BRIDGING FUNCTIONAL PERFORMANCE AND SHOW RINGCRITERIA: CORRELATION OF LINEAR PHYSICAL TRAITS, PRODUCTIVE CAPACITY, AND SHOW RINGACHIEVEMENT IN U.S. DAIRY GOATS

By

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Abstract

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An investigation of the relationship between linear physical traits, milk production, and show ring outcomes in U.S dairy goats, with an emphasis on empirical analysis conducted in commercial and competitive contexts. A quantitative study conducted at Grande Ronde Dairy, in which nearly one hundred first- and second freshening does were systematically evaluated for key linear conformation traits and daily milk yield. Statistical analyses identified FA, UD, and DY as the most significant predictors of milk production within the commercial herd. The analysis extended to the national showring, comparing linear trait and production records among top-placing two-year-old does at the ADGA National Show. Through rigorous data standardization and comparative analysis, the study examines whether high productivity traits are recognized and rewarded in elite show placings. Findings reveal moderate correlations between show placings and both production-nbs and key udder-related traits, suggesting that national judges generally reward animals with superior conformation and production capacity. By integrating data from both production and performance settings, this report provides critical insight into the extent to which current selection practices in the U.S. dairy goat industry advance both functional and aesthetic objectives.

Contents

List of Tables

Page

List of Figures

Establishing the Ideal: History, Performance Programs, and the Science of Productivity in Dairy Goats

Review of Dairy Goat History

American Dairy Goats were introduced into the United States by settlers in Jamestown and Plymouth Rock during the 16^{th} century. Daniel Freeman Tompkins spearheaded selective dairy goat breeding in the late 1800s. Prior to the importation of four Toggenbergs in 1893, there were no purebred dairy goats in the United States. In 1904 the American Milch Goat Record Association was founded which later was renamed as the American Dairy Goat Association in 1964. Slowly, more purebred breeds were imported into the United States with Saanens in 1904, Nubians in 1906, Alpines in 1922. Additional breeds became recognized by the American Dairy Goat Associations with LaManchas in 1958, Oberhaslis in 1980, Nigerian Dwarfs and Sables in 2005. (ADGA)

Dairy goats, as part of the United Nations 2030 Agenda for Sustainable Development, play an increasingly important role in developing countries as they deliver a sustainable source of nutrition (Castro). Goats align with several of the UN proposed sustainable development goals with particular relevance to food and nutritional sustainability, economic sustainability, and environmental sustainability. The growing prominence of dairy goats in the global agricultural sector is additionally due to their adaptability and the intensifying demand for goat milk, as studies have shown it consists of unique organoleptic properties and less allergens.

Though growing in popularity, the dairy goat industry is still hindered by limited education and research, often relying on dairy cattle research. However, the significant physiological differences between the two ruminants have proven that the exchange of lactation knowledge from dairy cattle to dairy goats is inadequate (Castro). Additionally, the high variability in most traits, principally due to genetic diversity, makes further studies about mammary gland physiology, milk yield, and composition essential for a growing dairy goat industry.

The Rise and Relevance of Dairy Goat Production

When selective breeding of dairy goats began in the late 1800s the goal was to breed does with the potential to produce two quarts of milk per day (ADGA). Over the past fifty years, dairy goat production has emerged as a vital and growing sector within global agriculture with unprecedented growth. From 1970 to 2022, the global goat inventory increased by 182%, and dairy goat production itself rose by 196%. The economic value also followed a steep trajectory, nearly quadrupling with a 375% increase between 1991 and 2022 — a trend expected to continue through 2050. Projections indicate that this growth trend will continue, with expected increases in both inventory (53.37%) and production (71.29%) from 2024 to 2050. This surge is not incidental but speaks to the adaptability and growing importance of dairy goats in the global food system, both in marginal agro-ecological zones as well as develop countries with more affluent markets. (Navarrete-Molina, Meza-Herrera and Santiago-Miramontes)

By 2022, global goat milk production reached 19.19 million metric tons (Mt), up from 6.48 Mt in 1970. Projections indicate an increase to 32.87 Mt by 2050, reflecting a 71% growth. This growth rate outpaces that of other ruminants, despite dairy goats requiring less land, capital, and feed. These trends underscore the economic and agricultural viability of dairy goats throughout many agrarian and production systems.

Review of Dairy Goat Ideal

The American Dairy Goat Association adopted a unified scorecard (See Appendix A) which is an embodiment of the ideal dairy goat, and such scorecard is used in the physical evaluation of stock during sanctioned shows and performance programs. Developed as a collaborative effort of dairy goat industry breeders, judges, and experts, the goal of the unified scorecard is to aid in the selection of the type of dairy goat that can function efficiently over a long productive lifetime (American Dairy Goat Association). This standardized evaluation system utilizes an one-hundred-point framework to assess various aspects of a goat's phenotype with an emphasis on functional traits, as the four main categories are: general appearance (35 pts), dairy strength (20 pts), body capacity (10 pts), and mammary system (35 pts).

General appearance entails the conformational soundness of a dairy goat and is defined as "an attractive framework with femininity (masculinity in bucks), strength, upstandingness, length, and smoothness of blending throughout that create an impressive style and graceful walk" (American Dairy Goat Association). General appearance is comprised of the following secondary categories: head and breed characteristics (5 pts), front end assembly (5 pts), back (5 pts), rump (5 pts), and legs pasterns & feet (15 pts).

Dairy Strength, as listed on the ADGA scorecard, is a combination of two key attributes in dairy goats: dairyness (angularity and openness) and strength (depth and width of chest). Dairy strength is classified as openness and angularity throughout, with a strong yet refined bone structure. Identifiable areas include neck, withers, ribs, flank, thighs, and skin (American Dairy Goat Association). Body capacity references the width and depth of the animal's barrel (6 pts) and chest (4 pts).

The mammary system should be capacious, well attached, balanced, and indicative of heavy milk production over a long period of usefulness (American Dairy Goat Association). It accounts for thirty five percent of the scorecard with secondary categories of udder support (13 points), fore udder (5 points), rear udder (7 points), balanced, symmetry, & quality (6 points), and teats (4 points).

When the ADGA scorecard was designed in the mid-1900s it was not based on any data nor research; however, many esteemed goat dairymen today believe it to accurately reflect a strong, productive dairy animal (Acton, Owen and Bice).

Review of Linear Traits and Performance Programs

The American Dairy Goat Association offers several different performance programs, one of which is Linear Appraisal. Linear Appraisal was originally designed to be a sire proving program and offers an insight into the strength of traits that are transmitted to offspring. Type classification, such as Linear Appraisal, is a tool that aids producers in breeding selection by allowing them a greater understanding of the strengths and weaknesses in the body of an animal (American Dairy Goat Association). The performance program evaluates economically important and heritable individual type traits that affect functional and structural durability. Theoretically, conformation traits-traits that facilitate an animal successfully performing- should have a direct correlation with productivity, disease resistance, and longevity (Mauricio Valencia-Posadas). The American Dairy Goat Association's system of assigning numerical values to individuals and their traits is similar to other programs offered in different species, with a strong resemblance to the classification program used in dairy cattle.

Traits are scored on a fifty-point linear scale that ranges from one biological extreme (0) to the other (50), hence the term linear in the name. There are fourteen linear traits, twelve of which are primary traits and two secondary traits. Primary traits are those that have economic significance and variation while the secondary traits are scored as a way to gather more data. The twelve primary traits are: stature, strength, dairyness, rump angle, rump width, rear legs side view, fore-udder, rear-udder height, rear-udder arch, medial suspensory ligament, udder depth, teat placement rear-view, and teat diameter. The secondary linear traits are rear-udder side view and body depth (American Dairy Goat Association).

Breeders who are appraising their herd must score all eligible does. Eligible does are those that are fresh under the age of five who were not scored the year prior and does greater than five years old with no permanent score. Bob Bartholomew, an appraiser and judge for ADGA, explains that "when we're looking at goats, we need to be able to see all of the goats since the purpose is to see what all the daughters of a particular buck look like." To obtain a precise and comprehensive understanding of the buck's performance, all of his daughters—regardless of whether their traits are favorable, unfavorable, or undesirable—must be evaluated. (Bartholomew).

Dairy Strength, as listed on the ADGA scorecard, is a combination of two key attributes in dairy goats: dairyness (angularity and openness) and strength (depth and width of chest). Dairy strength is identified in six main areas: neck, withers, ribs, flank, thighs, and skin. These traits are separated and analyzed individually in a linear aspect.

Dairyness is defined as having a long bone pattern throughout with openness and angularity. It is assessed as a visual evaluation from the side and evaluated as openness of bone and flatness of rib. Length, cleanness and flatness of bone, length and leanness of neck, definition and sharpness of withers, degree of fleshing, femininity and refinement, and fineness and texture of skin are also considered. Dairyness is scored from coarse (≤10 points) to extremely sharp (≥40 points), with exceptionally round-boned, tight-ribbed animals receiving ≤5 points and extremely flat-boned, open-ribbed animals receiving ≥45 points (American Dairy Goat Association). The reference scale (Figure 2) for dairyness scores are: 5 – extremely thick and coarse, extremely round bone; 15 – thick and coarse, round bone; 25 – intermediate angularity and flatness of bone; 35- sharp and angular, clean flat bone; 45 – extremely sharp and angular, extremely clean flat bone (American Dairy Goat Association).

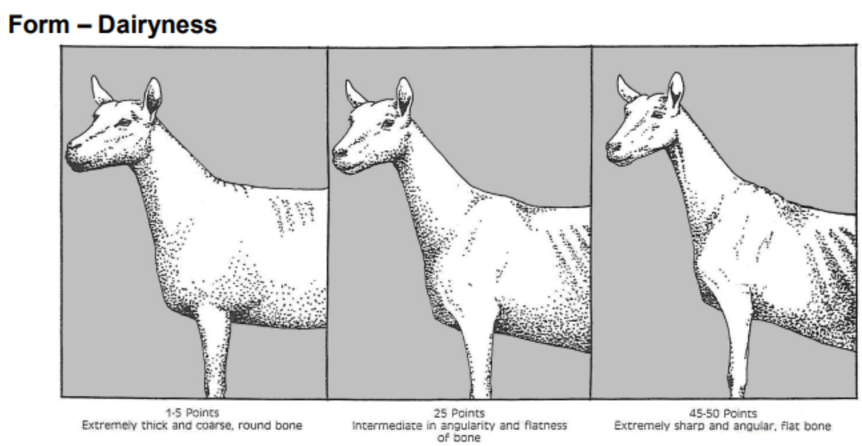

Figure 1: ADGA Linear Appraisal Dairyness Scoring Reference

Strength is evaluated based on the width and depth of the chest, muzzle width, and bone substance in the front end. It is visually assessed from the front and typically ranges from extremely narrow and frail (<20 points) to wide and strong (>30 points), with an intermediate range of 20-30 points (refer to figure 2).

