

a. Project Summary/Abstract

(i) Project Type: Research.

(ii) Summary Statement. This is a Research project.

Lamb production from pasture has great potential for expansion in the US Northeast. Combined with increased consumer appreciation for grass-fed animal products is an emerging demand for lamb by a rapidly increasing ethnic population. Since most sheep producers make frequent use of anthelmintics, resistant populations of gastrointestinal parasitic nematodes are now common. Although most conventional sheep producers believe that gastrointestinal parasites cannot be controlled with grazing management alone, preliminary studies with the sheep flock on the WVU Organic Research Farm gave favorable results. Following 5 years of observations we now propose to test protein supplementation of periparturient ewes, forage allowance and creep grazing of lambs as management regimes for the control of *Haemonchus contortus* (the most prevalent and lethal of the internal parasites for sheep) in lambs. In 2005 we compared 3-, 4-, 5- and 6-days of occupancy as part of pasture management to control *Haemonchus contortus*. In 2006 we supplemented periparturient ewes (2 wk before and 1 wk after lambing) with a high (18%) or low (12%) protein diet (fed at the rate of 270 g per head per d on a DM basis), introduced a creep gate and increased forage allowance (>2x the daily forage DM intake per animal). In spite of the fecal egg count being relatively high (>1000 egg/g), creep-grazed lambs showed no symptoms of nematode parasitism. Furthermore, the packed cell volume was within range for a normal lamb (30 - 33%), and daily gain was >150 g/d at weaning. The FAMACHA scores were between 2 and 3, with >50% of the lambs scoring a 2 or better indicating that the lambs were resilient to *H. contortus* parasitism (if score is greater than 3, dosing is recommended for lambs). Further testing of forage allowances and creep grazing of lambs born of protein-supplemented ewes in a replicated trial is essential to allow us to provide recommendations on the effectiveness of using grazing management alone to control *Haemonchus contortus*. Therefore we propose to randomly assign 64 ewes and their approximately 96 lambs to four replicates each of four treatments, two forage allowances (2.5x or 1.5x the daily forage DM intake) with creep or no creep in a replicated study. Animals will occupy a paddock for 7 days and each paddock will be rested for 28 days. This grazing management will assure that the pasture will have infective stage larvae. All animals will be weighed, sampled for feces and blood, and scored for body condition (ewes only) and anemic status, at start of experiment (early April), at weaning (late June), in August and late in October. Treatments will be compared using body weight changes, fecal egg counts, packed cell volume, body condition score (ewes) and FAMACHA scores. Forage allowances will be controlled by adjusting paddock area weekly. The experiment will be repeated a second year to evaluate year-to-year consistency of results. This field experiment, combined with experiments already conducted, will result in grazing management recommendations for both conventional and organic sheep producers in the US Northeast. We expect to provide a solution to deal with *Haemonchus contortus* parasitism using non chemical means.

Project Narrative

Title: Immune status of lambs, born of protein-supplemented periparturient ewes and creep-grazed in spring, against *Haemonchus contortus*

(i) Problem, Background and Justification

Problem:

Sheep production has potential in the NE because it relies on grassland. Not only are large areas of grassland available in the region but, there is an emerging appreciation for grass fed animal products and ethnic demand for lamb, mainly from Middle Easterners, Hispanics, Greeks and Caribbean Islanders, (Stanton, 2000; Jones, 2004; Larson and Thompson, 2004). Gastrointestinal nematode infection in grazing sheep is a universal problem limiting sheep production. Conventional sheep production assumes that synthetic anthelmintics are required, at least in small amounts, on a regular basis, and the majority of recommendations for internal parasite control in the past 50 or so years include grazing management only as an aid to synthetic anthelmintics. Sheep producers spend several million dollars each year to clinically manage this and related internal parasites (Larsen et al., 1995). However, dependence on synthetic anthelmintics has become a critical issue due to buildup of resistance (Van Wyk and Malan, 1988; Overend et al., 1994; Vanimisetti et al., 2004). In addition, organic production methods must rely on management to adhere to the National Organic Rule that prohibits use of synthetic materials, except in isolated cases.

A fresh approach to internal parasite control is required, one that will not only provide a means for conventional producers to rely less on synthetic products but will also support organic sheep production. This fresh approach is a systems approach - emphasizing animal and grazing management to take advantage of natural immunity as well as animal resilience. The WVU organic research farm, started in 1999 and certified in 2003, offers the opportunity to conduct such research. The following proposal will use this farm and the flock of sheep managed under organic rules since 2001.

