156 female goats presented after natural mating at the Veterinary Reproduction Clinic, University of Poonch Rawalakot, Azad Jammu and Kashmir, were studied (January 2022-December 2024). Pregnancy was determined 30-45 days post-service through transabdominal/transrectal ultrasonography, and categorization was done by age (young: <2 years, n=104; adult: >2 years, n=52) and season (winter: October-March, n=49; summer: April-September, n=107). Analyses were using chi-square and binary logistic regression. The overall prevalence was 30.1 (47/156), and it was greater in winter (35 per cent, 17/49) than in summer (28 per cent, 30/107). No significant independent relationship was found (season: kh2=0.43, p=0.512; age: kh2=0.46, p=0.497). Interaction effects showed substantial differences between winter and summer (young goats: 72, 24/34; adults: 40.5, 15/70), with both groups showing significant differences between the seasons. The model's significance was indicated by logistic regression (kh2=28.21, p=0.001; pseudo-R2=0.134), with decreased odds in young goats (OR=0.40, 95% CI=0.17-0.95, p=0.039) and winter elevation at the margin (OR=2.93, p=0.094). These findings indicate the age- and season-specific vulnerabilities to environmental stressors, and suggest nutritional supplementation and artificial reproductive technologies to improve the fertility of high-altitude goat farming.

Keywords: Age effects, Goat, Repeat breeding, Ultrasonography, Seasonal variation, Rawalakot Pakistan

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INTRODUCTION

Goats are one of the most important livestock species in Pakistan, making a significant contribution to rural livelihoods and the country's agricultural economy. Goats are the most rapidly expanding livestock category in the country, with approximately 95.8 million heads, according to the latest Agricultural Census 2024, whose main products are meat, milk, fiber, and hides (1). Pakistan has a great variety of native goat breeds, with more than 36 known breeds, including the notable Beetal, Teddy, Dera Din Panah, Kamori, and Nachi, which are well-adapted to a wide range of agro-climatic conditions, both lowland and high-altitude regions (2). These breeds are especially successful in both smallholder and commercial farming systems, especially in areas where large ruminants would not do well because of severe environmental limitations.

Goat keeping plays a significant role in reducing poverty and improving household food security, especially among smallholder farmers with limited resources. Goats have a relatively low startup cost, a high reproductive rate, early maturity, and high resistance to unfavorable climatic conditions (3). Regular production and sale of offspring in the market generate a steady stream of income for households in rural areas. Although national production of goat milk and goat meat is slowly rising, overall productivity remains limited by several reproductive and management issues.

Repeat breeding, which is considered a failure to conceive following repeated services after regular estrous cycles and without the visible defects of the reproductive tract, is one of the most economically harmful reproductive disorders in goats (4). The condition results from a multifactorial etiology, which can include breed-specific susceptibility, nutritional deficiencies, climatic stressors, parasitic infections, and poor management practices such as poor estrus identification and delayed mating (5,6). Poor-quality crop residues and seasonal grazing are usually the primary sources of goats in Pakistan, but they do not always meet the energy, protein, and mineral requirements necessary to sustain optimal ovarian activity and embryo survival (7). Further impaired uterine health and conception rates are caused by parasitic burdens and chronic diseases (8). There is also genetic susceptibility and breeding adaptability, but little breeding history is available to evaluate them (9).

Management-related factors common in smallholder systems will worsen repeat breeding by utilizing uncontrolled natural service, lack of access to proper veterinary services, and the adoption of reproductive technologies such as estrus synchronization (10, 11). Hormonal balance, estrous expression and embryo viability are disturbed by environmental factors, especially heat stress in summer and cold stress in winter, with moderate seasons generally allowing higher conception rates (12). Age is also a modulator of risk, where young animals are more likely to fail conception because of incomplete reproductive development and old age because of subclinical uterine infection (13).

The economic costs associated with repeat breeding include high inter-kidding intervals, low kid birth rates, high culling rates, and low farm profitability. Despite it being recognized as a key limitation to goat productivity at a global scale, region-specific information on its occurrence, especially the interactive effects of nutrition, age, season, and climate, in Pakistan is limited. The current ultrasonographic study has been conducted to determine the frequency of repeat breeding in goats under the subtropical highland agro-climatic conditions of Rawalakot, Azad Jammu and Kashmir, to guide specific reproductive management interventions to improve goat production and farmers' livelihoods.

