

Understanding gestational and feed management practices of New England sheep producers

Miriah R. Kelly,^{†,1} Arielle Halpern,^{‡,1} Sarah A. Reed,^{‡,◉} Steven A. Zinn,[‡] and Kristen E. Govoni^{‡,2}

[†]Department of Extension, University of Connecticut, Storrs, CT 06269-4040, USA; and [‡]Department of Animal Science, University of Connecticut, Storrs, CT 06269-4040, USA

ABSTRACT: Several sources of information are available to producers for guidance in managing their breeding flocks; however, it is unknown if sheep producers utilize any or all of these resources. Because maternal diet during gestation can have immediate and long-lasting negative effects on growth and health of offspring, it is important for producers to insure they are providing appropriate nutritional management to ewes during breeding and gestation. Historically, New England sheep producers have not been included in USDA surveys of sheep producers, and therefore, there is a lack of information about how New England producers manage their flocks, especially in terms of nutrition and gestation. The objective was to determine flock size, breeds, pregnancy detection methods, and feeding management practices of New England sheep producers. To meet this objective, a 12-question survey was developed and disseminated to New England sheep producers via Qualtrics using e-mail survey links, with a 33.2% response rate ($n = 96$ responses). Data were analyzed using SPSS. Of the respondents, 61.5% have flock sizes of 11 to 50 sheep, whereas 15.6% had 10 or less and 23%

had greater than 50 sheep. Most respondents (63.5%) maintain one breed of sheep; however, larger flocks (>50 sheep) are more likely to maintain multiple breeds ($P < 0.05$). The largest percentage (40.6%) use their sheep for both meat and fiber production, 38.5% for meat only, and 20.8% manage sheep for fiber only. Spring (January to May) is the primary (59.4%) lambing season. The majority (76.0%) of New England sheep producers do not have their feed chemically analyzed for nutrient composition, which presents an opportunity for improving feeding management. There were associations ($P < 0.05$) between flock size and flock purpose, flock size and number of breeds owned, flock size and feed type, feed type and feed analysis, feed type and source of feed information, and source of feed information and state. In conclusion, New England sheep producers have flocks of varying size and purpose, and would likely benefit from outreach education on the value of diet analysis and formulation for their breeding flocks, especially during gestation. Furthermore, findings of this survey may represent the management needs of smaller flocks throughout the United States.

Key words: extension outreach, needs assessment, sheep management

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¹Authors contributed equally to this study.

²Corresponding author: kristen.govoni@uconn.edu

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INTRODUCTION

Over the past 25 yr, the U.S. Department of Agriculture (USDA) has conducted several

national assessments of sheep producers across the United States (USDA, 2011). However, these surveys were not administered in any of the six New England states, leaving a gap in knowledge for this region. Over the past few years, national sheep production has remained constant (USDA, 2020). However, the New England lamb crop increased by 6% from 2017 to 2018 (USDA, 2020). Although the majority of U.S. sheep production (two-thirds) is found in Southern Plains, Mountain and Pacific Regions, and Texas and California, the Northeast is a major market for lamb due to greater populations of Middle Eastern, Caribbean, and African consumers (Hahn, 2020). Additionally, lamb meat imports in the United States have increased over the past decade and account for nearly one-half of lamb consumed within the United States (USDA, 2019). Thus, there is a demand for sheep products and the potential for growth of the American sheep industry. It is known from these USDA surveys that ewe health and management (including nutrition) are the top concern for producers (Miles, 2019).

We and others have shown that maternal nutrition during gestation is an influential factor in fetal programming, thereby impacting offspring growth, health, and product quality (Bee, 2004; Caton et al., 2009; Ford and Long, 2011; Reed et al., 2014; Du et al., 2015; Aiken et al., 2016; Hoffman et al., 2016; Pillai et al., 2017). Therefore, understanding how farmers manage their flocks will help Extension outreach and engagement professionals align field practices with the latest scientific findings related to the importance of maternal nutrition during gestation.

Sheep producers use many management practices to ensure optimal nutrition during gestation and lactation. For example, consultation with a veterinarian, feed representative, or Extension agent can provide knowledge on guidelines to meet nutrient requirements for pregnant and lactating ewes. Due to the variability of forage quality throughout the year (Corson et al., 1999; Van Saun, 2013), analysis of feed allows for proper diet formulation to meet the needs of sheep at their specific stages of production. Ultrasonography is also a useful tool for managing bred ewes (Jones et al., 2016). In addition to determining if a ewe is pregnant, this technology has advanced such that producers can better estimate the day of gestation and number of offspring (Jones et al., 2016), both important factors when determining the nutritional requirements for a pregnant ewe. Such information allows the producer to improve nutrition management during gestation, rather than risking over- or undernourishing

the ewe and lambs. Fetal growth can also be measured through transabdominal ultrasound, and irregularities in development can be observed early, providing producers with information needed in the decision to intervene in a timely manner.

