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Estimating the effectiveness of extension information systems using farm trials and subjective probabilities

Wayne H. Howard [a], Robert W. Blake [b], Thomas O. Knight [c], C. Richard Shumway [c] and Michael A. Tomaszewski [d]

[a] *Department of Agricultural Economics and Business, University of Guelph, Ont., Canada*
[b] *Department of Animal Science, Cornell University, Ithaca, NY 14853, USA*
[c] *Department of Agricultural Economics and*
[d] *Department of Animal Science, Texas A&M University, College Station, TX 77843, USA*

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ABSTRACT

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A method of combining survey data and Dairy Herd Improvement Association (DHIA) records to achieve low cost farm trials is presented. Farm trials and surveys of current practices and production responses are useful to identify yield gaps between expectations predicted from experimental findings and actual field results. Different management schemes can be ranked using subjective probabilities and stochastic dominance to enhance successful implementation of research findings and to increase the feedback between researchers, extension workers, and producers.

A survey of current masitis control practices and expected milk yield response is the example. Combining survey results with DHIA records allowed estimating the relationship between somatic cell counts (SCC) and milk yield. Eliciting beliefs about the relationship between SCC and milk yield showed that producers agreed with predictions from the statistical model. Subjective probabilities about SCC and mastitis control practices showed that our sample of experts and producers consistently ranked the different practices but extension agents had no consensus about the the most or least effective ones.

Correspondence to: W.H. Howard, Department of Agricultural Economics and Business, University of Guelph, Guelph, Ont. N1G 2W1, Canada.

INTRODUCTION

Two important responsibilities for publicly-funded agricultural experiement stations and extension services ate to develop new technologies and procedures and to disseminate information about new methods to producers. How efficiently the information is disseminated and the impact the information has on production methods are important concerns of these institutions.

Little refereed literature has been devoted to the differences between experimental responses to dairy herd management changes and the production responses achieved by the adopting producers. This potentially large difference between the results obtained in experiments and those achieved by typical producers has been termed "slippage" (Dillon, 1977). Substantial slippage between expectations based on experimental findings and the results obtained by the producers using a new practice may reduce credibility of extension and research programs and future rates of adoption. Therefore, quantifying economic aspects of slippage can provide important feedbacks enabling research and extension workers to estimate prediction errors in farm level responses. This kind of information can promote synergistic working relationships and help modify programs of research and extension education to best serve the targeted clientele.

Slippage can be estimated using farm trial or survey data to quantify farm level production responses. Farm trials have been used to introduce new cultivars and cultivation methods in developing countries (Zandstra, 1981; Barlow et al., 1983). This procedure complements experimental testing with farmers using a new practice under the supervision of an extension agent. In addition to measuring slippage, this technique identifies constraints and problems of application, and provides research and extension workers with feedbacks about effectiveness of the new practice and the system of delivering information about it.

FARM TRIALS AS RESEARCH METHODS

The objective of this paper is to present a low-cost method of measuring adoption frequency and slippage between experiment and field results by combining farm survey data with Dairy Herd Improvement Association (DHIA) production data. Similar methods have been used previously, but are infrequently reported in scientific journals (Mohammad et al., 1984). Controlled experiments usually are preferred because of the confounding effects from less controlled field studies. To our knowledge there are no refereed reports about using farm trials to determine the economic value of dairy management practices.

The National Mastitis Council recommends a mastitis control program consisting of hygienic washing and drying of udders before milking, regular milking machine maintenance, teat dipping after milking, antibiotic therapy of all cows at drying off, and culling of cows with recurrent mastitis (Philpot, 1984). Economic studies of controlled experiments showed these recommended practices to have substantial returns over cost (Natzke, 1981; Philpot, 1984). However, producers are not equally skilled at effectively implementing each of several practices in a management program. Given this reality of management limitation, it would be helpful to reconcile the hierarchical importance and comparative net economic values to dairy managers, researchers, and extension workers of management practices being recommended.

MATERIAL AND METHODS

Two methods are discussed that were used in a study of producers' use and perceptions of recommended mastitis control practices in Texas dairies (Howard et al., 1987). In our example, survey data were combined with DHIA data to determine the extent that practices were utilized by producers, and to estimate the relationship between milk yield, SCC, and these management practices. Producers', researchers', and extension agents' subjective evaluations of recommended mastitis control practices were examined using stochastic dominance. Model specification and results are in (Howard et al., 1987).

