

GENETIC EVALUATION OF DAIRY GOATS FOR YIELD AND TYPE

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(The following text is from a factsheet that will be included in the Extension Goat Industry Handbook, which currently is in press. A list of related literature has been added at the end of the text.)

USDA calculates annual genetic evaluations of dairy goats from yield data collected through the National Cooperative DHI Program and from type and pedigree data supplied by the American Dairy Goat Association (ADGA). Evaluations for milk, fat, and protein yields have been calculated since 1983 for bucks and since 1984 for does. An animal model replaced the sire model for yield in 1987. Evaluations for type have been calculated since 1986 for final score and since 1989 for linear type traits. In 1995, a multitrait animal model replaced the sire model for type.

Evaluations are computed for Alpines, Experimentals, LaManchas, Nubians, Oberhaslis, Saanens, and Toggenburgs and for crossbred animals from these breeds. Only animals with registered sires are evaluated.

Yield Traits

Yield for only the first 305 days of each lactation is considered. Shorter records are projected to a 305-day equivalent; however, terminated records must have at least 15 days in milk, and records in progress must have at least 40 days. Records with shorter lactation lengths or more than 305 days in milk are excluded.

Lactation records are adjusted for age and season of kidding by standardizing yield to the equivalent of that for 3-year-old does kidding from December through March. A doe's birth date must be on or after July 1, 1973; her kidding date must be on or after January 1, 1976. The interval between a doe's kiddings must be at least 6 months.

Actual milk yield per day must be at least 2 pounds but no more than 30 pounds at the start of lactation. As the number of days in milk increases to 305, this upper limit is reduced to 25 pounds. Fat percentage must be at least 2.0 but no more than 7.5. After record projection and adjustment, milk yield for a doe's entire lactation must be at least 400 pounds but no more than 6500 pounds.

Only the first six lactations are included in a doe's evaluation for computational convenience and because lactations after sixth contribute little additional information for estimation of genetic merit. Later-lactation records from does with a missing first-lactation record are included as are later-lactation records from does that have changed herds. Although including such records may introduce some bias into genetic evaluations, the improvement in accuracy from the added information is considered to be more important.

Milk, fat, and protein yields are evaluated directly with an animal model across breeds; evaluations for fat and protein percentages are calculated from yield evaluations. The formula that represents a 305-day lactation record adjusted for age and month of kidding is:

$$y = m + a + p + c + e,$$

where y is the adjusted lactation record, m is the effect of management group, a is the doe's genetic merit (breeding value), p is the effect of a doe's permanent environment, c is the effect of the interaction between a doe's herd and her sire, and e is the remaining unexplained residual.

Management groups are defined by herd, kidding month, and parity (first or later). The number of adjacent kidding months included in a management group (kidding season) can range from 2 to 12. A kidding season is extended in 2-month increments to include at least five lactation records in each management group. If the requirement for five lactation records is not satisfied by a 6-month kidding season, then records from first and later lactations are combined, and the required number of records is reduced to three. If a sufficient number of records for comparison still is unavailable, the kidding season continues to be extended up to a maximum of 12 months. Because analysis is across breeds, mixed-breed does can serve as management group mates.

Pedigrees are traced back as far as possible, but every ancestral path eventually ends with unknown parents. Animals with only one kid, no lactation records, and parents that are not being evaluated also are considered to be unknown parents. The unknown parents are grouped, and their average genetic merit is included in evaluations of descendants. Separate groups of unknown parents are defined for each breed to recognize differing genetic backgrounds of each breed and for parents of animals born before or after 1974 to recognize the genetic improvement that has occurred over time.

The effect of permanent environment is included in addition to the effects of management group and genetic merit to represent nongenetic factors (such as disease or superior rearing) that influence only an individual doe's yields but are not passed on to offspring.

The similarity in yield between daughters of the same buck that are being milked in the same herd that is not due to genetics is reflected by the herd-sire interaction. Impact of a single herd on a buck's evaluation can be limited by accounting for this interaction, which also has a particularly large influence on evaluations of bucks with distinctly unequal numbers of daughters per herd.

A heritability of 25% is assumed for milk, fat, and protein yields. The portion of phenotypic variation assigned to other random factors is 16% for permanent environment, 14% for herd-sire interaction, and 45% for the remaining unexplained residual.