Adult nematodes reside in the host animal, mainly along the gastrointestinal tract. Eggs laid by these adult nematodes are excreted in the feces onto pasture. Under optimum weather conditions the eggs hatch and the resulting larvae undergo further development reaching the third stage (L₃), the infective stage, within 4 to 6 days. Once infective larvae (L₃) are ingested along with the forage material by the animal, they undergo further development to L₄ which can mature to the adult stage and start laying eggs (Skinner and Todd, 1980; Hendrix, 1998). Development of L₄ in the animal may be inhibited or arrested if conditions are unfavorable. The phenomenon of inhibited or arrested growth of the L₄ stage is common and is due to seasonal climatic conditions and host resistance (Eysker, 1993; Waller et al., 2004).

Gastrointestinal nematodes of economic significance for sheep are the trichostrongylid nematodes including *Haemonchus contortus* (*H. contortus*), *Ostertagia* (*Teladorsagia*) *circumcincta* and *Trichostrongylus colubriformis*. *Haemonchus contortus*, commonly referred to as the “barber pole worm,” “stomach worm”,

“wireworm” or “bankrupt worm” (Levine et al., 1974, 1976; Zajac et al., 1992) is the most common and most important in the northeastern region of the US. This blood-sucking parasite pierces the lining of the gastrointestinal tract, causing blood loss, anemia, and poor growth (Olsen, 1974; Hendrix, 1998). Monitoring programs rely on clinical symptoms e.g. pale color of mucous membrane, edema or bottle-jaw, severe loss of condition, diarrhea or on fecal egg counts.

Young lambs are highly susceptible whereas older sheep can develop immune system responses that allow them to tolerate low levels of infection. Sheep exposed to parasites will, to a certain degree, be able to inhibit parasite development and egg-laying, whereas sheep imported from areas free of the parasite may have less resistance than sheep produced on lightly infested pastures (Whittier et al., 2003).

Expression of immunity by the susceptible animal is paramount in dealing with nematode parasitism. Expression of immunity requires elevated levels of metabolizable protein because many components of the immune system (immunoglobulin, mucoproteins and products of inflammatory cells) are proteinaceous in nature; in addition, metabolizable protein is needed for protein synthesis to balance losses that occur during parasite infections (Houdijk et al., 2000). Thus, protein nutrition ought to reduce the penalty placed on the immune functions of the periparturient ewe, and, by extension that of the lamb. A high level of dietary protein benefits animals with established parasitic infections resulting in an improvement in their clinical condition, a reduction in fecal egg count and increase in resistance to re-infection compared to animals on a basal diet (Laurence et al., 1951; Brunson, 1964).

Coop and Holmes (1996) reported that periparturient ewes supplemented with a high protein diet (120 to 190 g crude protein (CP)/kg DM) compared to a low protein diet (60 to 88 g CP/kg DM) increased the rate of acquisition of immunity and resistance to re-infection, but not the initial establishment of nematode infection. Kahn et al. (2003) concluded that protein supplementation (250 g/d cotton seed meal) of periparturient Merino ewes either selected for increased resistance to *H. contortus* or at random increased resistance to nematode parasites. In the Kahn et al. (2003) study, the benefits of periparturient supplementation in lowering the rise in fecal egg counts were extended for up to 10 weeks after supplementation ended.

Coop and Kyriazakis (1999) have argued that animals give the highest priority to the allocation of scarce nutrients for maintenance functions and reproductive effort (developing conceptus and mammary gland); immune functions seem to have a relatively low priority. Although immune functions have been regarded as part of maintenance, evidence now suggests that at least some aspects of immunity are sensitive to nutrient supply (Coop and Kyriazakis, 2001). Houdijk et al. (2000, 2001) concluded that protein supplements with up to 250 g cotton seed meal reduced fecal egg count and worm burden, and increased the concentration of globule leukocytes in the abomasal mucosa of periparturient ewes, the response being greater for single-rearing than twin-rearing ewes.

Most work reported in the literature has concentrated on the immune response to gastrointestinal parasites of periparturient ewes fed supplemental protein. There are no reports examining the immune response of lambs born of protein-supplemented ewes, and how grazing management may affect that response. Exposure of lambs to infective nematode larvae can be reduced by allowing the lambs to graze ahead of the ewes (creep-graze) and by increasing herbage allowance (how high in the vegetation animals eat).