Overall, there is a lack of information on sheep gestational and nutritional management practices for New England sheep producers, and an obvious importance of maternal nutrition for offspring growth and development throughout life. As described above, there are a number of cost-effective and easily implementable management strategies producers can use to achieve superior maternal nutrition in their flocks. Based on the lack of information about current flocks and their management practices in New England, the objective was to determine flock size, breeds, pregnancy detection methods, and feeding management practices of New England sheep producers in an effort to gauge the current needs of New England sheep producers and opportunities for Extension services to better meet these needs. Based on the current survey results and the increasing number of small flocks in the United States (Miles 2019), these findings are applicable to producers across the United States.

MATERIALS AND METHODS

The survey was developed in consideration of existing literature and in consultation with survey design and sheep production content experts. The 12-item questionnaire covered topics of interest related to breeding and feeding management specific to producers in the New England region. The instrument was then piloted to a select group of sheep producers ($n = 5$) and changes were made accordingly. Once the questionnaire was finalized, it was entered into Qualtrics for distribution via e-mail (Supplementary Material 1).

The pool of potential participants was curated through the following means: First, public member lists from New England sheep producer associations ($n = 6$) were obtained. These lists were combined and then checked using internet research to ensure that those producers listed were still likely to be active in sheep production and only one survey was sent to each household. Second, a recruitment table was set up at the Blue Ribbon Sheep Forum, an annual event held at the University of Connecticut for all six New England states, to share information about the survey project and to allow producers to volunteer for participation. Third, additional participants were identified as those who e-mailed us to ensure they were on the list of

potential participants after learning of the survey through word of mouth. The cumulative list of New England sheep producers ($n = 286$) was then imported into a contact list in Qualtrics for customized survey link distribution.

The survey was initially e-mailed to 286 possible participants in 2017, yielding a 33.2% response rate ($n = 96$ responses). Two reminders were sent to participants who had not yet completed the questionnaire before the survey was closed. The data were then imported into SPSS (IBM Corp. Released 2017, IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY) for analysis. Data were then cleaned and coded. Descriptive statistical tests were run for each variable. Additionally, where appropriate, nonparametric relational tests between variables were analyzed in SPSS through the crosstab function with phi and chi-square tests and post hoc Cramer's V tests, where significance was identified. Significance was set at $P \leq 0.05$. Data presented as percent are based on the 96 respondents, and total percent may be greater than 100% if multiple responses were selected.

RESULTS

Responses to Survey

Flock demographics. Ninety-six sheep producers responded to the survey from all six New England states, for an overall response rate of 33.6% (Table 1). The greatest percentage of survey respondents (37.5%) had flocks (total number of sheep) in the 11 to 25 range, and more than one-half of respondents (61.5%) have flocks between 11 and 50 total animals. Twenty-three percent have flocks with more than 50 animals (11.5% with 51 to 100; 11.5% with 100+) and 15.6% with 1 to 10 animals. The majority of respondents (79.2%) use their flocks to produce meat, although a large number (61.5%) produce fiber. There is an overlap of 40.6%

Table 1. Response rate of New England sheep producers by state

State	Producers e-mailed ¹	Response rate ²
Connecticut	97	26.8%
Maine	67	40.2%
Massachusetts	49	38.8%
New Hampshire	18	61.1%
Rhode Island	39	17.9%
Vermont	19	31.6%

The total number¹ of producers contacted via e-mail, by New England state, and the response rate² of that total number of producers who participated in the survey.

of respondents who use their flocks for both meat and fiber production. Only four flocks were used to produce sheep milk, and none of those flocks produce milk as the sole product. When asked which specific breeds they own, producers in our survey named over 40 breeds, indicating a large diversity of breeds in the region (Supplementary Material 2). However, the majority (63.5%) of sheep producers in New England who responded to our survey only own one breed of sheep, whereas 17.7% own two breeds, 10.4% own three breeds, and 8.3% own four or more breeds.