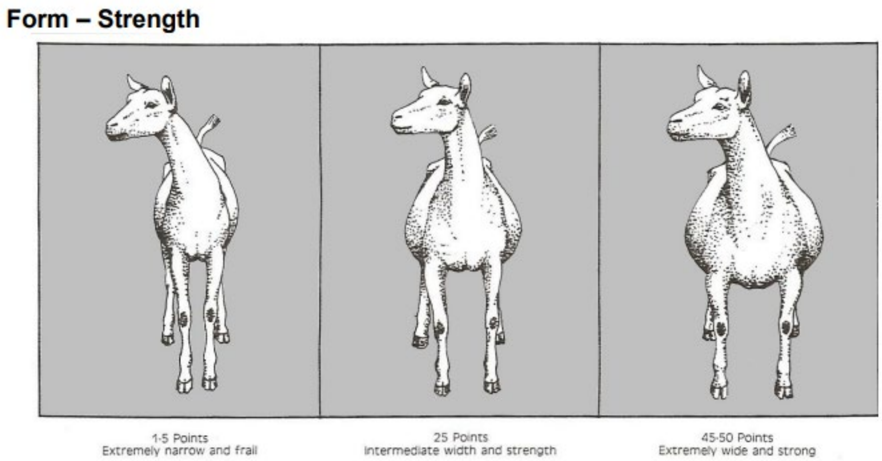

Figure 2: ADGA Linear Appraisal Strength Scoring Reference

Rump width is measured by standing from the rear and placing a ruler – or other approved measuring device- on top of the rump. The width is then calculated from between the thurls, specifically at the outermost top portion of the pelvic bone, using a level crosspiece for accuracy. It is scored on a scale from extremely narrow (≤5 inches, ≤5 points) to extremely wide (≥9 inches, ≥45 points). An intermediate rump width score of twenty-five points indicates a rump that is 7” wide, each additional 1/4” is five points (refer to Table 1)fine

Table 1: ADGA Linear Appraisal Rump Width Scoring Reference

LINEAR SCALE – RUMP WIDTH

Standard Inches	Miniature Inches	Linear Score
≤ 5"	4.5"	5
5.5"	4.75"	10
6"	5"	15
6.5"	5.25"	20
7"	5.5"	25
7.5"	5.75"	30
8"	6"	35
8.5"	6.25"	40
9"	6.5"	45

Much of the remaining linear traits evaluate the mammary system. Rear udder arch evaluation considers both the width and the shape of the rear udder attachments. Differences in hair and skin texture between the udder and escutcheon are used as guidelines for determining the point of attachment. A narrow and pointed rear udder arch receives 5 or fewer points, while an intermediate arch is assigned 25 points, and an extremely wide and well-arched rear udder earns 45 or more points (refer to Figure 3).

Mammary – Rear Udder Arch

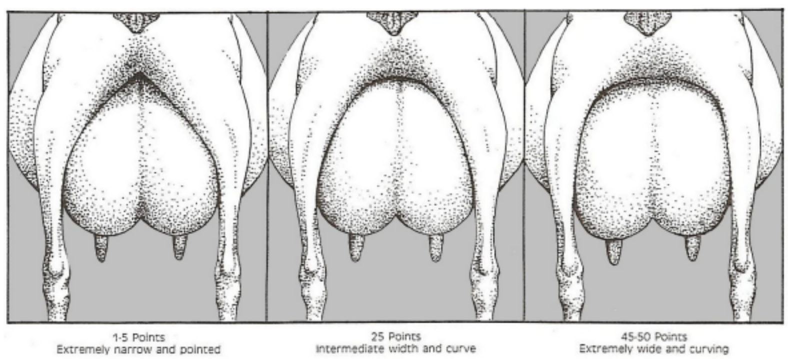

Figure 3: ADGA Linear Appraisal Rear Udder Arch Scoring Reference

Udder depth is measured in relation to the hocks, specifically as the vertical distance between the udder floor and the hock when the rear leg is naturally positioned. A deep udder, extending at least 2 inches below the hocks, receives 5 or fewer points, while an intermediate

Mammary – Udder Depth

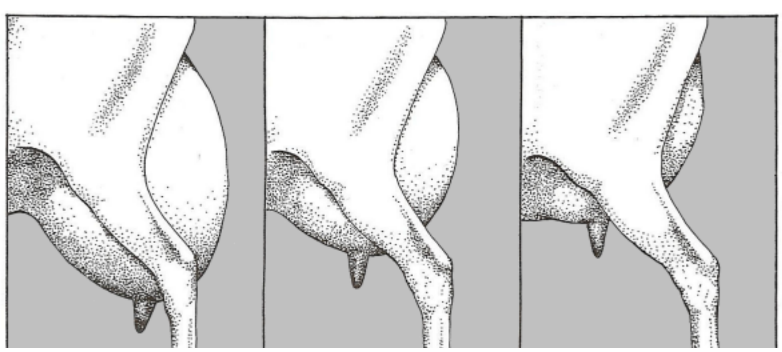

Figure 4:ADGA Linear Appraisal Udder Depth Scoring Reference

udder, positioned 2 inches above the hocks, is assigned 25 points. A shallow udder, sitting 6 inches or more above the hocks, earns 45 or more points (refer to figure 4).

Fore udder attachment is measured by evaluating the strength and tightness of the lateral ligaments as they extend forward and laterally to the body wall. The evaluation also considers how far the udder extends forward from the teats, the lateral extension, and the width across the lateral, without factoring in the udder's position on the body wall. Fore-udder attachment is graded from 1-50 points with a loose attachment receiving 5 or fewer points, while an extremely snug and strong attachment earns the highest score (refer to Figure 5).

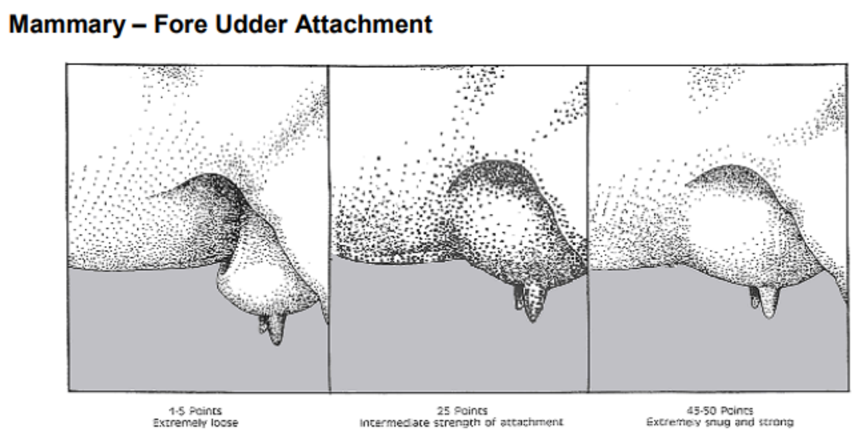

Figure 5: ADGA Linear Appraisal Fore Udder Attachment Scoring Reference

Rear udder height (RUH) is scored in proportion to the goat’s body, based on the attachment point relative to the hock and pelvic arch. Hair and tissue texture differences between the rear udder and escutcheon help determine the exact attachment point. The mammary system is visually assessed with the midpoint between the pelvic arch and hock receiving a point value of 10, and with scores increasing as the attachment moves higher. When the attachment point is

5/8 between the pelvic arch and point of hock the score received is 20 points, ¾ = 30 points, 7/8 = 40 points, and at the pelvic arch is 50 points (refer to Figure 6).

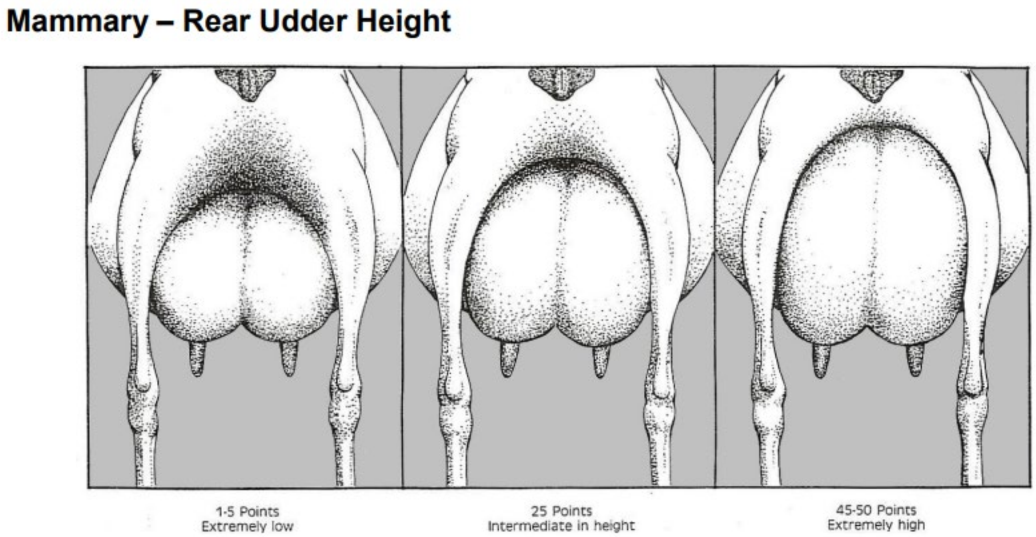

Figure 6: ADGA Linear Appraisal Rear Udder Height Scoring Reference

Bartholomew explains that appraisers do not dictate what is good in terms of linear score. He states that most traits are optimally in the moderate range; however, "every herd owner and published set of ideal linear trait values; however, industry veterans have their own concept of an ideal score. Baden, a renowned appraiser and judge, coined the term 40-trifecta in regards to linear mammary system scores. The three traits foreudder attachement, rear udder height, and rear udder arch should ideally be scored forty points or higher as they correlate to productivity and mammary function (Baden). Baden further expands on his observations in what he labels the "5-4-3-2-1 theory". To piece together the supreme animal there are five traits that should score in the forty's (foreudder attachment, rear udder height, rear udder arch, stature, and rump width), four traits that score in the thirty's (rump angle, dairyness/strength, udder depth, and medial suspensory ligament), three traits that score twenty-five (teat placement, teat diameter, and teat legnth), and rear-leg sideview should score in the twenty's (Baden).

Review of Correlation Between Linear Traits and Productivity

Milk productivity in dairy goats is a multifactorial trait shaped by both genetic and environmental influences. Effective improvement in production depends on breeders' ability to select for an optimal balance of production and conformation (type) traits. Overemphasis on a single trait, such as milk yield, can compromise essential physical characteristics - most notably udder structure—which can increase the risk of undesirable traits like pendulous udders and, ultimately, lead to involuntary culling (Valencia-Posadas).

Linear traits, which include standardized measures of conformation such as udder depth, teat placement, and body capacity, have long been used as indirect predictors of milk production potential. While selection based on linear traits has been widely validated in dairy cattle (Prabowo) (Getu and Misganaw), the direct study of these correlations in dairy goats remains limited, especially in breeds recognized by the American Dairy Goat Association (ADGA). Given the limited U.S.-based research, much of the current knowledge derives from European, Latin American, and Mediterranean studies, and lessons from dairy cattle are often extrapolated to goats, though the species-specific context is critical.

Research on dairy goats indicates that several linear traits are positively correlated with milk yield. In Spanish dairy sheep, Legarra and Ugarte found moderate to strong correlations between udder depth, fore udder attachment, teat size, and milk production (Legarra and Ugarte). Manfredi similarly reported that goats with higher, better-attached udders tend to have increased milk yields across lactations (Manfredi). Udder depth, in particular, has been emphasized: within functional limits, deeper udders are associated with greater milk yields, but excessive depth may increase mastitis risk and milking difficulties (Montaldo and Manfredi, 2002).