FARM TRIALS BY SURVEY

Only producers on the DHIA SCC option were surveyed because individual SCC scores were required for the analysis. This expressed interest in SCC information may indicate that these producers were more aware of mastitis losses (costs) and mastitis control methods than average producers. Compounded potential bias was from enrollment in DHIA, itself an optional program. As a result, like much dairy research, inferences based on our sample are aimed at DHIA producers who acknowledge that SCC is related to mastitis.

Table 1 shows the initial six of 27 questions in the first survey. The entire survey, which is available from the senior author, was designed for objective 'yes or no' answers about specific management practices potentially affecting SCC. Subjective evaluation of management skill has been used to account for differences in milk yield but can contribute to enumerator bias (Goodger et al., 1984). To reduce chances of bias, potential multiple choice answers were written to anticipate most responses with constraints to

TABLE 1

Initial questions from the Texas A&M Mastitis Survey I

Your help with this survey is greatly appreciated. Confidentiality will be maintained throughout this study. If you have any questions or are not sure about any of the questions, feel free to call Wayne Howard at (800) 555- . If you would like a copy of the results of this survey, please mark here _______.

DHI Herd Code Number _______ Today's Date _______.

DHI Supervisor _______

Please circle your responses.

MILKING PRACTICES

1. ARE UDDERS ROUTINELY WASHED BEFORE MILKING?
   11. NO – If no please go to question No. 6.
   12. YES

2. WASHING METHOD: (circle all that apply)
   21. PRE-WASH IN THE HOLDING AREA.
   22. PREP-STALL.
   23. HAND-HELD SPRAYER IN THE PARLOUR.
   24. BUCKET AND SPONGE OR CLOTH.
   25. OTHER METHOD – Please explain other method:
   ____
   ____

3. WASHING SOLUTION USED:
   31. PLAIN WATER.
   32. WATER AND SANITIZER.
   NAME OF SANITIZER: ___________.
   USED FOR _______ MONTHS, _______ YEARS.

4. DRYING METHOD:
   41. ALL COWS "DRIP DRY" IN PARLOUR PRIOR TO MILKING.
   DRIED BY HAND USING A
   42. RE-USABLE CLOTH TOWEL.
   43. SINGLE USE PAPER TOWEL.
   44. RE-USABLE SPONGE.

5. ARE UDDERS EVER WET WHEN MILKING MACHINE IS ATTACHED?
   51. NEVER.
   52. SOMETIMES.
   53. FREQUENTLY.

TABLE 1 (continued)

Initial questions from the Texas A&M Mastitis Survey I

MILKING PRACTICES
6. DO YOU DO A PREMILKING CHECK FOR ABNORMAL MILK? 61. NO – if no please go to question No. 8. 62. YES, FROM EACH TEAT OF EVERY COW. 63. YES, ONLY ON "PROBLEM" COWS OR QUARTERS WITH ABNORMALITIES.

facilitate data coding and analysis. A preliminary version of the survey was tested prior to general distribution to aid revision and to delete poor questions. Survey directions were simple, and followed the guidelines in (Dillman, 1978).

The survey was enumerated by DHIA supervisors who were paid US$5 per completed survey. A training session was conducted at a regularly scheduled supervisor meeting. Payment approximated the opportunity cost of a supervisor's time. One hundred fifty surveys were distributed in September 1985, and 138 usable ones were returned in October and November 1985. Total cost was approximately $800 for supervisor labor, printing, envelopes, and franking.

Milk yield, SCC, herd size, and herd average yield data were obtained from DHIA records. Relationships between milk yield, SCC, and producer and management characteristics from the survey were estimated using a two equation, three stage least squares model (Judge et al., 1982; Howard et al., 1987). Daily milk yield for an individual cow was estimated as a function of the SCC, stage and number of lactation, and rolling herd average milk yield. The SCC for a cow was estimated as a function of mastitis control practices, stage and number of lactation, producer characteristics, herd size, and rolling herd average milk yield.