Gestational management. Most sheep producers in our survey (97.9%) target January through May for lambing season (Early and Late Spring). A smaller number (14.6%) target Fall (September through December) and Summer (3.1%; June through August); no producers use only Fall lambing. Flushing is the technique of increasing caloric intake just before and during the breeding season in sheep. Approximately one-half of the respondents utilize flushing in New England (Yes—53.1%; No—46.9%). For methods of pregnancy confirmation, ram marking, where the ram wears a colored wax crayon affixed to a chest harness to mark ewes when they are bred, is used by 41.7% of sheep producers in our survey sample, whereas only 28.1% of producers in our sample use ultrasound for pregnancy confirmation. The remaining use visual (13.5%), body weight (10.4%), or waiting/none (10.4%) to confirm pregnancy. The 6.3% who selected “other” either use a blood test or have their veterinarian confirm pregnancy.

Nutritional management. The largest percentage of sheep producers surveyed (40.6%) obtain their feed information from a feed salesperson or producer. Brochures and veterinarians are utilized for information by 24.0% and 28.1% of survey participants, respectively. Only 18.8% of respondents in our survey obtain feed information from the Extension System. The remaining respondents use internet (15.6%), other producers (14.6%), other (13.5%), family (11.5%), and research (8.3%) for nutrition information. Among the population we sampled, the most commonly used method for determining how much to feed a flock is based on body condition score (BCS; 64.6%). Additionally, 25.0% of survey participants utilize a farm standard operating procedure, such as a standardized feed scoop or coffee can measure ration size. The remaining respondents use nutritionists (7.3%), other (6.32%), or bag label (3.1%). Only 2.1% follow the National Research Council (NRC) guidelines for the feeding of their flocks. The majority (66.7%) also utilize

BCS to monitor how well they are feeding their pregnant ewes during gestation. The calendar, or the timing of gestation per ewe, is used by 20.8% of sheep producers in our survey to adjust their feeding methods and 8.3% use body weight, 4.2% use visual, and 42% use other methods. Lastly, the vast majority (76.0%) of respondents do not send their feed out for analysis (Yes—24.0%). The most common feed types used by respondents are hay (95.8%), pasture (79.2%), and concentrate (37.5%), with the remaining using other (9.4%), haylage (7.3%), and corn silage (3.1%).

Associations Between Producer Management Practices

Associations by state. There was an association between state and source of feed information ($P = 0.023$; Table 2). The most common sources of feed information used by producers from Connecticut, Massachusetts, New Hampshire, and Rhode Island are feed salespeople. Feed salespeople and feed brochures were equally common among New Hampshire producers as sources of feed information. The most common source of feed information used by producers from Maine is Extension specialists. Among producers from Vermont, the majority of sources of feed information are feed brochures (33%), state Extension resources (33%), other sheep producers (33%), and personal research (33%).

Association of state by flock size ($P = 0.802$), flock purpose ($P = 0.880$), number of breeds owned ($P = 0.843$), lambing season ($P = 0.792$), flushing ($P = 0.742$), method to determine amount of feed ($P = 0.907$), feed monitoring method ($P = 0.669$), feed analysis ($P = 0.789$), feed types ($P = 0.398$), number of feed types ($P = 0.952$), pregnancy confirmation method ($P = 0.097$), and preferred

producer learning style ($P = 0.825$) were not found to be significant.

Association of management practices. There was an association of flock purpose by flock size ($P = 0.014$), with the greatest number of producers having flocks between 11 and 50 sheep that they use for both meat and fiber production (Table 3). The relationship between flock size and the number of breeds owned was significant ($P < 0.001$), with 30.2% of New England sheep producers owning one breed and possessing a flock between 11 and 25 sheep in size (Table 4). The likelihood of owning a single breed decreases in flocks above 100 or more sheep in size, with the greatest percentage of flocks in this range comprising four or more breeds. There was an association between feed type and flock size ($P = 0.046$; Table 5); the most common feed types used across all flock sizes are hay and concentrate, with pasture as the third most common feed type used across all flock sizes, though the greatest disparity between these three was observed among flocks with 11 to 50 sheep (Table 5).

Association between flock size by flushing ($P = 0.381$), flock size by number of feed types ($P = 0.641$), flock size by pregnancy confirmation method ($P = 0.273$), flock purpose by flushing ($P = 0.463$), and flock purpose by feed analysis ($P = 0.098$) was not found to be significant.