Udder morphology has been rigorously studied. Gall, in one of the most comprehensive analyses of dairy goats, established that udder size—measured by length, width, and circumference—was positively correlated with milk yield, and visual assessment of the udder could provide a reliable estimate of productivity (Gall). In a study of 588 Czechoslovakian Saanen goats, Horak (as cited by Gall, 1980) found significant correlations between milk yield and udder length (0.41), width (0.20), circumference (0.43), teat length (0.21), and teat circumference (0.22). Notably, goats with pendulous udders produced slightly more milk (1,119 kg in the second 300-day lactation) than those with round or egg-shaped udders (1,092 kg), although the causal direction between udder size and milk production remains unresolved.

Body traits such as chest width, body length, and stature are also positively correlated with milk yield, albeit less strongly than udder traits. Carta et al. found that body weight, skeletal size, abdominal volume, and udder volume all positively influenced milk production at different lactation stages (Carta, Casu and Salaris), with body weight accounting for 20–30% of the variation in milk yield and 70% of first-lactation variation explained by body characteristics and growth rate (Gall). However, increases in body weight benefit milk yield only when due to increased rumen and udder volume, not fat or muscle mass, as goats with more muscle tend to produce less milk (Gall).

A U.S.-based study (Castaneda-Bustos) focused on the productive life – defined as total days in production or stayability – and functional productive life – the ability to avoid involuntary culling- in their research. Castanda-Bustos identified udder depth (UDD), rear udder width (RUW), and fore udder attachment (FUA) as key type traits most strongly correlated with productive life (PL72) and functional productive life (FPL72) in American dairy goats. The study found that intermediate scores in dairyness (DAI) and udder depth, and extreme scores in

FUA and RUW, were associated with longer productive lives. These findings parallel cattle studies where type traits are robust predictors of longevity and culling risk (Castaneda-Bustos)

Other international studies reinforce the importance of functional udder traits for both productivity and longevity. Montaldo & Martinez-Lozano and Capote et al. found positive correlations between milk yield and well-attached, deep, and large-volume udders (Montaldo and Martines-Lozano) (Capote, Argullo and Castro). Bowl- or round-shaped udders were also linked to higher production and lower somatic cell counts, indicating better mammary health (Vrdoljak, Ugarkovic and Vnucec) (Montaldo and Martines-Lozano).

The dairy cattle industry provides a richer body of research, much of which supports the use of linear traits in selection programs for productivity and longevity. The dairy cattle industry has extensively documented the relationship between linear traits and milk production. Short et al. (1992) demonstrated in Holstein cattle that udder traits alone explained 20–25% of the variation in milk yield (Short and Lawlor). The Holstein Association reports that cows scoring higher in traits like fore udder attachment, rear udder height, and teat placement produce significantly more milk over their lifetimes (Holstein Association USA). In their linear scoring system, a one-point increase in udder composite score corresponded to an average increase of 120 kg of milk per lactation.

Prabowo et al. investigated 11 body width traits in Friesian Holsteins and found that rear udder width (RUW) had the strongest correlation with milk yield, while pin width (PNW) was important in heifer selection (Prabowo). Ahmed Saleh's study of 1,300 Friesian cows demonstrated that udder width and rear depth were reliable predictors of both milk yield and lactation length (Ahmed Saleh). Similarly, Getu and Misganaw highlighted the influence of udder depth, rear teat placement, and feet and leg structure on milk yield, longevity, and reproductive efficiency in dairy cattle (Getu and Misganaw). Functional type traits also play a significant role in reducing involuntary culling by supporting udder health, milking efficiency, and animal welfare. These findings have clear implications for dairy goats, especially given the genetic and management similarities between the species (Castaneda-Bustos).

Despite positive associations, the relationship between linear traits and productivity is complex and not always causal. Many traits are genetically correlated due to pleiotropic gene action, and selection for one may unintentionally alter others (Mauricio Valencia-Posadas). Furthermore, up to nine percent of variation in milk yield in dairy goats can be attributed to type traits, with the remainder explained by genetic, management, and environmental factors (Mauricio Valencia-Posadas).

Recent studies emphasize the importance of selecting for intermediate rather than extreme values in certain traits to maximize productive life and functional longevity (Castaneda-Bustos). Functional traits—such as udder health, teat placement, and feet and legs—can improve economic efficiency not solely by increasing yield but by reducing culling, improving animal welfare, and lowering production costs (Vrdoljak, Ugarkovic and Vnucec) (Getu and Misganaw). Given the limited U.S. research on ADGA breeds, there is a clear need for additional studies focused on American populations to better inform selection programs and optimize both productivity and longevity in dairy goats.

Substantial evidence from both goat and cattle studies confirms that certain linear traits—particularly those related to udder morphology and body capacity—are positively correlated with milk yield and productive life. While international research provides important guidance, species- and breed-specific studies, particularly within the American context, are necessary to refine selection programs for dairy goats and to ensure sustainable improvement in both production and animal welfare.

A Two-Toned Industry:

The dairy goat industry in the United States is comprised of two distinct but interconnected sectors: the show industry and the commercial production sector. While both share the overarching goal of genetic improvement and sustainable productivity, their selection criteria, management practices, and priorities often diverge, resulting in a noticeable gap between the two. In certain countries and historical periods, the emphasis on show ring performance has outweighed the importance placed on systematic production recording (Gall).

The show industry, primarily organized under the American Dairy Goat Association, focuses on the exhibition of goats that conform to established breed standards of excellence. There are more than twelve hundred ADGA sanctioned shows annually, including the National show which is held in the summer. Goats are evaluated based on a linear appraisal system and a detailed scorecard, with major emphasis on conformation traits such as general appearance, body capacity, dairy strength, and most notably, the mammary system. The mammary system alone can account for up to thirty-five percent of the total score in the ADGA system (American Dairy Goat Association). Success in the show ring is often associated with prestige, increased animal and offspring value, as well as the presumption of superior genetics and type.

Historically, the show industry has prioritized the visual appeal and structure of goats, sometimes at the expense of traits directly tied to productive longevity and milk yield. For example, judges may favor udders that are highly attached and aesthetically pleasing, yet these may not always reflect the best traits for long-term milk production or resistance to health issues such as mastitis (Mauricio Valencia-Posadas). Similar patterns have been observed in dairy cattle, where emphasis on show ring success has occasionally resulted in the selection of animals that are less suitable for commercial milk production (Miller).

In contrast, the commercial dairy goat sector is driven by the demands of efficient milk production and herd profitability. Selection criteria in this context emphasize traits such as milk yield, lactation persistency, reproductive efficiency, disease resistance, and overall animal health (Acton, Owen and Bice) (Castaneda-Bustos). Breeding decisions are data-driven, often relying on milk records and performance evaluations, with less regard for strict visual conformity to breed standards. Management practices are optimized for productivity, including advances in nutrition, health management, and milking technology (Acton, Owen and Bice).

As previously mentioned, the commercial sector has seen substantial growth in recent decades, in part due to increased consumer interest in goat milk products and diversification of the dairy industry. As reported by the USDA, the number of dairy goats in the U.S. has increased steadily since the 1990s, with commercial operations adopting more intensive management systems and larger herd sizes (USDA).

The differing priorities between the show and commercial sectors have created a persistent gap, particularly regarding selection for functional versus aesthetic traits. Studies in both goats and cattle have shown that exclusive selection for show traits can negatively impact functional attributes such as udder health, productive life, and milking efficiency (Mauricio Valencia-Posadas) (Castaneda-Bustos). For example, a review of U.S. dairy cattle found that while show winners often possessed superior physical traits, they did not always rank highest in lifetime milk production or longevity (Miller).

Conversely, commercial operations may select for high-yielding animals with less attention to conformation, which can occasionally result in structural weaknesses that impact animal health or milking ability over time (Gall). Bridging this gap has become a topic of discussion in both industries, with increasing calls for the integration of performance and type traits into breeding programs.

Similar divides have existed in the dairy cattle industry, where show ring winners and high-producing commercial cows historically represented different genetic lines. Recent efforts to align show and commercial priorities have included the incorporation of performance data into show evaluations and greater emphasis on functional traits in both selection and judging (Miller). These approaches have begun to inform the dairy goat industry, with some breeders and organizations advocating for a more balanced selection philosophy that values both conformation and productivity (Castaneda-Bustos).

The U.S. dairy goat industry stands at a crossroads, with two sectors pursuing related yet divergent goals. The show industry continues to set standards for breed type and visual appeal, while the commercial sector focuses on efficiency, yield, and sustainability. Addressing the gap between these sectors—by integrating functional and type traits into selection programs and fostering collaboration—will be essential for the future advancement and sustainability of the dairy goat industry as a whole.

Dairy Goat Linear Trait-Productivity Relationships: A Case Study from Grande Ronde Dairy

Design

This experiment was conducted at the Grande Ronde Dairy based in La Grande, Oregon, where more than one thousand head of dairy goats are bred, raised, and milked with a nationally competitive show herd adjacent. In addition to producing raw goat milk that is supplied to the California creamery Laura Chenel, this dairy has also bred national champion and elite does. While ensuring productivity and functionality of does in order to necessitate a profit, owner Stephanie Rovey also fosters an appreciation for the elite show animal as a dedicated life-time member of the American Dairy Goat Association.

In this experiment, roughly one hundred head of first and second freshening does were scored and given a numerical value to represent the following traits outlined in the American Dairy Goat Association Scorecard: dairyness, strength, rump width, rear udder arch, rear udder height, udder depth, fore-udder attachment, and medial suspensory ligament. These traits were identified in discussions amongst seasoned dairy goat breeders as they are commonly believed to have the most direct impact on milk yield. In addition to the linear traits, a scale was developed to score the rear legs from a rear view as described in the procedure section of this chapter. On the dairy, daily milk weights for each individual are recorded using their RFIDs. After quantifying certain traits, a comparison is made to the production records of each individual in order to find correlations between high production and certain traits.

Procedure

The procedures used to evaluate and score the does are strongly based on the standard operating procedures for linear appraisal, published by the American Dairy Goat Association (American Dairy Goat Association). Additional guidelines stem from the American Dairy Goat Association Unified Scorecard (American Dairy Goat Association) , and vast personal judges' training and experience.

In an attempt to reduce the numerous variable factors that potentially influence production, all does are either first-freshening yearlings or second-freshening two years old all of whom have roughly the same length of current lactation (February-April). The selected head are of various and mixed breeds, most commonly Saanen, Sable, Nubian, and LaMancha. Additionally, does are milked twice a day in the same fashion and consume the same daily diet. On the dairy, milking animals are housed in a singular loafing barn but separated into numerous large pens. There are four pens in total with animals being divided roughly by age.

Scoring criteria for the linear traits - dairyness, strength, rump width, rear udder arch, rear udder height, udder depth, fore-udder attachment, and medial suspensory ligament – are outlined above in Chapter 1 of this report. Additionally, the designed guidelines for scoring rear legs rear view are as followed: scored on a scale of 1-50 with 5 pts – hocks almost touching 15 pts – very hocked in 25 pts- slightly hocked in 40 – hocks squared.

Measurements

On April 26th, 2025, I, along with ADGA judge Dan Greene, went to Grande Ronde Dairy. With collaboration and discussion, animals were scored in a joint effort to optimize results and minimize personal scoring bias. Goats were randomly selected and scored. Fifty-five does were scored from pen one -containing first-freshening does of one year of age- and an additional fifty does were scored from pen two- consisting of second freshening two-year-old does. The data sets from the yearlings and two-year-olds were kept separate. Full production records were harder to obtain than anticipated, as the dairy had just finished freshening one-thousand head and were behind on inputting does into the system. However, accurate daily milk weight averages were able to be compiled.