Genetic evaluations are reported to the dairy goat industry as predicted transmitting abilities (PTA's). A PTA is half of breeding value and is the genetic merit that an animal is expected to contribute to its offspring. To show the sources of information that contribute to an evaluation, a PTA can be represented as:

$$PTA = w_1(PA) + w_2(YD/2) + w_3[\text{avg}(2PTA_{\text{kid}} - PTA_{\text{mate}})],$$

where the w's are weights that sum to 1 and indicate how much emphasis should be placed on each source of information, PA is the animal's parent average, and YD is the doe's yield deviation. The PA indicates the contribution to the animal's evaluation from its parents and is the average PTA's of its parents. If either parent is unknown, an unknown-parent group effect is substituted for the PA for that parent. A doe's own performance is represented by YD, which is the average of the doe's lactation yields minus the effects of management group, herd-sire interaction, and permanent environment weighted by factors dependent on lactation length. The contributions of offspring to an animal's evaluation are expressed by $\text{avg}(2PTA_{\text{kid}} - PTA_{\text{mate}})$, which is the average of the portion of offspring evaluations (PTA_{kid}) that can be attributed to the animal's genetic merit after adjusting for the genetic merit of mates (PTA_{mate}). If a mate is unknown, an unknown-parent group effect is substituted for PTA_{mate} , and that kid receives a weight of only two-thirds when calculating offspring average.

Although all breeds are analyzed together, yield PTA's are comparable only within breed because the average genetic merit of does born in 1990 for each breed is subtracted from the animal's genetic merit (Table 1). This procedure establishes does born in 1990 as the genetic base for each breed. The base is updated every 5 years.

Table 1. Differences between breeds in the average estimated breeding value for does born in 1990.

Breed	Milk (pounds)	Fat (pounds)	Protein (pounds)
Alpine	0	.0	.0
Experimental	-114	-.7	-1.3
LaMancha	-334	-4.8	-5.4
Nubian	-531	4.4	-1.9
Oberhasli	-476	-15.7	-14.3
Saanen	60	.8	1.9
Toggenburg	-18	-6.4	-3.5

For bucks, a weighted average of daughter YD's that have been adjusted for the merit of mates is provided with evaluations. This daughter yield deviation (DYD) provides an indication of the performance of the buck's daughters without consideration of his parents or sons.

In addition to PTA, PA, YD, and DYD, a predicted producing ability (PPA) is calculated and provided to the industry to indicate a doe's future production. The PPA includes the effects of permanent environment and herd-sire interaction as well as genetic merit and is useful in predicting a doe's relative performance in the next lactation rather than the performance of future offspring.

Evaluations for milk, fat, and protein yields are combined into an economic index called milk-fat-protein dollars (MFP\$). The economic values for milk components used for calculating MFP\$ for dairy cattle are used for dairy goats:

$$\text{MFP\$} = \$0.031 (\text{PTA milk}) + \$0.80 (\text{PTA fat}) + \$2.00 (\text{PTA protein})$$

Although goat milk has substantially higher economic value than cow milk, the relative weights for milk, fat, and protein are useful for combining those traits into a single index. The weights are updated every 5 years when the genetic base is updated.

Percentile rankings of dairy goats are based on MFP\$. High-ranking does and bucks are designated as elite based on percentile ranking. For bucks to qualify, they must be in the top 15% of bucks with daughters born during the last 4 years. Does must be in the top 5% of does kidding during the last 2 years and have a termination code in their latest record that indicates that they are still alive.

The measure of an evaluation's accuracy is called reliability (REL). All sources of information are converted to daughter equivalents (DE's). A DE is the amount of information contributed by one daughter with one lactation. The DE's from an animal's parents, its own records, and its offspring are summed. Then REL is calculated as $\text{DE}/(\text{DE}+14)$. The value 14 is a reflection of the heritability of yield traits. For bucks, an additional daughter in the same herd contributes less than another daughter in a different herd.

Yield evaluations are computed in July of each year and distributed to the dairy records processing centers and to ADGA for release to the industry. The evaluations are also available from queries on individual bucks and does or as downloadable files and printable lists at the Animal Improvement Programs Laboratory's web site (<http://aipl.arsusda.gov>).

Evaluations in July 1998 included 198,698 does and 43,763 bucks, of which 9,075 bucks had at least 5 daughters, which is required for release of a buck evaluation to the industry. Genetic trend for does born in 1996 (Table 2) differed by breed.

Table 2. Genetic trend for yield traits of does born in 1996 based on quadratic regression of breeding value on birth year.

Breed	Does born in 1996 (no.)	Trend (pounds/year)		
		Milk	Fat	Protein
Alpine	1177	18.9	.42	.52
Experimental	170	9.5	.16	.25
LaMancha	512	7.5	.29	.31
Nubian	770	12.5	.63	.46
Oberhasli	162	21.3	.81	.60
Saanen	582	15.3	.70	.50
Toggenburg	391	1.3	.08	.13

Type Traits

Appraisals for final score and 13 primary linear traits (stature, strength, dairyness, rump angle, rump width, rear legs in side view, fore udder attachment, rear udder height, rear udder arch, medial suspensory ligament, udder depth, teat placement in rear view, and teat diameter) are provided through the ADGA type program. Linear traits are scored between biological extremes on a continuous scale. Final scores range from 50 to 99; scores for linear traits range from 1 to 50. Type records are adjusted for a doe's age at appraisal. All appraisals for a doe are included in genetic evaluations.