MATERIALS AND METHODS

Study Location and Animals: It was a retrospective study conducted at the Veterinary Reproduction Clinic, Faculty of Veterinary and Animal Sciences, The University of Poonch Rawalakot (UPR), Azad Jammu and Kashmir, Pakistan. The clinic mainly serves reproductive cases referred by smallholder farmers in rural and peri-urban areas of Rawalakot. Female goats were offered as outpatients for routine reproductive assessment following natural mating in traditional farming systems. The selection standards included a documented history of natural service and apparently fertile bucks and no gross external genital abnormalities. Ovine females that had previously received hormonal therapy or had apparent clinical abnormalities (e.g., purulent vaginal discharge or frank uterine infection) were not included in the study.

Weather at the location of the study: Rawalakot is located at 33deg51'N and 73deg45'E, with an elevation of about 1,634 meters (5,374 feet) above sea level. The climate in the area is subtropical highland, with four seasons: mild spring and fall, hot and humid summer, and cold winters with the possibility of snowfall. Temperatures can reach 38 °C in summer and drop below 1 °C in winter. It is mainly monsoonal (July-September) with snowfall during the months of December and January.

Time and Duration of study and Ultrasonographic scan: The retrospective review was conducted on clinic records from January 2022 to December 2024. This was done through pregnancy diagnosis 30-45 days after mating, using transabdominal and/or transrectal ultrasonography with a portable ultrasound machine having a 5.0-7.5 MHz linear-array transducer. Visualization of embryonic vesicles, fetal heartbeat or placentomes was positive and confirmed as pregnancy. The goats with no ultrasonographic characteristics of pregnancy were classified as repeat breeding positive (non-pregnant), whereas those with a proven pregnancy were classified as repeat breeding negative (pregnant).

Age and Seasonal Classification: The history was categorized by age: owner-provided history supported by dentition: young goats (<2 years) and adult goats (>2 years). Seasons were also separated into winter (October-March), characterized by lower temperatures and reduced forage availability, and summer (April-September), characterized by higher temperatures and greater nutritional resources.

Data Visualization and Statistical Analysis: The data were organized in a spreadsheet and evaluated with the R statistical software (version 4.3 or higher; R Core Team, Vienna, Austria) using the following packages: base R, dplyr to handle the data, and broom to tidy the model. Descriptive statistics involved calculating frequencies and percentages of repeat-breeding cases by age group and season. Contingency tables were created to depict cumulative impacts. The Chi-square test of independence was used to determine the associations between categorical variables (age group or season) and repeat breeding status, with significance set at $p < 0.05$. Binary logistic regression was conducted to examine independent and interactive effects; repeat breeding status (positive = 1; negative = 0) was the binary outcome variable. Predictors were season (winter = 1; summer = 0), age group (young = 1; adult = 0), and their interaction term. The significance of the models was tested using the likelihood-ratio Chi-square, and goodness-of-fit was measured using the McFadden pseudo-R2. Plotly in R (plotly package) was used to create interactive figures (e.g., contingency tables, sunburst charts) to show prevalence by age and season.

RESULTS

Effect of Age and Season on Repeat Breeding Prevalence in Goats: Seasonal changes played a significant role in breeding repeat amongst goats, with the highest incidence observed during winter in Rawalakot. Of the 49 goats sampled during the winter season, 17 (35 per cent) were diagnosed as repeat breeders, whereas only 28 per cent of the 107 goats sampled during the summer season were repeat breeders. This suggests that the longer winter days in Rawalakot, characterized by low temperatures and possible feed scarcity, may also contribute to the increase in repeat breeding prevalence. Hormonal regulation and estrous cycles in goats may be affected by cold stress, which increases the incidence of non-conceptive mating. Moreover, the statistics showed that 72 per cent of young goats (less than 2 years old) observed during the winter experienced repeat breeding, with 65 per cent of the adult goats experiencing the same problems. This suggests that although both age groups are affected, younger goats appear more vulnerable to repeat breeding in winter. These results indicate that environmental stress factors, such as long, cold seasons, can exacerbate reproductive inefficiencies, particularly in younger goats that may not be fully developed to reach their reproductive potential **(Table and Figure 1).**