A dataset was generated in excel with each row being a single animal identified by their RFID and columns with values for linear traits, peak milk, and average daily milk weights. Group averages were calculated using excel formulas. In order to combine the two age groups, the data was age adjusted by comparing individual's trait and production values to the trait and production averages for their respective age group. The dataset, now combined and age adjusted, consisted of 98 animals as there were seven does with no production data that were removed from the dataset.

Outliers – high leverage and influence points - were identified using two objective statistical measures: leverage and Cook's distance. Thresholds used were leverage > 0.204 (2×[(# predictors+1)/n]) and Cook's Distance > 0.041 (4/n). Points with leverage greater than 2 x [(k+1)/n] (where k is the number of predicters and n is the sample size) were flagged, as they have unusual predictor values. Additionally, points with Cook's distance greater than 4/n were considered influential, as they exert a disproportionate effect on the fitted model. Individuals exceeding either threshold were removed to ensure that the regression results reflected the typical patterns in the data, rather than being distorted by atypical or highly influential cases. In total, there were seven individuals who exceeded one of the thresholds. The database is now comprised of a more consistent group of ninety-one does, resulting with lower p-values that indicate greater statistical significance. Correlations were then generated using Excel Analysis ToolPak.

Multiple regression was used to estimate the unique effect of each linear type trait on 24-hour average milk yield, controlling for all other traits. This approach avoids confounding from correlated predictors and provides insight into which traits have independent predictive value for production. Model fit was assessed by R2R^2R2 (proportion of explained variance), and statistical significance was evaluated using t-tests and p-values for each coefficient.

Single regression examines the relationship between one linear trait and milk yield at a time, providing insight into the overall association between each trait and production. However, this approach does not account for the fact that many physical traits are correlated and can influence milk yield together. Multiple regression, by contrast, evaluates all traits simultaneously, allowing for the identification of which traits have independent, statistically significant effects on milk yield when controlling for the others. In this analysis, multiple regression is the preferred method because it provides a clearer and more accurate understanding of which linear traits are most strongly and independently associated with 24-hour average milk yield in dairy goats.

Stepwise regression is a variable selection technique that systematically adds or removes predictors based on statistical criteria (based on p-values for inclusion and removal). Starting with no predictors, traits were added if their p-value was less than 0.05 and removed if their p-value exceeded 0.10, ensuring a parsimonious model. This process was repeated until no further changes improved the model.

Results

Correlation analysis revealed that fore udder attachment (FA) exhibited the strongest positive association with 24-hour average milk yield (24 HR AV), with a correlation coefficient of 0.44 (see Table 2). Udder depth (UD) was moderately negatively correlated with 24 HR AV (r = –0.43),. Dairyness (DY) showed a weak positive correlation (r = 0.23) with milk yield, while rump width (RW) and rear udder arch (RUA) displayed weaker positive relationships (r = 0.15 and r = 0.25, respectively). Other traits, including legs (LEGS, r = –0.08), strength (STR, r = –0.05), rear udder height (RH, r = 0.16), and medial suspensory (MS, r = 0.03), showed very weak or negligible correlations with milk production in this dataset. Other noteworthy correlations include the relationship between RW and STR (0.65) as well as the relationship between RH and RUA (0.68).

Table 2: Correlations Between Linear Traits and 24 Hour Milk Production

Linear Type Trait Correlations with 24 Hour Milk Production Average		
Trait	Correlation with 24 HR AV	Interpretation
LEGS	-0.084	Very weak, negative; leg score is not meaningfully associated with milk yield.
STR	-0.047	Negligible; strength does not correlate with 24 HR AV.
DY	0.225	Weak positive; more “dairy” appearing animals tend to produce slightly more milk.
RW	0.151	Very weak positive; wider rumps may be slightly associated with higher milk yield.
FA	0.443	Moderate positive; stronger fore udder attachment is associated with higher milk yield.
RH	0.158	Weak positive; higher rear udders have a slight association with yield.
RUA	0.249	Weak positive; more arched rear udders slightly associated with more yield.
MS	0.034	Negligible; medial suspensory shows little relationship to yield.
UD	-0.428	Moderate negative: deeper udders (lower score) are associated with higher yield.

Table 3: Multiple Regression Analysis Between Linear Type Traits and 24-Hour Average Milk Production

Multiple Regression Analysis Between Linear Type Traits and 24-Hour Average Milk Production			
Trait	Coefficient	p-value	Interpretation
Fore Udder Attachment (FA)	0.127	<0.001	Significant, positive association
Udder Depth (UD)	–0.158	<0.001	Significant, negative association
Dairyness (DY)	0.128	0.019	Significant, positive association
Strength (STR)	–0.088	0.039	Significant, negative association
Legs (LEGS)	NS	NS	Not significant
Rump Width (RW)	NS	NS	Not significant
Rear Udder Height (RH)	NS	NS	Not significant
Rear Udder Arch (RUA)	NS	NS	Not significant
Medial Suspensory (MS)	NS	NS	Not significant

Multiple regression analysis identified FA, UD, DY, and STR as significant predictors of 24-hour average milk yield (24 HR AV) after accounting for all other traits. The coefficients resulted with FA 0.127 ($p < 0.001$), UD –0.158 ($p < 0.001$), DY 0.128 ($p = 0.019$), and STR –0.088 ($p = 0.039$). Other traits—including legs, RW , RH, RUA, and MS—were not statistically significant (see Table 3).

Stepwise regression analysis further refined the predictive model for 24 HR AV, selecting FA, UD, and DY as the most influential linear traits. The final model equation was:

$$24 \text{ HR AV} = -0.003 + 0.137 \times FA - 0.164 \times UD + 0.144 \times DY$$

Each one-point increase in FA score was associated with a 0.137-unit increase in milk yield, while each one-point increase in UD (higher score = shallower udder) was linked to a 0.164-unit decrease in yield, and each one-point increase in DY corresponded to a 0.144-unit increase in milk yield. All coefficients were statistically significant ($p < 0.01$), and this model explained approximately 38% of the variance in 24-hour milk yield.

Discussion

This study provides a comprehensive evaluation of the relationships between linear type traits and 24-hour average milk yield in dairy goats, integrating evidence from correlation analysis, multiple regression, and stepwise regression models.

Correlation analysis highlighted that udder-related traits, particularly FA and UD, exhibited the strongest associations with milk yield. FA was moderately positively correlated ($r = 0.44$) with 24-hour milk yield, indicating that does with more forward extension of attachment to the udders tend to produce more milk. Conversely, UD showed a moderate negative correlation ($r = –0.43$), suggesting that deeper udders (lower scores) are associated with higher production, consistent with their greater storage capacity. DY also demonstrated a weak but positive correlation ($r = 0.23$), reflecting the role of overall dairy character in productivity. The remaining traits, including leg structure, strength, and rump width, showed weak or negligible correlations with milk yield, suggesting they have limited value as direct predictors of production.

Multiple regression analysis provided additional insights by estimating the independent effect of each trait while accounting for the influence of others. This approach confirmed the importance of FA, UD, and DY as significant predictors of milk yield, with strength (STR) also emerging as a significant, though negative, predictor. Notably, the coefficient for fore udder attachment (0.127, $p < 0.001$) reinforces its positive impact on yield, while the negative coefficient for udder depth (–0.158, $p < 0.001$) reaffirms the advantage of deeper udders within the range observed. The positive coefficient for DY (0.128, $p = 0.019$) supports continued selection for this trait.. Other linear type traits did not demonstrate significant independent effects, indicating that their relationships with milk yield are either weak or mediated by the more predictive udder-related traits.

Stepwise regression analysis refined the predictive model further, retaining only FA, UD, and DY as significant predictors that explained approximately thirty-eight percent of the variance in milk yield. In layman terms, each one-point increase in FA, UD, and DY results in +0.137, -0.164, and + 0.144 pounds of milk per day respectively. While this may seem insignificant, calculating the effect on a standard 305 day lactation reveals that a single point increase in FA, UD, and DY contributes to +41.785, -50.02, and +43.92 pounds per lactation.

The coefficients estimated in the full multiple regression model and the stepwise regression model differ because each coefficient represents the unique contribution of a trait to milk yield while controlling for the other variables included in the model. When all traits are present in the full multiple regression model, shared variance and correlations among predictors (collinearity) may dilute or redistribute the apparent effect of each trait. In the stepwise model, only the most predictive traits of FA, UD, and DY remain. The removal of less informative or redundant predictors allows the coefficients of the remaining traits to more fully reflect their relationship with milk yield. As a result, coefficients in the stepwise model appear larger and more stable, since these predictors are not competing with correlated variables for explanatory power.

Each of these traits has a direct or indirect biological connection to a doe's productive capacity, which is well-supported by both practical experience and scientific literature. Biologically, the conclusion of UD (-0.164) , FA (+0.137), and DY (+0.144) affecting short-term milk production is highly rational and anticipated. As elaborated in Chapter One, UD (-0.164) describes the vertical distance from the point of attachment at the body wall to the lowest point of the udder, usually relative to the hocks. In theory, UD is indicative of milk storage and biological efficiency. A moderately deep udder generally has greater storage capacity, which can translate into higher yields per milking. Additionally, deeper udders that are also well-attached often indicate mature secretory tissue and good glandular development, both prerequisites for sustained high milk output. Undoubtably, udder depth must cautiously be balanced with health. Overly deep (pendulous) udders can be prone to injury, mastitis, or milking difficulties. Thus, it is logical to presume that optimal productivity is seen in does with deep but well-supported udders with enough capacity, but not so deep as to impair function or health.

The need for well-supported udders leads to the significant yield predictor of FA (+0.137). Referring to the strength and smoothness with which the fore portion of the udder blends into the abdominal wall, strong, wide fore udder attachments are vital for the longevity and productivity of dairy animals. Various reasons include overall support and stability, capacity and shape, and milkability. A well-attached fore udder prevents sagging, reducing physical stress on the udder tissues. This support helps maintain udder health, facilitates efficient milk let-down, and lowers the risk of injury or mastitis. Secure attachments often allow for a larger, more capacious udder that can store greater volumes of milk between milkings. Lastly, proper conformation can make machine or hand milking more efficient and complete, potentially reducing residual milk and improving milk yield records.

DY (+ 0.144) is a complex, composite trait reflected in the overall physical appearance as a combination of angularity, leanness, flatness of bone, and openness of rib, that signals a genetic predisposition toward milk production rather than body condition for meat or fat deposition. Dairy animals tend to partition more nutrients toward milk synthesis rather than muscle or fat. High scores in dairyness are associated with traits indicative of an animal that efficiently mobilizes body reserves and dietary intake for lactation. Conversely, while DY is positively associated with short-term milk production, it should be cautioned that extreme angularity may reduce reproductive longevity.

Collectively, these analyses underscore the central importance of udder conformation and dairy character in optimizing milk yield in dairy goats. The consistent significance of FA and UD across all statistical approaches aligns with established understanding that well-attached, capacious udders are fundamental for high and sustained milk production. The contribution of DY further highlights the value of overall dairy form, which is linked to metabolic efficiency and lactation potential. By contrast, structural traits such as leg conformation and strength, though important for animal health and longevity, do not appear to exert direct effects on short-term milk production within the observed population.