Subjective probabilities to evaluate management practices

Perceptions about the relationship between milk yield and SCC (i.e., the milk loss function for an individual cow) and subjective probability distributions (SPD) of SCC for herds given various management scenarios were elicited from eight experts, eight extension agents, and eleven producers. These results were combined to determine whether the information from experts about predicted changes in milk receipts associated with mastitis control practices was the same as that received by producers and extension

TABLE 2

Subjective Milk Loss Function Survey Instrument from Texas A&M Mastitis Survey II

The purpose of this survey is to see what you think about various management practices that have been recommended to control mastitis. There are no right or wrong answers – we are interested in what you think given the information available to you. The information you give is confidential.

I. Suppose there is a second lactation Holstein cow that is part of a medium producing herd (a rolling herd average between 14,300 and 16,940 pounds), that is well managed and healthy overall. She has never had a case of clinical mastitis, but you do not have record of her SCC in her first lactation. Currently she is producing 100 pounds a day in her second month after freshening and has a SCC score of 0.
Now suppose nothing has changed except that her SCC score is now 1. How many pounds a day would you expect her to be producing? _______.
Nothing has changed except that her SCC is now 2. How many pounds a day would you expect her to be producing? _______.
Nothing has changed except that her SCC is now 3. How many pounds a day would you expect her to be producing? _______.
Nothing has changed except that her SCC is now 4. How many pounds a day would you expect her to be producing? _______.
Nothing has changed except that her SCC is now 5. How many pounds a day would you expect her to be producing? _______.
Nothing has changed except that her SCC is now 6. How many pounds a day would you expect her to be producing? _______.
Nothing has changed except that her SCC is now 7. How many pounds a day would you expect her to be producing? _______.
Nothing has changed except that her SCC is now 8. How many pounds a day would you expect her to be producing? _______.
Nothing has changed except that her SCC is now 9. How many pounds a day would you expect her to be producing? _______.

agents. Experts were current or past members of the National Mastitis Council and persons recommended by them. Extension agents were area dairy specialists and county extension agents in Texas where dairying is a major agricultural enterprise. Producers were randomly selected from those surveyed. Respondents were first enlisted by telephone and then Survey II (Tables 2 and 3) was mailed to them. Predicted milk losses and SPDs were elicited with a subsequent telephone call.

Estimating milk loss functions. Subjective milk loss functions were elicited for a hypothetical cow and herd by asking respondents to predict milk yield changes associated with increasing SCC score, all else constant. The starting point was SCC of zero and 100 pounds ($\approx$ 45 kg) milk per day for direct correspondence to a percentage reduction.

TABLE 3

Selected questions from Texas A&M Mastitis Survey II to elicit subjective probability distributions

II. Think of a medium producing herd (14,300 to 16,940 pounds) that has 100 cows on the milking line. They are on a owner-operated dairy farm, the owner/operator does most of the milking, and is generally thought of as having good "cow sense". The current management practices include washing udders with a water/sanitizer solution and a hand-held sprayer, drying udders with single use paper towels, teat dipping all quarters of all cows after milking, treating all quarters of all cows with an antibiotic at drying off, having the milking system serviced every year, and usually culling a cow with "problem mastitis" or a SCC that is consistently 7 or above.

This herd has never been down graded because of high SCC, but has had the usual number of clinical mastitis cases that are quickly treated and the milk discarded, but there is no separate hospital string.

Given the above information, and your knowledge and experience, how many of the 100 cows would you expect to be in each of the following SCC classifications?

|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|

SCC 0 1 2 3 4 5 6 7 8 9

III. Suppose nothing has changed, except that the milker is no longer *teat dipping* after milking. Now how many of the 100 cows would you expect to be in each of the different SCC classifications?

|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|

SSC 0 1 2 3 4 5 6 7 8 9

What do you think the savings in cost would be by not teat dipping? (Or what do you think is the cost of teat dipping? When you think of the cost of doing something please note that the cost includes the costs of labor, equipment, fuel, materials, and the cost of your own time). $ _____ per _____ (cow or herd) per _____ (month or year).

IV. Recall the original situation in question II. Nothing is changed except that we stop treating cows with an *antibiotic at drying off*. Now how many of the 100 cows would you expect to be in each of the SCC classifications?

|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|

SCC 0 1 2 3 4 5 6 7 8 9

What do you think the savings in cost would be by not doing the dry cow treatment? (Or what do you think is the cost of the dry cow treatment?). $ _____ per treatment.