Table1: Combined Effect of Age and Season on Repeat Breeding Prevalence in Goats

Season	Age Group	Total Goats Examined	Repeat Breeding Cases (n, %)	Non-Repeat Breeding (n, %)
Winter	Young (<2 years)	34	24 (72%)	10 (28%)
	Adult (>2 years)	15	10 (65%)	5 (35%)
Summer	Young (<2 years)	70	15 (21.4%)	55 (78.6%)
	Adult (>2 years)	37	15 (40.5%)	22 (59.5%)

The table shows the combined effect of age and season on repeat breeding prevalence in goats. Winter season shows a significantly higher prevalence of repeat breeding in both young and adult goats, with young goats exhibiting the highest prevalence (72%)

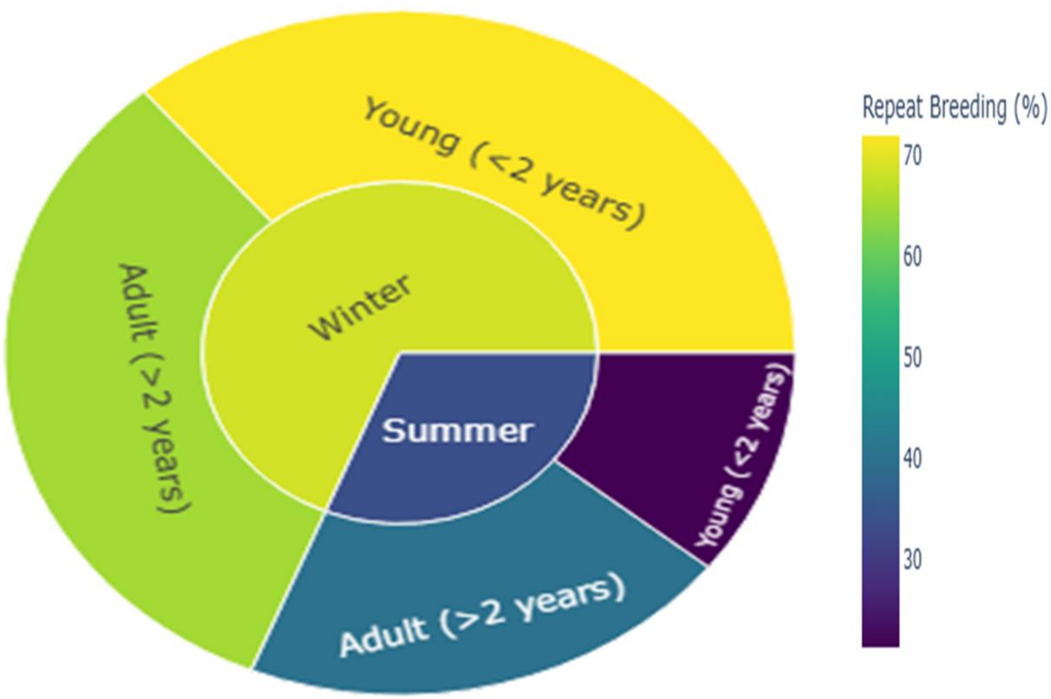

Figure 1: Sunburst Chart of Repeat Breeding Prevalence by Age and Season in Goat. The chart visually represents the prevalence of repeat breeding in goats across different age groups (Young and Adult) and seasons (Winter and Summer). The size of each segment corresponds to the repeat breeding percentage, and the color scale indicates the magnitude of prevalence, with higher percentages in darker hues. This chart highlights the impact of seasonal and age-related factors on repeat breeding prevalence, showing a higher incidence of repeat breeding in young goats during winter and in adult goats during summer.

Association Between Age Group and Repeat Breeding Status: A chi-square test of independence was used to assess the relationship between age group (young: <2 years; adult: >2 years) and repeat breeding status (positive vs. negative) in the goat population studied (N=156). The frequencies were as observed: 29 repeat breeding positive (RBP) and 75 repeat breeding negative (RBN) among young goats (n=104), and 18 repeat breeding positive (RBP) and 34 repeat breeding negative (RBN) cases among adult goats (n=52).