Although the majority of respondents do not perform feed analysis, of those that do, the greatest percent feed hay and/or concentrate (Table 6). This is likely indicative of these feeds being the most commonly fed, rather than a statistical likelihood that either will make it more likely for a producer to use feed analysis. The association between feed type used by producers and the source of feed information is complex, as there are many sources of feed information. In decreasing order, the most

Table 2. Association between feed information source and state¹

		State					
		Connecticut	Maine	Massachusetts	New Hampshire	Rhode Island	Vermont
Feed information source	Feed sales person	53.8	14.8	47.4	45.5	85.7	16.7
	Brochures	15.4	14.8	26.3	45.5	42.9	33.3
	Family	19.2	3.7	5.3	18.2	28.6	0.0
	Extension	15.4	33.3	10.5	9.1	0.0	33.3
	Experience	0.0	11.1	5.3	9.1	14.3	16.7
	Other producers	7.7	18.5	10.5	27.3	0.0	33.3
	Veterinarian	46.2	22.2	26.3	9.1	28.6	16.7
	Research	7.7	7.4	5.3	9.1	0.0	33.3
	Internet	19.2	18.5	15.8	18.2	0.0	0.0
	Other	15.4	7.4	10.5	36.4	0.0	16.7
Number of respondents		25	27	19	11	7	6

¹Data are represented as a percent of the number of survey respondents in each state. $P = 0.023$. Respondents could select multiple responses.

common (>20.0%) information sources for producers who feed hay are a feed salesperson, a veterinarian, and brochures; the most common sources of information for producers who feed concentrate are a feed salesperson and veterinarians (Table 7).

DISCUSSION

The current survey findings demonstrate some similarities between New England producers and U.S. producers included in the USDA surveys (USDA, 2011). In addition, with the recent shift in U.S. sheep operations to smaller flock sizes (73% of U.S. sheep operations are 20+ sheep; Miles, 2019), the findings from this survey will be applicable

Table 3. Association between flock purpose and flock size¹

		Flock purpose		
		Fiber	Meat	Milk
Flock size	1 to 10	9.4	13.5	0.0
	11 to 25	28.1	25.0	2.1
	26 to 50	14.6	19.8	0.0
	51 to 100	2.1	10.4	2.1
	100+	7.3	10.4	0.0

¹Data are represented as a percent of the total number of survey respondents (96). $P = 0.014$.

Table 4. Association between flock size and number of breeds owned¹

		Breed number owned			
		1	2	3	4+
Flock size	1 to 10	11.5	2.1	2.1	0.0
	11 to 25	30.2	3.1	3.1	1.0
	26 to 50	15.6	7.3	0.0	1.0
	51 to 100	5.2	3.1	2.1	1.0
	100+	1.0	2.1	3.1	5.2

¹Data are represented as a percent of the total number of survey respondents (96). $P < 0.001$.

Table 5. Association between flock size and feed type¹

		Feed type						Number of respondents
		Pasture	Hay	Concentrate	Haylage	Corn silage	Other	
Flock size	1 to 10	6	14	10	1	0	0	15
	11 to 25	9	36	29	1	1	5	36
	26 to 50	10	23	19	1	0	3	23
	51 to 100	5	9	9	3	0	1	11
	100+	6	10	9	1	2	0	11
Number of respondents		36	92	76	7	3	9	

¹Data are number of respondents. $P = 0.046$. Respondents could select multiple responses.

to smaller scale sheep productions across the United States.

Although New England producers are comparable with the national percentage of producers who use their flocks for meat production (79.2%), New England has a greater percentage of producers who produce wool (61.5%) than national producers, with a 40.6% overlap of New England producers who produce both meat and wool from their sheep flocks. Similar to the findings in New England, national sheep producers did not focus on milk production, and only a small percentage market milk from their flocks (USDA, 2011).

Based on respondent information, New England producers use a variety of feed, hay, pasture, and concentrate to feed their flocks. The USDA reported that 46.0% of sheep producers use open or fenced range and 75.8% of producers use pasture, with an additional 37.9% of producers feeding their flocks in drylots (USDA, 2011), whereas New England producers feed primarily hay and concentrate. In those states considered to represent the East by the USDA (IA, KY, MI, MN, MO, NY, OH, PA, VA, and WI), 80.3% of sheep producers use pasture to feed their flocks (USDA, 2011). This is not surprising considering that the climate of New England and other northern states is one in which pasture is typically not available for 5 to 8 mo of the year. The USDA survey did not collect information regarding the supplementation of hay and concentrate for flocks regardless of, or in relationship with, their use of pasture or range, and so a direct comparison of those feed types based on the current data and the USDA survey is not possible.