Though not as impactful to short-term milk production, other notable correlations with 24 HR AV include: RW (0.151), RH (0.158), RUA (0.249). The RUA and RH are presumed to indicate the goat's potential capacity for milk, in that the width and shape of the rear udder attachment affects udder capacity, and the udder's ability to hold its shape and position through repeated lactations. Additional prominent correlation between linear traits include: RW x STR (0.653), STR x RUA (0.304), RW x RUA (0.29), and RUA x RH (0.684). RW is crucial as it affects kidding ease, overall body width, and udder capacity. Wider rumps relate to kidding ease, providing more space for birthing, reducing complications during delivery. Improved RW also indicates greater general body width, contributing to structural balance, and allows for better udder development and attachment, which supports higher milk production.

These findings provide clear guidance for selection and breeding programs, emphasizing the prioritization of udder quality and dairy character to improve productivity. The moderate proportion of explained variance also suggests that additional factors—including management, environment, and other genetic influences—contribute to milk yield and warrant further investigation. Continued research with larger and more diverse populations could refine these relationships and help identify potential non-linearities or interactions among type traits.

Bridging the Gap: Conformation, Productivity, and Industry Trends in Show Ring Dairy Goats

Design

The National Dairy Goat Show, sponsored by the American Dairy Goat Association, is the premier exhibition of elite dairy does. Held once annually, in rotating locations, licensed National Show judges - who were voted on by the members - evaluate and rank does in their respective breed and age classes. Judges are trained to adhere to the ADGA scorecard when ranking and selecting individuals. It is presumed that high ranking individuals embody desirable traits and are close representatives of the dairy goat ideal. Additionally, breeders with nationally competitive animals have a higher rate of participation in performance programs.

The dairy goat industry must critically assess whether selection practices are rewarding does for their functional productivity or simply prioritizing aesthetic qualities. Selection criteria often differ between commercial and show herds, reflecting a broader trend observed in other livestock species, where a pronounced gap has emerged between animals optimized for commercial production and those favored in the showring. Such discrepancies prompt an important consideration: are current selection practices advancing functional, productive animals, or are they emphasizing visual appeal at the expense of utility?

Procedure

The linear scores and milk production values of the top twenty individuals from prior national shows were obtained to form a collective database. The selection criteria included top twenty does from the standard breeds Alpine, LaMancha, Nubian, and Saanen in the two-year-old class. The two-year-old class was selected for its greater depth of competition, volume of animals in the class, and the value obtained from the evaluation of first and second lactation animals. In national classes where there are greater than twenty animals, the judges (main and consulting) make an initial cut of the top twenty animals and then work those top twenty animals for final placings.

Utilizing the online databases for the American Dairy Goat Association and the Council on Dairy Cattle Breeding (CDCB), linear trait values and production records were pulled for the two-year-old lactation. CDCB 305 'actual' lactation values were used to standardize results. 'Actual' production weights were then compared to the National Breed Standard Averages (NBS) – which was calculated in an effort to reduce breed variability.

Measurements

Lactation records are calculated for a 305-day lactation based on on-the-farm milk tests that typically occur monthly by Dairy Herd Improvement Association (DHIA) Certified Milk Testers. DHIA processing center estimates full production by plotting weights on a lactation curve. Results are then forwarded to CDCB who uses milk records from different herds to calculate genetic evaluation for each animal. Actual 305 production values were then pulled from the public CDCB database.

Linear trait values (see Chapter 1 for description of Linear Appraisal Program) were scored by trained ADGA appraisers and accessed through the ADGA database. All the does linear trait values and production records were complied into an excel spreadsheet. Only does with full datasets were used in this experiment. Considering that four different standards breeds were being utilized, an Anova single factor showed that breed had a significant impact on production levels. In order to remove the breed effect, 305 averages were calculated for each breed. Does production totals were then compared to their respective national breed average , establishing a new value of production-national breed standard (production-NBS). Rerunning the Anova single factor showed that breed no longer had a significant effect on production.

The analysis evaluated the relationship between individual linear type traits and the National Breed Standard (NBS) production scores among the top-placing 2-year-old dairy goats at the national show. The dataset was comprised of 99 animals, scored for eight linear traits: Strength (STR), Dairyness (DY), Rump Width (RW), Fore Udder Attachment (FA), Rear Udder Height (RH), Rear Udder Arch (RUA), Medial Suspensory (MS), and Udder Depth (UD), alongside their corresponding production-NBS values.

Outliers were then determined using a box and whiskers plot. After calculating standardized residuals, leverage, and Cook's Distance, individuals exhibiting high leverage or influence were excluded from the dataset to improve model robustness.

Descriptive statistics and quartile groupings were computed for all linear traits and production-NBS. Correlation analysis was performed using Excel Analysis ToolPak to quantify associations between linear type traits, production-nbs, and show placings. Scatterplots with fitted trend lines were generated to visually assess the direction and strength of these relationships. For comparative analysis, the means of the top five percent of national show placers were calculated and compared side-by-side with breed average means for the commercial 2-year-old does from Grande Ronde Dairy (See Chapter 2).

Results

The table below (table 4) summarizes the correlation coefficients between each linear trait, production-NBS, and placing (See Appendix D for full correlation coefficients). Significant negative correlations were found between show placing and several udder and dairy strength traits, indicating that higher trait scores are associated with better (lower numbered) placings. The strongest negative correlations were observed for FA (-0.46), RUA (-0.41), STR (-0.31), DY (-0.23), and production-nbs (-0.43). A positive correlation was observed with UD (+0.24).

Table 4: Correlation Coefficients Between Linear Type Traits, Production-NBS, and Show Placings

Correlation Coefficients Between Linear Type Traits, Production-NBS, and Show Placings			
Trait	Placing	Production-NBS	Interpretation
Fore Udder Attachment (FA)	-0.462	+0.355	Strong predictor for both placing & production
Rear Udder Arch (RUA)	-0.411	+0.294	Favored in show and moderately linked to production
Dairyness (DY)	-0.228	+0.343	More “dairy” animals favored and more productive
Strength (STR)	-0.305	-0.047	Favored in placing, little production impact
Rump Width (RW)	-0.207	-0.008	Slight benefit in placing, not in production
Rear Udder Height (RH)	-0.150	+0.115	Modest benefit in both
Udder Depth (UD)	+0.244	-0.165	Deeper udders score lower; deeper increases production and place better
Stature (ST)	+0.065	+0.070	Little impact on either outcome
Medial Suspensory (MS)	-0.038	-0.059	Little impact on either outcome

Scatterplots with fitted trend lines visually confirmed these relationships, with downward-sloping trends for production-nbs, FA, RUA, DY, and STR versus show placings (see figures 8 - 12). UD displayed an upward sloping trend (figure 7). Outliers were minimal, and the relationships remained consistent across the data set, indicating reliable associations.

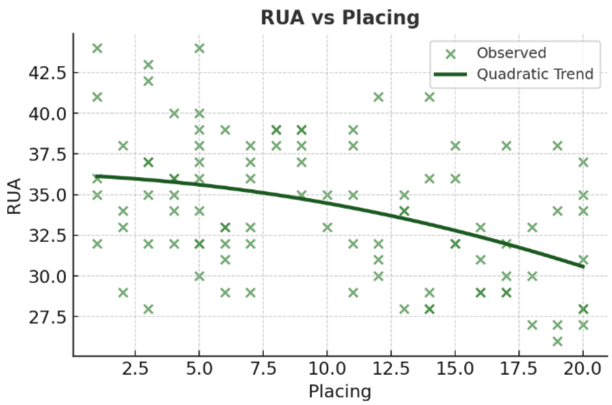

Figure 12:RUA vs Placing Scatterplot

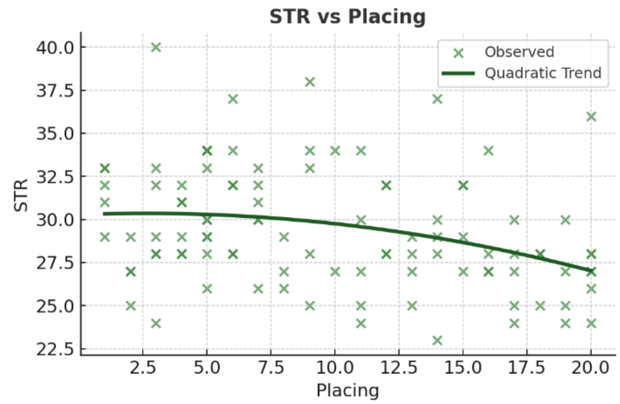

Figure 10: STR vs Placing Scatterplot

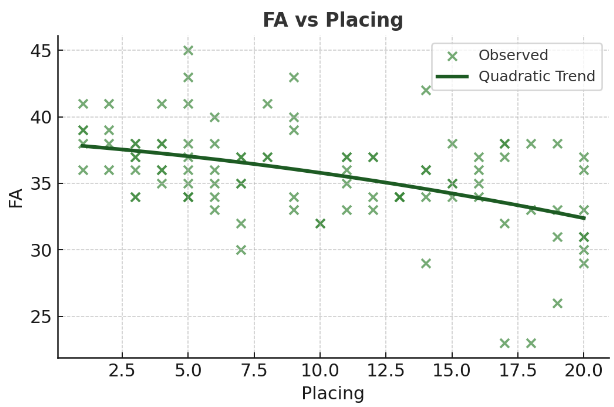

Figure 11: FA vs Placing Scatterplot

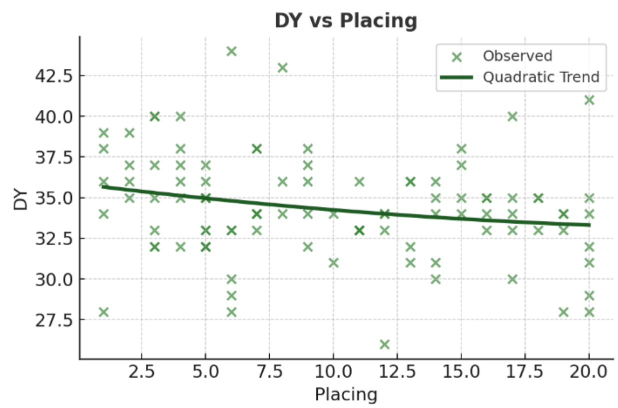

Figure 9: DY vs Placing Scatterplot

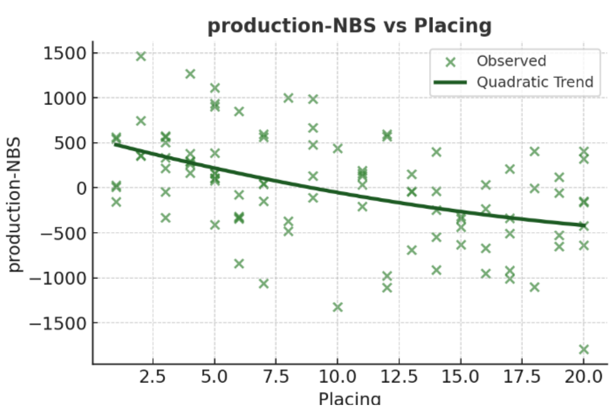

Figure 7: Production-NBS vs Placing Scatterplot

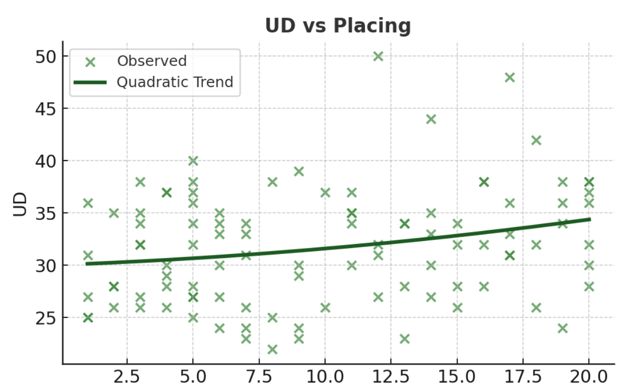

Figure 8: UD vs Placing Scatterplot

A comparison of means between the top five individual two-year-old national placers and the group average for two-year-old does on Grande Ronde Dairy (see table 5), top does had mean trait scores five to thirteen points higher than the Grande Ronde Dairy population averages for udder-related traits, demonstrating marked structural advantage. The means for the top five ADGA National placing does vs the group average on Grande Ronde Dairy are as follows: STR (31.9, 26.8), DY (37.2, 31.6), RW (34.7, 28.5), FA (39, 26.9), RH (40.7, 30.3), RUA (37.8, 28) , UD (30.1, 27.5), and Peak (12.9, 9.97).