Subjective probability distributions. Sample questions to elicit subjective predictions about different management practices are in Table 3. The initial management scenario included all recommended mastitis control practices except culling cows with recurrent clinical mastitis infections, which was considered too difficult to quantify.

TABLE 4

Scenarios used to elicit subjective probability distributions from Texas dairy farmers

Scenario	Management Practices
First	Washing udders with a water/sanitizer solution and a hand-held sprayer, drying udders with single use paper towels, teat dipping all quarters of all cows after milking, treating all quarters of all cows with an antibiotic at drying off, having the milking system serviced every year, and culling "problem" cows.
Second	Eliminate teat dipping.
Third	Eliminate antibiotics at drying off. [1]
Fourth	Eliminate sanitizer from the washing solution.
Fifth	Eliminate drying with paper towels.
Sixth	Service milking system every six months.

[1] Previously eliminated practices are included again.

Respondents were asked to estimate how many cows in a 100-cow herd they would expect in each SCC score category. The management scenario was subsequently altered, one practice at a time, to obtain revised predictions. The six management scenarios are in Table 4. An SPD was elicited from each respondent, i.e., the respondent's belief or subjective probability that a randomly chosen cow has a specific SCC score is the frequency corresponding to each SCC category. Costs of each practice or the savings by not using it also were elicited.

Economic analysis. Marginal value products (MVPs), the additional milk receipts from implementing each management practice were computed by using the initial management scnenario (i.e., all practices) as a benchmark and comparing the expected values of the five alternative scenarios (i.e., each missing one practice). Additional receipts per cow per year were computed for each scenario by multiplying the SPD by the milk loss function and multiplying the result by the milk blend price in Texas ($28/kg at time of study). Marginal input costs (MICs), the additional cost of each practice, were those given by the respondents (Table 3).

Ranking management practices. Management scenarios can be ranked by marginal net return (MVP minus MIC), but such a ranking is only based on the mean of the subjective distribution. Stochastic dominance is useful to compare management practices at all points of the distribution, not just the mean.

To illustrate, assume two income-generating practices, $f(y)$ and $g(y)$, without a guaranteed return, but with a distribution of possible returns

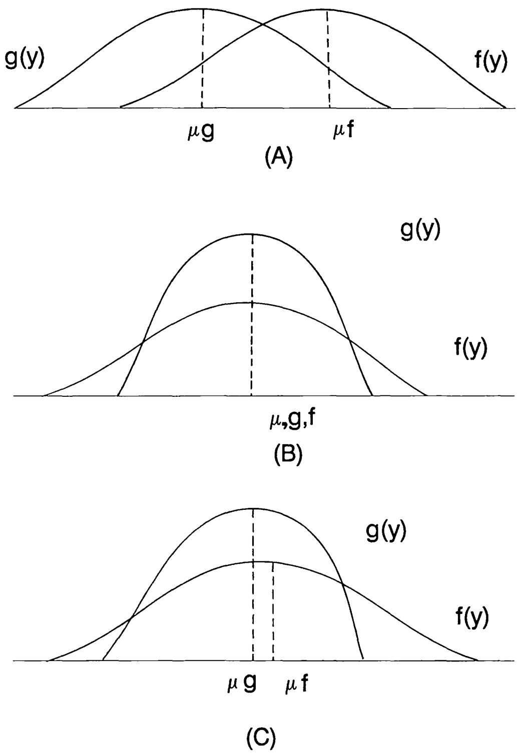

Fig. 1. Possible distributions for two income generating practices, $f(y)$ and $g(y)$, where the probability of receiving a return from the practice is the area under its curve. If $E[f(y)] > E[g(y)]$, and their variances are the same, then $f(y)$ is preferred to g(y) (panel A). If $E[f(y)] = E[g(y)]$, but f(y) has a larger variance than $g(y)$, then $g(y)$ is preferred (panel B). It is less straightforward to compare $f(y)$ and $g(y)$ when both their expected values and variances are different (panel C).