With the understanding of how maternal nutrition during gestation contributes to fetal programming (Reed et al., 2014; Hoffman et al., 2016) and how the various regions of the U.S. feed their flocks using different management practices, it is important to improve producer understanding of the nutrition they are providing to their breeding flocks. Feed analysis is a simple, inexpensive method for

improving diet calculations and ensuring that animals are being fed to meet their nutrient requirements. Due to the large number of producers that utilize hay and concentrate in New England, and other states in northern climates, there is a greater chance for variability in forage quality. Therefore, encouraging producers to analyze feed, especially hay and forage, will allow for modification of nutritional management throughout the year and prevent under- or overfeeding of ewes during gestation, which can lead to impaired growth and muscle development and metabolic dysregulation in offspring (Caton et al., 2009; Reed et al., 2014; Gauvin et al., 2020). For example, if forage quality is high, less grain may be needed, thereby reducing the cost to feed the flock and vice versa, when forage quality is low, producers can supplement with grain to avoid undernutrition during gestation. Based on the large number of producers that use concentrates as part of their nutritional management, it is not surprising that feed salesperson is one of the most used sources of feed information. Use of veterinarians, feed salespeople, and nutritionists, along with feed analysis, will ensure that producers are providing

optimal nutrients before, during, and after gestation based on ewe requirements (Van Saun, 2013). Educating producers about the value of this information, options for feed analysis, and how to utilize this information when there is variability in forage quality within and between years has the potential to improve production efficiency and decrease costs for these smaller flocks.

In the case of smaller flock sizes, it is possible for producers to more intensively manage flocks. For example, use of ultrasound to determine fetal number or timing of gestation would allow farmers to separate ewes based on day of gestation and litter size (Jones et al., 2016, 2017). Survey respondents demonstrated that a greater number of producers in New England use ultrasound than reported for U.S. producers. This is encouraging, but since less than one-third of producers use this method, there is a need for additional Extension engagement on this topic. Ultrasound machine portability has increased, resulting in a low cost per animal investment for veterinarians and producers (Jones et al., 2016, 2017), providing opportunities to further educate producers about management practices that can be utilized with this information. For example, separating pregnant ewes into groups based on litter size or time of gestation could prevent under- or overfeeding when this information is used to guide appropriate nutrition based on the physiological status of the ewe (Jones et al., 2016), which we and others have demonstrated leads to decreased growth, decreased muscle, increased fat, and altered metabolism in offspring (Du et al., 2014; Reed et al., 2014; Hoffman et al., 2016; Gauvin et al., 2020). These effects can lead to decreased product quantity and quality, poor health, and ultimately increased costs for the producer.

Table 6. Association between feed type and use of feed analysis¹

		Feed analysis	
		Yes	No
Feed type	Pasture	12.5	25.0
	Hay	20.8	75.0
	Concentrate	20.8	58.3
	Haylage	5.2	2.1
	Corn silage	1.0	2.1
	Other	3.1	6.3

¹Data are represented as a percent of the total number of survey respondents (96). $P = 0.003$.

Table 7. Association between feed type and feed information source¹

		Feed type					
		Pasture	Hay	Concentrate	Haylage	Corn silage	Other
Feed information source	Feed salesperson	13.5	39.6	36.5	1.0	3.1	4.2
	Brochures	8.3	24.0	18.8	2.1	0.0	3.1
	Family	5.2	11.5	10.4	0.0	0.0	2.1
	Extension	6.3	17.7	12.5	3.1	0.0	2.1
	Experience	2.1	5.2	5.2	1.0	1.0	1.0
	Other producers	6.3	14.6	10.4	0.0	0.0	2.1
	Veterinarian	9.4	28.1	26.0	4.2	1.0	1.0
	Research	4.2	8.3	5.2	1.0	1.0	2.1
	Internet	10.4	14.6	12.5	1.0	0.0	3.1
	Other	4.2	12.5	11.5	0.0	0.0	3.1

¹Data are represented as a percent of the total number of survey respondents (96). $P = 0.049$.

Overall, the survey findings demonstrate an opportunity to further educate producers about options to improve nutritional management of gestating ewes. Although the majority of New England sheep producers have an overall different profile and management style compared with larger producers in the rest of the country, intensively managed small-scale sheep production is not unique to New England based on the increasing number of smaller flock sizes across the United States, and educational resources available to meet the needs of these producers could be applicable outside our region. Findings from this inquiry will be used to develop future Extension outreach opportunities for New England and other smaller sheep producers across the United States.

SUPPLEMENTARY DATA

Supplementary data are available at *Translational Animal Science* online.

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Conflict of interest statement. None declared.

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