Table 5: Comparison of Means Between Top 5% of National Placing Does and Grande Ronde Dairy

Comparison of Means Between Top 5 National Placing Does and Grande Ronde Dairy		
Trait	Top 5 National Does Mean	Grande Ronde Dairy Avg
Strength (STR)	31.9	26.8
Dairyness (DY)	37.2	31.6
Rump Width (RW)	34.7	28.5
Fore Udder Attach. (FA)	39.0	26.9
Rear Udder Height (RH)	40.7	30.3
Rear Udder Arch (RUA)	37.8	28.0
Udder Depth (UD)	30.1	27.5
Peak Milk (lbs)	12.9	9.97

Discussion

Analysis of the correlations between linear appraisal traits, national breed-standardized production (NBS), and show placing in 2-year-old dairy goats reveals distinct patterns in the attributes rewarded in the national showring. Notably, fore udder attachment (FA) demonstrated a moderate negative correlation with placing (r = -0.462), indicating that animals with stronger fore udder attachments are more likely to achieve superior show results. Similarly, rear udder arch (RUA) exhibited a moderate negative correlation (r = -0.411), further emphasizing the importance of udder structure for competitive success.

Strength (STR) also showed a weak to moderate negative correlation (r = -0.305), suggesting that judges are actively selecting individuals that align with the dairy strength category of the ADGA scorecard. While the linear trait of strength is not directly related to short-term production, animals that have adequate strength tend to have improved function, which correlates to longevity. This is similar to other traits such as feet and legs and rump width. Production-NBS, which measures milk production relative to national breed standards, was moderately negatively correlated with placing (r = -0.434), signifying that goats that exceed their breed average for production are generally rewarded with better show placings. Dairyness (DY) and rump width (RW) displayed weak negative correlations (r = -0.228 and r = -0.207, respectively), highlighting a secondary but present association with favorable outcomes. In contrast, rear udder height (RH) and medial suspensory ligament (MS) exhibited very weak correlations (r = -0.150, r = -0.038 respectively), suggesting these characteristics play a limited role in determining show success in this group. Interestingly, udder depth (UD) presented a weak positive correlation (r = +0.243) with placing, indicating that goats with shallower udders (higher UD scores) are more likely to have worse placings.

Collectively, these findings illustrate that national show judges tend to prioritize udder attachment traits, strength, and breed-adjusted production when awarding top placings, while other traits have a less pronounced influence on competitive outcomes. While productivity

(NBS) is moderately associated with better placings, conformation traits—particularly those related to udder structure—remain the most consistent predictors of show ring success.
Elite does (top 5%) are distinguished by exceptional scores in fore udder attachment, rear udder height and arch, and dairyness, with deeper udders also contributing to their advantage. The mean differences between the national elite and dairy herd averages (Grande Ronde Dairy) underscore the magnitude of these traits in winning show animals. Importantly, while production is not the sole criterion for show success, the observed correlations confirm that higher-producing animals are, to some extent, being recognized and rewarded in the national show ring.

The data indicate a clear alignment between show ring success and both superior udder conformation and dairy strength traits. Notably, the traits most strongly associated with high placings—fore udder attachment, rear udder arch, and dairyness—also demonstrate moderate to strong positive correlations with actual milk production, as measured by production-NBS. This suggests that, at the national level, contemporary show ring standards do reward animals that not only exemplify breed ideals in physical structure but also exhibit superior productive capacity.

It should be optimistically acknowledged that the correlations between positive influential milk productivity traits and top show placings signifies the validity of ADGA performance programs. Judges, and appraisers, are actively adhering to the ADGA scorecard by selecting and rewarding the type of dairy goat that can function efficiently over a long productive lifetime. While there is a discernable trend with higher scores in milk productivity correlated traits (FA, DY, UD) and top placings, animals are not solely placed according to these traits and short-term production. In as much as those traits should be recognized, it can be presumed that judges are rewarding the balanced animal that combines high milk production, correctness in functional type, and traits that improve productive life.

Breeders, judges, appraisers, and industry members are continually shaping the industry through genetic advancements and selection of certain types of dairy goats. The information brought about by analysis of this single report's database shows that the industry is, tentatively, both growing in a direction that supports the commercial dairy goat industry as well as rewarding those seedstock and show herds, However, it should be cautioned that this data is based on a limited set of animals due to the relative low participation in performance program, namely DHIA and linear appraisal. Full participation in these programs would offer a more complete analysis and comparisons between these two major sectors of the dairy goat industry.

The dataset compilation process uncovered the contributory negligence of breeders. Merely sixty-two-and-a-half percent of the top twenty national placing animals utilized DHIA production program, with only forty-one-and-a-half percent having linear appraisal scores for that year. Notwithstanding the fact that there is no requirement to participate in ADGA performance programs, the correlations brought to light in this study indicate that all dairy goat breeders – both seedstock and commercial- could benefit from herd participation. Though this study confirms that current selection practices do, in fact, advance functional, productive animals rather than simply emphasizing visual appeal at the expense of utility; it prompts a new question of whether breeders are genuinely committed to advancing productivity within the industry or are primarily driven by the pursuit of competitive success in the show ring.

Nourishing The Future: Dairy Goat Production and the Reimagining of Sustainable Agriculture

In the face of escalating global challenges such as food insecurity, climate change, poverty, and gender inequality, the world must reevaluate its agricultural priorities. Dairy goat production (DGP), often overshadowed by industrial livestock systems, offers a compelling, underutilized model of sustainable development. Rooted in centuries-old traditions yet remarkably adaptable to modern crises, DGP occupies a unique intersection of ecological resilience, nutritional value, economic empowerment, and cultural preservation. Drawing on current data and trends one can argue that goats — particularly dairy goats — are among the most viable livestock species for achieving the Sustainable Development Goals (SDGs) (United Nations) and cultivating resilient futures in a rapidly changing world.

Over the past fifty years, dairy goat production has emerged as a vital and growing sector within global agriculture with unprecedented growth. Projections indicate that the current steep growth trend will continue, as previously explained in Chapter One. This rapid growth, which surpasses that of other ruminants, highlights the adaptability, economic importance, and resource efficiency of dairy goats, especially in the Global South and marginal agro-ecological zones (Navarrete-Molina, Meza-Herrera and Santiago-Miramontes).

Environmental Adaptability and Climate Resistance

The importance of dairy goat production is multifaceted. This rapid expansion reflects the unique advantages that goats offer in a world increasingly challenged by climate change, resource depletion, and food insecurity. Dairy goats possess exceptional ethological, adaptive, and physiological plasticity, enabling them to survive and even thrive in marginal environments where other livestock cannot. Their ability to resist drought, consume low-quality forage, reproduce quickly, and grow rapidly positions them as a key "animal of the future," especially under clean, green, and ethical production schemes. Far beyond its traditional role in smallholder farming, DGP today represents a forward-looking strategy for resilience, prosperity, and environmental stewardship.

Climate change is disrupting agricultural systems globally, particularly in arid and semi-arid regions. Goats demonstrate exceptional resilience by consuming vegetation of low nutritional value, withstanding drought, and reproducing efficiently. This adaptability makes DGP an environmentally responsible form of livestock farming. Goats' ability to graze on diverse, often underutilized plants contributes to wildfire prevention and biodiversity maintenance. Their manure serves as a natural fertilizer, enhancing soil health and closing nutrient loops in agroecological systems. Furthermore, goats' browsing behavior reduces parasite loads in pastures and helps prevent forest fires by controlling underbrush, providing important ecosystem services that contribute to land conservation and biodiversity protection. In this light, dairy goats are not merely surviving climate volatility — they are actively mitigating it, contributing to sustainable land stewardship.

Given the alarming pace at which humanity is depleting natural resources—1.7 times faster than ecosystems can regenerate, according to the Global Footprint Network—sustainable food production methods are urgently needed. Unlike cattle or buffaloes, dairy goats have demonstrated remarkable environmental plasticity, thriving even under the harshest climatic conditions while maintaining high productivity. Their unique adaptive and physiological traits — such as drought resistance, short gestation periods, high fecundity, efficient feed conversion, and ability to consume low-quality forage — make them ideal for farming systems facing the pressures of climate change.

Economic Empowerment and Gender Equity

Economically, goat production serves as a critical livelihood source, particularly for smallholder farmers in low-income and food-deficit counties. Dairy goats' adaptability and versatility are crucial for the livelihoods of smallholder farmers, particularly in low-income and food-deficit countries, where 61% of the world's goats are found. The low initial investment required for goat farming, coupled with relatively high yields, and diverse income steams – meat, milk, cheese, hides, live animals - makes DGP an attractive and accessible option for marginalized populations. This makes them especially vital in contexts of rural poverty and crop failure, where goats often represent the only reliable source of livelihood. The growing global demand for goat meat, especially in the Middle East, Asia, and parts of Africa, alongside the market for goat milk and leather products, underscores their economic value. Furthermore, international trade in goat products, exemplified by major exporters like India and Australia, strengthens the role of goats in supporting national and local economies.

Socially, dairy goat production plays a transformative role, especially for women, who are primarily responsible for goat husbandry. DGP enables women to contribute financially to their households, gain economic independence, and strengthen their social standing. By empowering women to generate income and participate in household decision-making, DGP fosters greater gender equality (SDG 05) and helps reduce social inequalities (SDG 10). This additionally demonstrates how livestock systems can serve as a catalyst for social transformation.

Cultural Significance and Knowledge Preservation

By maintaining traditional knowledge and pastoral practices, DGP strengthens cultural heritage, supports rural economies, and reinforces community resilience. In many communities, goat husbandry is deeply embedded in social customs, rituals, and collective memory. Culturally, goats hold deep religious and social significance in numerous societies. They are featured prominently in rituals, festivals, and religious ceremonies, such as sacrificial offerings during the Islamic Eid al-Adha festival and ceremonial offerings in Hindu traditions. In regions like Sub-Saharan Africa, goats are deeply embedded in marriage rituals and symbolize wealth and social status, highlighting their role within the social fabric.