(Fig. 1). The probability of receiving a return is the corresponding area under the curve for each practice. If the expected return from $f(y)$ is greater than the expected return from $g(y)$, i.e., $E[f(y)] > E[g(y)]$, and their variances are the same (panel A), then $f(y)$ is preferred. If expected returns are the same, i.e., $E[f(y)] = E[g(y)]$, but $f(y)$ has larger variance than $g(y)$ (panel B), then $g(y)$ is preferred. It is less straightforward to compare practices if both the means and variances differ, as shown in panel C. Stochastic dominance with respect to a function compares functions like those in panel C by evaluating the cumulative returns at all points of the distribution (Hadar and Russell, 1969; Meyer, 1975). For our study, the respondents' SPDs were ranked to evaluate management practices at all points of the distribution using the STODOM algorithm (Richardson, 1981).

RESULTS AND DISCUSSION

Our farm trial survey revealed that even though most producers used most of the five recommended mastitis control practices, only about 30% used all five of them. This outcome was surprising for a group expected to be aware of mastitis control recommendations because of their enrollment to obtain SCC information.

Milk yield decreased with increasing SCC using the three stage least squares modelling approach in the same pattern but slightly more than in (Jones et al., 1984). Proper washing, teat dipping, assuring dry udders at milking, frequent milking system servicing, and regular veterinary attention were effective in lowering SCC. Other beneficial effects were from professional experience and formal and continuing education of the operator. Producers in operation the longest and who attended extension seminars often had lowest SCCs. Also, producers who had regularly scheduled veterinary visits had lower SCC than those using veterinary services only for emergencies.

Results conflicted with the notion that large herds and high milk yield are unfavorably associated with high SCCs (Etgen and Reaves, 1978). Largest herds in this study had a slightly lower SCC than smallest ones. Herd average milk yield was unassociated with SCC.

Subjective predictions

All respondents believed that milk yield decreased with increasing SCC. However, producers predicted greater losses than experts or extension agents (Fig. 2). This difference may indicate some slippage between experts' and producers' beliefs, but the milk loss functions of the three groups did not differ significantly. Experts had the smallest SD of estimated milk loss (2.68 kg at SCC = 4) and producers had the largest one (SD = 4.54 kg at SCC = 4), indicating more consistent predictions by experts and agents (SD = 3.39 kg at SCC = 4) than by producers. However, the producers' milk loss function agreed closely with predictions by the statistical model fit to the field data (Fig. 2). This result suggests that this sample of producers accurately understood the relationship between SCC and actual losses in milk, but with considerable variation in their beliefs.

Results from the economic analysis are in Table 5. All MVPs were positive and far greater than the MICs, except for the experts' belief that sanitizer in the washing solution had benefits smaller than its cost. For every practice, agents had the largest and experts had the smallest MVP. Distributions of the MVPs were highly skewed to the right, except producer's leftward skewed MVP for dry cow treatment, resulting in large

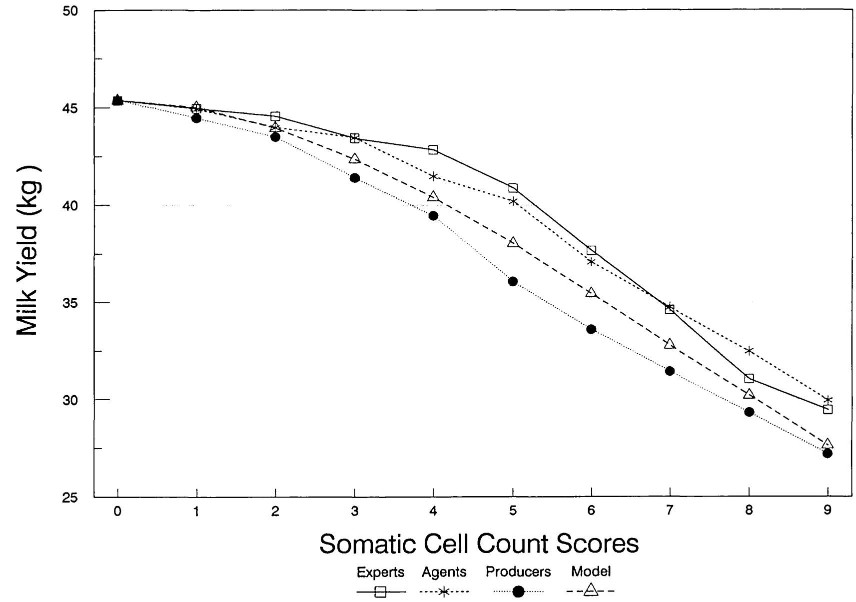

Fig. 2. Daily milk yield predictions for specified DHIA somatic cell count scores for experts, agents, producers, and the 3-stage least squares statistical model.

standard errors (Table 5). Agents believed that these mastitis control practices had large marginal net revenues, but with large variation in the amount of benefits.