The results of the test were χ^2 (1) = 0.46, p = 0.497. The frequencies of 31.33 RBP and 72.67 RBN, respectively, were the expected frequencies under the null hypothesis of no association with both young goats and adult goats. The null hypothesis could not be rejected as the p-value was more than the standard level of significance of 0.05. These findings suggest that there is no statistically significant correlation between age group and the prevalence of repeat breeding across the combined seasons (**Table 2**).

Table 2: Chi-Square Test Table based on the **age group** and **repeat breeding status** data

Age Group	RBP (Observed)	RBN (Observed)	Total (Observed)	RBP (Expected)	RBN (Expected)	Total (Expected)	Chi-Square (χ^2)	df	p-value
Young (<2)	29	75	104	25.13	78.87	104	1.93	1	0.165
Adult (>2)	18	34	52	21.87	30.13	52			
Total	47	109	156	47	109	156			

RBP= Repeat Breeding Positive, RBN =Repeat Breeding Negative, df= Degree of freedom

Association Between Season and Repeat Breeding Status: To test the relationship between season (winter: October-March; summer: April-September) and repeat breeding status (positive: non-pregnant after mating; negative: pregnant) in the goat population (N=156), a chi-square test of independence was used. A contingency table indicated that there were 17 repeat breeding positive (RBP) and 32 repeat breeding negative (RBN) cases during winter (n=49) and 30 repeat breeding positive (RBP) as well as 77 repeat breeding negative (RBN) cases during summer (n=107). The result of the chi-square test provided a chi-square value of kh2(1) = 0.43, p = 0.512 (exact p-value was calculated in the chi-square test with no continuity correction). Since the p-value was more than the usual level of significance of 0.05, season and repeat breeding status were not statistically significant when applied separately throughout the dataset. This lack of a substantial main effect of season, like that of age, highlights the possible importance of interaction effects or other factors that cannot be quantified as the cause of the observed descriptive changes in prevalence (**Table 3**).

Table 3: Chi-Square Test for Association Between Season and Repeat Breeding Status.

Season	RBP (Observed)	RBN (Observed)	Total (Observed)	RBP (Expected)	RBN (Expected)	Total (Expected)
Winter	17	32	49	14.76	34.24	49
Summer	30	77	107	32.24	74.76	107
Total	47	109	156	47	109	156
χ^2 (df=1)	**p-value**					
0.43	0.512					

Repeat Breeding Positive (non-pregnant); RBN = Repeat Breeding Negative (pregnant). Expected values rounded to two decimal places. χ^2 statistic and p-value are reported at the bottom for clarity.

Logistic Regression Analysis of Interaction Effects Between Age and Season on Repeat Breeding: To determine the independent and interactive relationships between age and season on repeat breeding status, a binary logistic regression model was estimated, with repeat breeding status (non-pregnant after mating = 1; pregnant = 0) as the dependent variable (N = 156). They were predicted by season (Winter = 1, Summer = 0), age group (Young < 2 years = 1, Adult > 2 years = 0), and their interaction term. The general model was statistically significant (Likelihood ratio χ2 (3) = 28.21, p = 0.001) with a pseudo-R2 (McFadden) of 0.134, suggesting moderate explanatory power. The odds of repeat breeding were much less between young goats and adults in general (OR = 0.40, 95% CI [0.17-0.95], p = 0.039). The trend of winter season increased odds, though marginally (OR = 2.93, 95% CI [0.83-10.32], p = 0.094). The interaction term was not significant (p = 0.169), and there was no strong statistical support for moderation, although descriptive patterns were observed (**Table 4**).