Traditional goat husbandry practices, passed down through generations, further reinforce cultural heritage and community identity. Moreover, traditional knowledge surrounding goat breeding, herding, and dairy processing has been passed down through generations, representing an intangible cultural asset. Preserving these practices is not merely about nostalgia; it is about sustaining community identities and food sovereignty. DGP thus fosters a form of sustainability that is not only ecological and economic but also cultural and epistemological — rooted in place-based wisdom and local traditions.

Nutritional Value and Food Security

The importance of DGP to food security cannot be overstated. As previously mentioned, 61% of the world's goat population is located in low-income and food-deficit countries (FAO). Nutritionally, goats offer vital dietary contributions, especially in areas with limited access to other animal-based proteins. For these communities, dairy goats offer both a reliable source of nutrition and a buffer against crop failures or market shocks, thereby playing a crucial role in building dietary resilience. Goat meat, known for being leaner than beef or lamb and rich in iron, zinc, and B vitamins, is considered a healthy alternative by many health-conscious consumers.

Goat milk is recognized globally for its nutritional richness. It contains high-quality proteins, fats, vitamins, and minerals and is easier to digest than cow's milk, making it particularly suitable for infants, the elderly, and people with lactose intolerance. It is a crucial source of calcium, phosphorus, and vitamin A. In many food-insecure regions, goat milk serves as a staple, offering critical micronutrients that combat malnutrition. In regions facing food insecurity, the ability of goats to provide consistent meat and milk supplies enhances dietary resilience and supports community health.

Raw milk—milk that has not been pasteurized—has gained renewed attention among local food advocates and health communities for its nutrient-dense profile and potential to address nutritional deficiencies, particularly in underserved or food-insecure populations. While the consumption of raw milk remains controversial due to concerns about food safety and the risk of pathogen exposure, proponents highlight several nutritional advantages that distinguish it from pasteurized and highly processed dairy products. One of the primary benefits of raw milk lies in its higher nutrient retention. Pasteurization, though effective at eliminating harmful bacteria, can also reduce or destroy certain heat-sensitive vitamins such as B12, B6, and folate, as well as enzymes like lactase and phosphatase, which support lactose digestion and calcium absorption. Raw milk also retains beneficial bacteria, or probiotics, which can help support gut health, enhance digestion, and may make raw milk more tolerable for those with mild lactose intolerance.

Table 6: Nutrient and Immune Factor Comparison Between Different Milk Types

Nutrients and Immune Factors	RAW Human Milk	RAW Goat or Cow Milk	Pasteurized Goat or Cow Milk	Pasteurized Almond Milk	Pasteurized Soy Milk
Beneficial Enzymes	ACTIVE	ACTIVE	INACTIVE	NONE	NONE
Diverse Probiotics	ACTIVE	ACTIVE	DESTROYED	NONE	NONE
Lactase-Producing Bacteria	ACTIVE	ACTIVE	DESTROYED	NONE	NONE
Healthy Fats	ACTIVE	ACTIVE	DAMAGED	DAMAGED	DAMAGED
AA, CLA, DHA, & EPA	ACTIVE	ACTIVE	DAMAGED	NONE	NONE
Proteins	ACTIVE	ACTIVE	DAMAGED	DAMAGED	DAMAGED
Bioavailable Vitamins	ACTIVE	ACTIVE	REDUCED	ALTERED	ALTERED
Bioavailable Calcium	ACTIVE	ACTIVE	INHIBITED	INHIBITED	INHIBITED
Bioavailable Phosphorus	ACTIVE	ACTIVE	INHIBITED	ALTERED	ALTERED
IgA/IgG Immunoglobins	ACTIVE	ACTIVE	DESTROYED	NONE	NONE

In addition to its vitamin and enzyme content, raw milk is a rich source of bioavailable minerals, including calcium, phosphorus, and magnesium—nutrients critical for bone health, development, and overall physiological function. It also provides healthy fats such as omega-3 fatty acids and conjugated linoleic acid (CLA), which are important for brain function, hormone production, and inflammation regulation. These properties make raw milk especially valuable in low-income communities, where access to nutrient-dense foods may be limited or prohibitively expensive. For individuals in these settings, raw milk offers a concentrated source of essential nutrients in a single, whole food.

Moreover, the natural probiotics present in raw milk contribute to improved gut health by maintaining a healthy microbiome, which has been linked to enhanced immunity, nutrient absorption, and even mental health. This can be particularly beneficial for vulnerable populations, including children, the elderly, and those recovering from illness or malnutrition. Because raw milk is often produced and distributed locally, it tends to be fresher and less processed, supporting holistic and localized nutrition. In regions with limited access to fresh foods, farm-direct raw milk sales can help deliver high-quality nutrition efficiently, reducing dependency on ultra-processed alternatives.

For children in food-insecure households, raw milk can help address common nutritional deficiencies, such as calcium, vitamin D, and healthy fats. When produced and handled under safe and hygienic conditions, raw milk can provide a reliable and affordable source of these essential nutrients, supporting proper growth, bone development, and cognitive health. Nevertheless, it is essential to recognize that the consumption of raw milk also carries inherent risks, as it may harbor harmful bacteria such as Salmonella, E. coli, and Listeria. These pathogens can cause serious illness, especially in young children, the elderly, and those with compromised immune systems. Therefore, if raw milk is to be consumed, it is imperative that it be sourced from reputable producers who adhere to rigorous hygiene and animal health standards, and that consumers are educated about safe handling practices.

Raw milk—when produced under controlled, sanitary conditions—offers a nutritionally rich alternative to highly processed dairy products. Its retention of enzymes, vitamins, minerals, and probiotics makes it especially valuable in combating nutritional deficiencies among vulnerable populations.

United Nations Sustainability Goals

The importance of DGP has been well established above. Due to their nutritional, economic, environmental, and cultural benefits goat production plays a vital role in addressing several of the United Nations Sustainable Development Goals (SDGs) (Appendix E), particularly in the areas of poverty alleviation, food security, and sustainable agriculture (see Table 7).

Culturally, goats are deeply embedded in the traditions of many communities, especially in rural areas, where they are often used in ceremonies and as a symbol of wealth. This cultural integration promotes social cohesion and preserves traditional agricultural practices, contributing to SDG 8 (Decent Work and Economic Growth) by providing livelihoods and employment for smallholder farmers and pastoralists. Economically, goat production is a key income generator for millions of people around the world, particularly in regions where access to other forms of livestock is limited due to challenging environmental conditions. By providing a steady source of income through the sale of meat, milk, and other products, goat farming supports SDG 1 (No Poverty) and SDG 2 (Zero Hunger), as it helps improve food security and nutrition.

Nutritionally, goat meat and milk are rich in protein, vitamins, and minerals, making them an essential part of the diet in many parts of the world, especially for vulnerable populations. Goat milk, in particular, is more digestible than cow's milk and provides an important source of nutrition for those with lactose intolerance. This makes goat products a valuable resource in combating malnutrition, in line with SDG 3 (Good Health and Well-being).

Furthermore, goat production promotes SDG 12 (Responsible Consumption and Production) due to the animal's ability to thrive on less intensive feed sources, which contributes to sustainable livestock management. Goats are more resource-efficient than larger livestock, requiring less land and water, and their grazing habits can help manage landscapes, thereby supporting SDG 13 (Climate Action) by reducing the environmental footprint of agriculture. In this way, goat production not only provides economic and nutritional benefits but also contributes to broader global efforts to create sustainable, resilient agricultural systems. In summation, the convergence of nutritional efficiency, environmental adaptability, economic accessibility, and social inclusion positions dairy goat production as a powerful tool for sustainable development.

Table 7: Contribution of Dairy Goat Production (DGP) to the United Nations Sustainable Development Goals (SDGs)

UN SDG	Goal Title	How Dairy Goat Production (DGP) Supports This Goal
SDG 1	No Poverty	Provides stable income and livelihood opportunities for rural and marginalized communities, helping to alleviate poverty.
SDG 2	Zero Hunger	Increases food security by supplying accessible, affordable, and nutritious milk and dairy products to vulnerable populations.
SDG 3	Good Health and Well-Being	Contributes to improved nutrition and health through the provision of nutrient-dense, easily digestible milk rich in essential vitamins and minerals.
SDG 5	Gender Equality	Empowers women by supporting their active participation in goat husbandry, thereby enhancing their economic status and decision-making power.
SDG 12	Responsible Consumption and Production	Promotes resource-efficient, low-input production systems that reduce environmental impact and encourage sustainable agricultural practices.
SDG 13	Climate Action	Enhances climate resilience and mitigation through adaptable, low-carbon livestock systems suitable for diverse and changing environments.
SDG 15	Life on Land	Supports biodiversity and ecosystem health by contributing to sustainable land management, preventing overgrazing, and maintaining soil fertility.

Dairy goat production is far more than a subsistence practice of the rural poor — it is a scalable, sustainable, and socially transformative agricultural system. In a world facing intensifying climate threats, biodiversity loss, and social inequities, DGP offers a model of farming that is ecologically sound, economically viable, and culturally respectful. It supports livelihoods, nourishes bodies, empowers women, and regenerates landscapes. As we search for agricultural systems that can meet the demands of the 21st century without sacrificing planetary or human health, dairy goats stand out as humble yet powerful allies. They are, indeed, animals of the future — and key partners in nourishing the future.

Adopting Dairy Goat Production

As global pressures on food, water, and ecosystems intensify, dairy goats offer a model of adaptive, efficient, and socially inclusive livestock production that can help fulfill the goals of the 2030 Agenda for Sustainable Development. Dairy goat production is not only a growing agricultural sector but also a critical tool for achieving sustainability that needs to be acted on and fully embraced. While it is evident the clear and dire role that DGP plays in low-income societies and marginalized lands, it is within local communities and households that the advancement and implementation of sustainable, resilient agricultural practices must also occur.

Though the protein "crisis" is publicized by Big AG, there is currently enough global calories being produced to feed the ever-growing human population (IEPS-Food). The issue lies not within production, but with the vast amount of food being blatantly wasted. Globally, the food system produces more than enough food calories to adequately feed every single human being and more, but only fifty-five percent of global food calories remain to be directly eaten by humans after calories being diverted to animal feed and biofuels. Additionally, one-third of the food produced globally (1,249 cal per person/day) is lost to spoilage, spillage, and other problems along the supply chain, or simply wasted by households and individuals (Gliessman). This costs the economy $940 billion each year and generates eight percent of greenhouse gases (GHG). Much food waste is linked to inefficiencies in supply chains – long supply chains, consumer preferences shaped by agribusiness, market imperatives. Considering the food waste problem stems from the way the food system is organized, it is relatively easy to solve compared to other food system issues.

The issue of food waste is one that personally exists in the backyards of many. Take a small dairy goat farm in Prosser, Washington for example. Greenehaven Farms strives to breed beautifully correct Nubian dairy goats that excel in the show ring while efficiently producing high levels of milk over a long productive lifespan. A small-scale operation, without a Grade A license, that annually freshens between twenty-five and thirty does. Managed similar to most dairies, kids are pulled and bottled raised while the does are milked twice a day. On this particular operation kids are weaned at twelve weeks of age, with the majority of kids finding their way to new herds before the end of the May. The does, however, remain in production roughly until the end of October when they are rebred. Currently, as of June 2025, sixteen does are in milk with a herd average of ten pounds per doe per day. As a result of the restrictive Washington State legislation, the milk is unable to be sold for human consumption, essentially mandating both nutritional and economic waste.