Type traits of dairy goats are evaluated with a multitrait animal model:

$$y = h + a + p + e$$

where y is the adjusted type record, h is the effect of herd appraisal date, a is the doe's genetic merit (breeding value), p is the effect of a doe's permanent environment, and e is the remaining unexplained residual. A multitrait evaluation permits scores from one trait to affect the evaluation of another trait through the genetic correlations among the traits. Heritabilities (Table 3) for type traits range from .19 for rear udder arch to .52 for stature; heritability for final score is .27.

Table 3. Heritabilities for type traits.

Trait	Heritability
Final score	.27
Stature	.52
Strength	.29
Dairyness	.24
Rump angle	.32
Rump width	.27
Rear legs (side view)	.21
Fore udder attachment	.25
Rear udder height	.25
Rear udder arch	.19
Medial suspensory ligament	.33
Udder depth	.25
Teat placement (rear view)	.36
Teat diameter	.38

Like yield evaluations, type data are analyzed across breeds. However, the resulting evaluations are not adjusted for breed averages and, therefore, are comparable among breeds.

Type evaluations for final score and linear traits are computed annually in November. The PTA's and REL's for each trait are provided to ADGA for further distribution to the industry. Evaluations also are available from queries on individual bucks and does and as downloadable files at the Animal Improvement Programs Laboratory's web site (<http://aipl.arsusda.gov>). The November 1997 evaluations included appraisals from 1988 through 1997. Evaluations for final score in November 1997 included 57,224 does and 19,135 bucks, of which 1,612 bucks had at least 5 daughters.

Production-Type Indexes

Genetic evaluations for yield and type are combined into a production-type index (PTI) that represents the economic merit of the traits evaluated for the animal. Yield is represented by MFP\$, and type is represented by PTA for final score. Two PTI's with differing weights are provided by ADGA to dairy goat producers: one with yield weighted twice as much as type and the other with type weighted twice as much as yield.

Summary

Genetic evaluations for yield and type traits of dairy goats are calculated annually by USDA. Yield evaluations are released to the dairy goat industry in July, and type evaluations are released in November. Evaluations are available to producers through ADGA or the internet (<http://aipl.arsusda.gov>).

Genetic evaluations are useful only if they lead to genetic improvement. Because of the large number of offspring possible for an individual buck, especially through artificial insemination, genetic improvement of bucks is a high priority.

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1999 Update:

Genetic evaluation of yield and type traits of dairy goats. G. R. WIGGANS,* Animal Improvement Programs Laboratory, Agricultural Research Service, USDA, Beltsville, MD 20705-2350.

Genetic evaluations of dairy goats are computed annually by USDA from records available through Dairy Herd Improvement (**DHI**) and the American Dairy Goat Association (**ADGA**). During 1999, 11,273 does were enrolled in DHI test plans used in genetic evaluations; 3784 does participated in linear appraisal programs, which was lower than the mean of 4285 does for the last 5 yr. For evaluation of yield traits, an animal model similar to that used for dairy cattle is used, but analysis is across breeds. Lactation records for the first six parities of does that were born since July 1973 and that kidded since January 1976 are edited within limits appropriate for goats, projected to 305 d, and adjusted for kidding age and month. Evaluations are computed for milk, fat, and protein yields and component percentages; an economic index for milk, fat, and protein (**MFP\$**) is calculated based on economic values for dairy cattle. A multitrait animal model is applied to 14 linear type traits and final score. Through canonical transformation, a single-trait calculation method is used. Annual genetic progress for does that were born during 1996 as a percentage of mean breed yield was lowest for Toggenburgs (-0.1, milk; 0.0, fat and protein) and highest for Saanens (0.9, milk and protein; 1.0, fat). Corresponding trend for type traits across breeds was 0.67 for stature; 0.37 for rump angle; 0.34 for teat placement; 0.22 for suspensory ligament; 0.20 for strength; 0.12 for rump width and fore udder width; 0.16 for teat diameter; 0.09 for rear legs; 0.06 for dairyness; 0.05 for final score; 0.02 for fore udder attachment; and 0.01 for udder depth. Two production-type indexes are computed by ADGA with 2:1 and 1:2 weightings for MFP\$ and predicted transmitting ability for final score. Genetic evaluations and information on pedigree and yield (including individual test-day data) are available at <http://aipl.arsusda.gov>. Based on developments for dairy cattle, test-day data eventually will be used directly in a test-day model for genetic evaluation of yield traits.

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