Table 4: Logistic Regression Results for Predictors of Repeat Breeding Status

Predictor	Coefficient (β)	SE	z	p-value	Odds Ratio	95% CI Lower	95% CI Upper
Constant	-0.383	0.335	-1.144	0.253	0.682	0.354	1.314
Season (Winter vs. Summer)	1.076	0.642	1.676	0.094	2.933	0.834	10.323
Age Group (Young vs. Adult)	-0.916	0.444	-2.065	0.039	0.4	0.168	0.955
Interaction (Season × Age)	1.099	0.799	1.375	0.169	3	0.626	14.367

Correlation Analysis of Factors Influencing Repeat Breeding in Goats: The correlation analysis showed significant relationships among factors affecting repeat breeding in goats. It is worth noting that the age group was moderately correlated with temperature and feed quality, suggesting that older goats may experience different environmental conditions and nutrition-diet programs than younger goats. It was found that season and temperature showed a strong correlation, suggesting that colder winter months may negatively affect reproductive efficiency. Also, the quality of feed was a major factor in repeat breeding status, with higher-quality feed associated with a lower repeat-breeding rate. These findings indicate the significance of controlling seasonal conditions and nutritional processes to enhance reproduction in goat farming systems **Figure 2**.

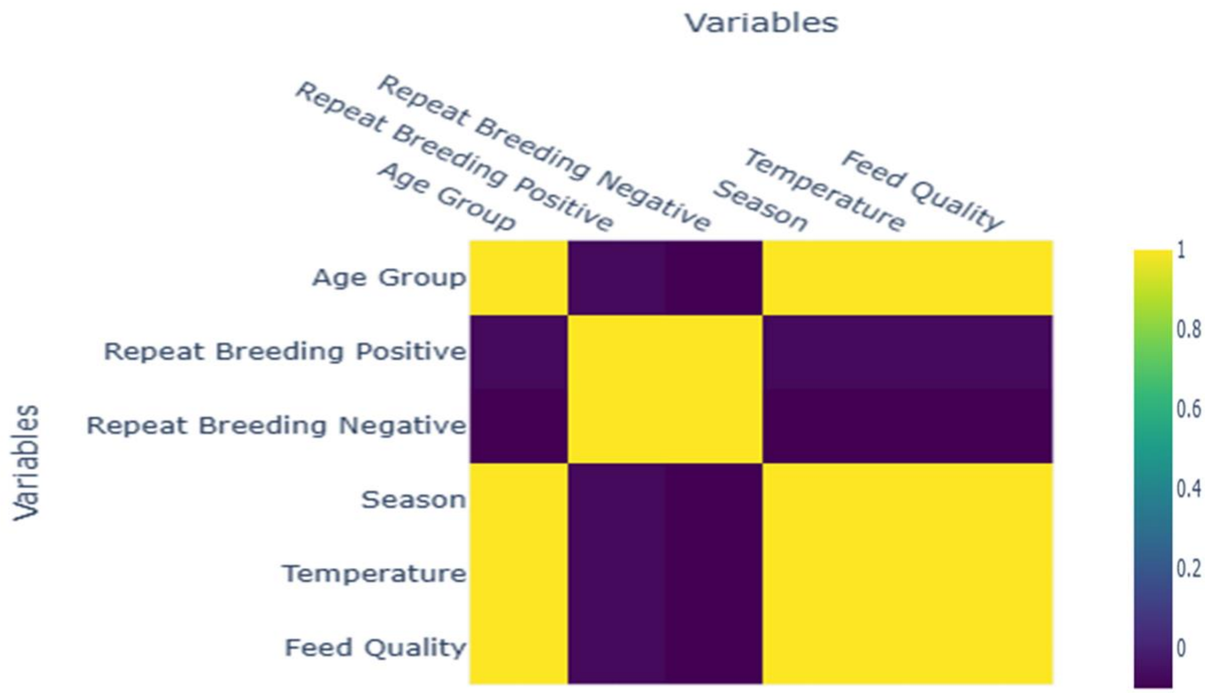

Figure 2. **Correlation Heatmap of Factors Influencing Repeat Breeding in Goats**. This heatmap visualizes the correlations between various factors, including age group, season, temperature, feed quality, and repeat breeding status (positive/negative). Stronger correlations are represented by darker colors. The analysis indicates key relationships between these variables, highlighting the influence of **temperature** and **feed quality** on repeat breeding occurrences in goats.

Principle component analysis for confounding factors involved in repeat breeding: A graphical representation of the data, reduced to the first two principal components (PC1 and PC2) to identify the most significant contributors, is shown in the 2D PCA score plot (Figure 3). The points denote Samples and are color-coded by age and season. The explanations of the various principal components are presented in the corresponding axes, indicating the amount of total variance that each element can explain. Such a plot helps visualize how the samples cluster or separate based on their scores along the first two principal components and may be used to identify patterns in reproductive performance in goats.