Ranking of management practices

Experts and producers were consistent in their rankings of effective mastitis control practices. Sixty-three percent ranked first the scenario including all recommended practices except sanitizer in the washing water. Eighty-eight percent ranked plain water over a sanitizer solution. The experts worst case was omission of dry cow treatment or teat dipping. Eighty-one percent of producers considered not using dry cow treatment or single-use paper towels as the worst case. Producers (91%) agreed with experts that omitting sanitizer or less frequent than semiannual servicing of the milking system from the set of practices caused the least harm. For agents the choice set of practices in the most profitable mastitis control program included all recommendations, with no consensus about either the most effective or least effective one. They seemed to believe that payoffs from each practices would result in correspondingly large (except for system servicing) net economic returns (Table 5). In contrast, the most

TABLE 5

Subjective marginal value products (MVP) and marginal net revenue (MNR) in $ per cow annually of experts, agents, and producers for the five mastitis control practices

Practice	Experts		Agents		Producer	
	MVP	MNR	MVP	MNR	MVP	MNR
Teat dip	77.49 [1]	64.61	135.64	127.40	119.17	102.93
	(76.39) [2]	(78.79)	(716.31)	(178.02)	(98.60)	(99.07)
	(1.30) [3]		(1.14)		(0.72)	
Dry cow treatment	80.57	50.19	141.75	116.02	132.36	126.63
	(74.73)	(44.13)	(135.16)	(145.21)	(112.09)	(112.59)
	(1.18)		(0.38)		(−0.76)	
Sanitizer	0.76	−3.43	116.27	110.66	37.64	33.06
	(2.14)	(3.88)	(294.04)	(295.59)	(75.50)	(75.79)
	(2.83)		(2.82)		(2.82)	
Paper towel	33.94	26.20	210.23	199.61	91.84	80.00
	(63.11)	(62.37)	(387.92)	(389.24)	(103.42)	(103.83)
	(2.69		(2.58)		(1.17)	
System servicing	14.41	13.45	54.66	53.89	24.51	23.79
	(24.33)	(24.32)	(93.91)	(93.88)	(43.16)	(43.21)
	(2.46)		(2.34)		(2.85)	

[1] Based on a 305-day lactation.
[2] Standard errors are in parentheses below the MVP.
[3] Skewness or the 3rd moment of the distribution.

efficacious program for producers and experts definitely included dry cow treatment and teat dipping, but without significant economic losses by omitting sanitizer or by less frequent servicing of the milking system.

SUMMARY AND IMPLICATIONS

Combining survey data and DHIA records to achieve low cost farm trials can be used to estimate the effectiveness of extension information systems. The adoption frequency of recommended practices and the beliefs producers have about the impact of those practices can be assessed. The example presented indicated that only 30% of the producers surveyed adopted all of the recommended management practices. Analysis of survey and DHIA data quantified the expected negative relationship between milk yield and

SCC and identified the management practices constituting the herd management effect that lowered SCC (i.e., proper washing, teat dipping, assuring dry udders, frequent milking system maintenance, and regular veterinary attention).

Subjective probabilities elicited from experts, extension agents, and producers showed that all groups believed that milk yield decreases with increasing SCC. Producers agreed most closely with predictions by the statistical model. Rankings by stochastic dominance showed that experts and producers were consistent in their hierarchial assessments of mastitis control practices, while our sample of agents was unable to distinguish between either the most or least beneficial practices. This finding could be useful in planning training or other educational programs involving agents.

Quantifying the relative economic benefits from alternative practices enables researchers and extension workers to develop and recommend practices with largest marginal net returns. This can enhance credibility of public service programs and may facilitate adoption of new technologies and innovations. These methods also may be useful in verifying the economic benefits from forthcoming exogenous treatments affecting animal performance (e.g., somatotropin growth stimulants, beta agonists).

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