In the United States, the production and sale of milk are governed by a combination of federal and state regulations aimed at ensuring public health and safety. The U.S. Food and Drug Administration (FDA) enforces the Pasteurized Milk Ordinance (PMO), which sets nationwide standards for milk sanitation and pasteurization. These standards are designed to prevent foodborne illnesses and ensure milk safety.

In Washington, the Department of Agriculture oversees dairy operations under Chapter 15.36 RCW. All milk producers and processors must obtain appropriate licenses. This includes Grade A Milk Producer and Milk Processing Plant licenses, ensuring compliance with health and safety standards. Raw milk intended for human consumption must come from herds tested negative for diseases like brucellosis and tuberculosis within the past year. Additionally, raw milk must be bottled on the farm where it was produced and labeled appropriately. On the farm sales of raw milk would require the farm to obtain both a Grade A Milk Producer and a Grade A Milk Processing Plant license.

Boarding states, such as Oregon and Idaho, impose more innovative regulations compared to the imporous Washington State legislation. Oregon offers a more flexible approach for small-scale dairy producers through ORS 621.012. This statute allows farmers with up to two producing dairy cows, nine producing sheep, or nine producing goats can sell raw milk directly to consumers on the premises where the milk is produced, without needing a license. These small-scale producers are exempt from specific standards related to pasteurization, labeling, and testing, provided they meet the criteria outlined in ORS 621.012 .

In an era marked by rising food insecurity and growing concern over sustainability, legislative reform is urgently needed to allow for on-farm sales of dairy products—especially raw milk—from small producers. Current federal and state regulations, particularly in places like Washington State, impose strict licensing and safety standards that, while well-intentioned, disproportionately burden small-scale farmers and lead to unnecessary food waste. Meanwhile, more flexible models, such as Oregon's exemption for producers with fewer than nine goats or cows, offer a glimpse into how common-sense policy can enhance local food systems without compromising safety.

Washington's regulatory framework requires costly licenses and compliance protocols, often placing small dairy producers at a disadvantage. These regulations can prevent the legal sale of milk that is perfectly safe and nutritious, resulting in spoilage and economic losses. By contrast, Oregon's law permitting direct, on-farm raw milk sales empowers small farmers to distribute their products efficiently, reduce waste, and meet local demand.

Enabling on-farm dairy sales fosters deeper farmer-to-consumer relationships and restores transparency and trust in the food system. Consumers benefit from access to fresh, locally sourced milk, while farmers gain greater autonomy over their livelihoods. Moreover, reducing regulatory barriers for small producers aligns with sustainability goals by minimizing food miles, supporting diversified farm economies, and reducing reliance on industrial supply chains.

The previous example of Greenehaven Farms is just one of hundreds across the nation. Washington's stringent regulations prioritize safety but inadvertently contribute to food waste and limit small-scale market participation. Oregon's more lenient approach for small producers demonstrates how regulatory flexibility can enhance food availability, reduce waste, and support local economies. Policymakers might consider these dynamics when evaluating and updating dairy regulations. To build a more just and resilient food system, states like Washington must adopt legislative reforms that support, rather than stifle, small-scale dairy production. It’s time to modernize dairy laws to reflect the needs of today’s food landscape, one that values access, sustainability, and community resilience.

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APPENDIX

APPENDIX A

American Dairy Goat Association

ADGA registry, based on original import records, is your warranty of good breeding and worldwide acceptance.

PO Box 865, Spindale NC 28160
(828) 286-3801 | support@adga.org | ADGA.org

ADGA SCORECARD

The goal of the Unified Scorecard is to aid in the selection of the type of dairy goat that can function efficiently over a long productive lifetime.

		POINTS		
		SR. DOE	JR. DOE	BUCK
A.	**GENERAL APPEARANCE** An attractive framework with femininity (masculinity in bucks), strength, upstandingness, length, and smoothness of blending throughout that create an impressive style and graceful walk.	35	55	55
	Head & Breed Characteristics - clean-cut and balanced in length, width, and depth; broad muzzle with full nostrils; well-sculpted, alert eyes; strong jaw with angular lean junction to throat; appropriate size, color, ears, and nose to meet breed standard.	5	10	8
	Front End Assembly - prominent withers arched to point of shoulder with shoulder blade, point of shoulder, and point of elbow set tightly and smoothly against the chest wall both while at rest and in motion; deep and wide into chest floor with moderate strength of brisket.	5	8	10
	Back - strong and straight with well-defined vertebrae throughout; taller at withers than hips, and level chine with full crops into a straight, wide loin; wide hips smoothly set and level with chine and loin.	5	7	6
	Rump - strong, uniformly wide and nearly level from hips to pinbones and thurl to thurl; thurls set two-thirds of the distance from hips to pinbones; well defined and wide pinbones set slightly lower than the hips; tailhead slightly above and smoothly set between pinbones; tail symmetrical to body and free from coarseness; vulva normal in size and shape in females(normal sheath and testes in males).	5	7	6
	Legs, Pasterns & Feet—bone flat and strong throughout leading to smooth, free motion; front legs with clean knees, straight, wide apart and squarely placed; rear legs wide apart and straight from the rear and well angulated in side profile through the stifle to cleanly molded hocks, nearly perpendicular from hock to strong, yet flexible pastern of medium length; strong feet with tight toes, pointed directly forward; deep heels with sole nearly uniform in depth from toe to heel.	15	23	25
B.	**DAIRY STRENGTH** Long bone pattern throughout. Openness and angularity with strong yet refined and clean bone structure, showing enough substance, but with freedom from coarseness and with evidence of milking ability giving due regard to stage of lactation (of breeding season in bucks). *Neck* - long, lean, and blending smoothly into the shoulders; clean-cut throat and brisket with adequate width of chest floor to support maintenance of body functions. Withers - prominent and wedge-shaped with the dorsal process arising slightly above the shoulder blades. *Ribs* - flat, flinty, wide apart, and long; lower rear ribs should angle to flank. *Flank* - deep yet arched and free of excess tissue. Thighs - in side profile, moderately incurving from pinbone to stifle; from the rear, clean and wide apart, highly arched and out-curving into the escutcheon to provide ample room for the udder and its attachment. *Skin* - thin, loose, and pliable with soft, lustrous hair.	20	30	30
C.	**BODY CAPACITY** Large in proportion to size, age, and period of lactation of animal (of breeding season for bucks), providing ample capacity, strength, and vigor.	10	15	15
	Chest—deep and wide, yet clean-cut, with well sprung foreribs, full in crops and at point of elbow.	4	7	7
	Barrel—strongly supported, long, deep, and wide; depth and spring of rib increasing into a deep yet refined flank	6	8	8
D.	**MAMMARY SYSTEM** Strongly attached, elastic, well-balanced with adequate capacity, quality, ease of milking, and indicating heavy milk production over a long period of usefulness.	35		
	Udder Support—strong medial suspensory ligament that clearly defines the udder halves, contributes to desirable shape and capacity, and holds the entire udder snugly to the body and well above the hocks. Fore, rear, and lateral attachments must be strong and smooth.	13		
	Fore Udder—wide and full to the side and extending moderately forward without excess non-lactating tissue and indicating capacity, desirable shape, and productivity.	5		
	Rear Udder—capacious, high, wide, and arched into the escutcheon; uniformly wide and deep to the floor; moderately curved in side profile without protruding beyond the vulva.	7		
	Balanced, Symmetry & Quality—in side profile, one-third of the capacity visible in front of the leg, one-third under the leg, and one-third behind the leg; well-rounded with soft, pliable, and elastic texture that is well collapsed after milking, free of scar tissue, with halves evenly balanced.	6		
	Teats—uniform size and of medium length and diameter in proportion to capacity of udder, cylindrical in shape, pointed nearly straight down or slightly forward, and situated two-thirds of the distance from the medial suspensory ligament on the floor of each udder-half to the side, indicating ease of milking.	4		
	TOTAL	**100**	**100**	**100**

APPENDIX B

Group Averages for Yearling and Two-Year Olds for Grande Ronde Dairy										
	Legs	STR	DY	RW	FA	RH	RUA	MS	UD	24 HR (lbs)
Yearlings	27.92	24.55	29.47	24.22	26.65	30.47	29.47	29.37	32.47	6.74
2 Year Olds	26.83	26.79	31.62	28.49	26.89	30.32	28.04	30.51	27.51	9.11

APPENDIX C

Grande Ronde Dairy Multiple Regression Between Linear Traits and 24 HR Milk				
Trait	Coefficient	95% Lower CI	95% Upper CI	p-value
Intercept	–0.029	–0.293	0.234	0.82
LEGS	0.006	–0.051	0.064	0.83
STR	–0.088	–0.172	–0.004	0.039
DY	0.128	0.022	0.234	0.019
RW	0.069	–0.031	0.168	0.17
FA	0.127	0.063	0.191	<0.001
RH	0.008	–0.106	0.122	0.89
RUA	0.076	–0.034	0.186	0.17
MS	0.015	–0.049	0.080	0.64
UD	–0.158	–0.239	–0.076	<0.001

APPENDIX D

Grande Ronde Dairy Correlations

	LEGS	STR	DY	RW	FA	RH	RUA	MS	UD	24 HR AV	Peak
LEGS	1										
STR	0.14102	1									
DY	-0.02444	0.130753	1								
RW	0.0125	0.652624	0.178242	1							
FA	0.054399	0.05494	0.061631	0.070533	1						
RH	0.029831	0.085154	0.120623	0.049801	0.109865	1					
RUA	0.12106	0.304472	0.156713	0.290427	0.21331	0.683749	1				
MS	0.236795	0.124874	0.135539	0.216297	-0.10709	0.206322	0.10568	1			
UD	0.234129	0.002533	0.055107	-0.11342	-0.16302	0.066034	0.014691	0.015992	1		
24 HR AV	-0.08411	-0.04734	0.225011	0.1509	0.442587	0.158215	0.249124	0.034266	-0.42825	1	
PEAK	-0.04082	-0.06617	0.266635	0.098225	0.366902	0.127371	0.230269	0.078073	-0.43887	0.92833	1

APPENDIX E

ADGA National Top Twenty Two-year-old Does Correalations

	Placing	ST	STR	DY	RW	FA	RH	RUA	MS	UD
Placing	1									
ST	0.06459	1								
STR	-0.30496	0.226810095	1							
DY	-0.22756	0.285947613	-0.137502225	1						
RW	-0.20661	0.716828272	0.320082352	0.248513239	1					
FA	-0.4624	0.138166062	0.170652286	0.325299435	0.096965639	1				
RH	-0.15017	-0.015371626	-0.039029316	0.356708016	-0.015630251	0.308494391	1			
RUA	-0.4112	-0.225168177	0.208336267	0.239477281	-0.003546046	0.486073329	0.461146935	1		
MS	-0.03765	-0.267649282	0.127651925	0.064173266	0.125580762	0.019769761	0.014733541	0.077099007	1	
UD	0.243469	-0.04269104	-0.139690866	-0.319821114	-0.215778869	-0.199056526	-0.119584115	-0.211841404	-0.20881945	1
production-NBS	-0.43353	0.069582736	-0.047019488	0.342712107	-0.007963495	0.35474934	0.114561935	0.293683075	-0.059198953	-0.164573339

APPENDIX F

(United Nations)