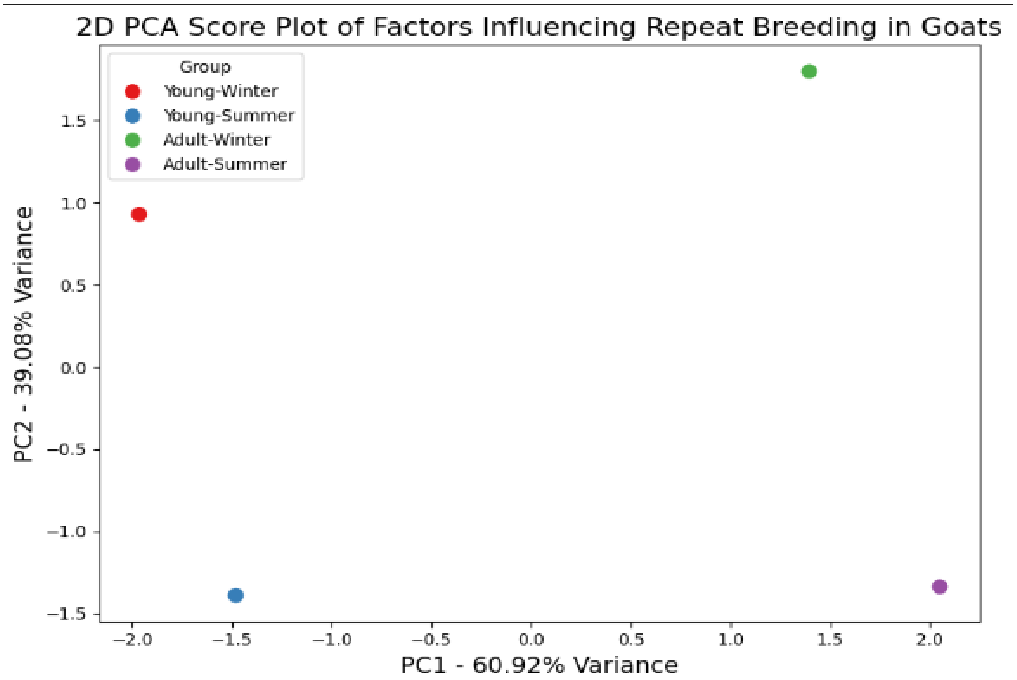

Figure 3. **2D PCA Score Plot of Factors Influencing Repeat Breeding in Goats**. This scatter plot shows the distribution of the data along the first two principal components (PC1 and PC2). The points are color-coded based on **age** and **season**. The explained variance for each principal component is shown on the axes, providing insight into the contribution of each component to the overall data structure.

DISCUSSION

The ultrasonographic experiment at Rawalakot sheds light on essential information regarding the polyfactorial characteristics of the process of repeat breeding in goats. Based on this, the descriptive tendency toward increased vulnerability in winter, especially in younger animals, is revealed, and statistically significant independent associations are not established in the chi-square tests. This implies that environmental stressors, such as low temperatures and reduced forage in high-altitude subtropical areas, might indirectly affect reproductive success by altering the oestrous cycle and embryo viability, as indicated by the 72 per cent prevalence of winter in young goats. The marginal seasonal effect of the logistic regression model (OR = 2.93, p = 0.094) supports these inferences and indicates that subclinical nutritional deficiencies might be exacerbated by metabolic demands in a stressful cold condition, resulting in impaired ovarian cyclicity and low conception rates (Khan *et al*. 2019). Also, breeding young goats less often (OR = 0.40, p = 0.039) could reflect underlying baseline resilience in young animals under optimal conditions, but this is again overcome by seasonal interactions, and adaptive management strategies are necessary to offset these compounded risks (Abdulkareem *et al*. 2012).

These observations are supported by comparative analyses with available literature and contextual differences are identified. An example of this is the study of seasonal breeding regimes of pastoral goat herds in Ethiopia, which showed that seasonal constraints enhanced liveweight gain and dam productivity by lowering breeding to periods of good forage compared to the greater prevalence of winter in Rawalakot, where seasonality seems to be a disadvantage (Hary and Schwartz 2002). This is in agreement with Turkish studies on the same, where winter conditions had a similar effect, increasing repeat breeding by disrupting photoperiodism, with reported rates as high as 40% in flocks (Khan *et al.* 2019). Nevertheless, the insignificant chi-square season (p = 0.512) of the current study contrasts with the Ethiopian data, where (Gidena 2017) showed that seasonal relations were strong (p < 0.05), which may be explained by the fact that, in the highland, Rawalakot is less affected by the extremes of seasonal changes than in arid lowlands. Age effects are also practical age-specific inferences indicate delayed reproductive maturity in stressed young goats (aged below 2 years), which is supported by extension guidelines that suggest that does enter puberty at age 7-10 months. Still, they need optimal nutrition to be fertile, and under-optimal conditions result in increased non-conception (Ott and Memon 1980). This aligns with international surveys on reproductive challenges affecting small ruminants, which reveal that young animals exhibit high repeat breeding due to underdeveloped gonads and increased sensitivity to environmental factors(Ali *et al*. 2019).

The emergent form of intervention would be management and technology-based interventions, since the medium model fit (pseudo-R2 = 0.134) highlights unaccounted factors, such as poor estrus detection in smallholder systems. The overall examination of repeat breeding syndrome in goats presents considerable challenges for inexperienced farmers and a lack of veterinary care, resulting in long intervals between kid births and lost profits (Baker and Gray 2004). Similarity in evidence from synchronization protocols used in dairy goats indicates that repeated estrus treatments can decrease fecundity without appropriate management, and that fixed-time breeding would improve seasonal inequalities by increasing conception rates (Selvaraju *et al*. 2020; Sun *et al*. 2024). Besides, endocrine manipulations to control seasonality in sheep and goats have been shown to be effective in temperate environments, shortening anestrus and enhancing fertility that can be extended to high-altitude environments to counteract the adverse effects of winter (Waqas and Tibary 2025). Conversely, research on the timing of insemination in Spanish breeds such as Murciano-Granadina shows that close control of breeding increases reproductive outcomes, where fertility rates are over 70% under controlled conditions, which is much higher than the favorable pregnancy rates of 28-35% in this study (Peláez Caro *et al*. 2024). These analyses underscore the importance of incorporating advances in reproductive technologies, as examined in the context of dairy goat production (Choi *et al*. 2019), to significantly improve outcomes in resource-constrained environments, such as Pakistan.

The limitations of the study include a relatively small sample size (N=156), which may have limited the identification of significant interactions, and the use of clinic-present cases, which could have been biased toward higher prevalence estimates. The use of owner-reported ages and the omission of breed-specific data only restrict generalizability, and unmeasured confounders should be cautioned in causal attributions, as parasitism is known to compromise the health of the uterus (Das *et al*. 2025). Future studies need to focus on bigger, prospective cohort studies that include nutritional assays, genetic profiling and breed comparisons to identify specific mechanisms. Also, interventional studies on estrus synchronization and nutritional supplementation for high-altitude goat flocks may yield actionable measures to enhance productivity and improve the livelihoods of farmers in Azad Jammu and Kashmir**.**

Conclusion: The present ultrasonographic research on Rawalakot, Azad Jammu and Kashmir, determines a general prevalence of 30.1% of breeding in goats under smallholder management, with considerable seasonal and age-specific differences, although without statistically significant independent relationships. It is worth noting that young goats (<2 years) had significantly higher repeat-breeding rates in winter (72%) than in summer (21.4%), whereas adult goats had a higher prevalence in summer (40.5%). Binary logistic regression showed a significant model fit, with lower overall odds in the younger animals (OR=0.40, p=0.039) and a marginally seasonal rise (OR=2.93, p=0.094). The results indicate the essential roles of climatic stressors and physiological maturity in reproductive efficiency in subtropical highland habitats, which are also characterized by cold-related metabolic stress and nutritional constraints, so that every embryo is likely to lose and fail to conceive. The findings also indicate how young goats are susceptible to winter environments, which require coach-specific interventions, i.e., supplemental feeding, better housing, and estrus synchronization systems at the time of the high-risk period.

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