Most conventional sheep producers use various anthelmintics to control internal parasites in sheep. While anthelmintic use often emphasizes regular treatment of lambs, de-worming of older sheep, annually or more frequently, is also commonly practiced. However, overuse of anthelmintics can lead to development of resistant nematode populations, and resistance to anthelmintics is now common (VanWyk and Malan, 1988; Overend et al, 1994; Vanimisetti et al., 2004). Thus, integrated programs combine strategic use of anthelmintics with a “safe” pasture concept, in which the number of infective larvae is reduced by haying, grazing with non-host livestock species or cultivation and re-planting of pastures, before allowing susceptible sheep to graze (Whittier et al., 2003). In organic systems, sheep producers lack effective chemotherapeutic remedies since synthetic anthelmintics are not permitted and approved natural materials are not always effective. Allen (1998) found no effective parasiticide to control parasites for organic lamb production; none of the materials tested, including an herbal mixture, garlic, diatomaceous earth or pyrethrum, were found to reduce parasite infection of lambs.

An alternative strategy of controlling nematode parasitism in sheep is by assuring that they are exposed to low levels of infective larvae while maintaining effective immune systems. Since lambs are more susceptible than ewes to rapid build up of parasites, exposing them to low levels of infection can possibly be achieved by grazing management, specifically by creep grazing and increasing herbage allowance. Although some reports, e.g. Levine et al. (1976) are critical of the role of pasture management in the control of nematode parasitism, several aspects of grazing management have either not been examined or have not been examined as part of an integrated system. While various rotational grazing managements have been tested (Levine et al., 1976) forage allowance (forage mass available to an animal per day) was neither measured nor controlled. Since forage allowance determines how closely animals graze to the ground and because infective larvae originate on the ground (from the feces) (Skinner and Todd, 1980), we hypothesize that the closer to the ground the animals graze the more infective larvae they are likely to ingest. This aspect of grazing management may be a key factor in controlling exposure of lambs. With creep grazing we further hypothesize that lambs would probably ingest the fewest infective larvae because they would access the tallest herbage since they would be grazing ahead of the ewes. In addition, creep-grazed lambs have the advantage of selecting the highest quality forage, thus, the level of nutrition obtained should support rapid growth in lambs, providing the base for development of the desired immune status against *H. contortus* parasitism.

Development of clinical symptoms of parasitism in sheep is complicated by variation in dose of infective larvae, levels of immunity, nutritional status of sheep and a variety of environmental factors. Lambs grazing heavily contaminated pastures may build up parasite loads to lethal levels within a few weeks. Lambs may tolerate low levels of infection, and develop higher levels of immune system response about 2 to 3 months after initial infection, leading to a sharp reduction in egg production by female worms (Soulsby, 1965). This immunity may inhibit establishment of newly ingested larvae, even when sheep are subsequently exposed to high levels of infective larvae.

Background:

The WVU Organic Research Farm maintains an active Grower/Producer

Advisory Committee which participates in setting research priorities. A mail survey was sent in December 2004 to a select group of 18 growers from West Virginia, Maryland, and Pennsylvania who had previously expressed interest in the project. A follow-up meeting was held January 8, 2005 to help clarify research needs and to explore new topics not addressed in the initial mail survey. Further, a number of sheep producers visited the Organic Research Farm in 2005/2006 during the grazing season and expressed the desire to have some aspects of increasing the immune status of lambs investigated, and that formed part of our basis for this proposal.

Livestock health maintenance practices were among the highest ranked needs of organic livestock growers in our survey. While the development of herbal remedies and worming treatments would be valuable, some growers expressed skepticism regarding their efficacy. Disease prevention is consistent with the organic ideal, as serious infestations require treatment of the animals with conventional medications to prevent needless suffering, and consequent loss of organic certification for those animals. Protein nutrition of the periparturient ewe and grazing management of the lamb represent a scientifically sound practice, based on the inherent biology of the parasite and attendant immunity, which could lower the doses of anthelmintics administered in conventional systems and simultaneously eliminate the need for using synthetic medications (prohibited in organic production), while improving pasture utilization and productivity.

Ongoing and Recently Completed Significant Activities at WVU Organic Research Farm

A flock of 30 ewe lambs (Merino x Dorsett) and a ram (Suffolk) were introduced to the Organic Research Farm in 2001. The first lamb crop was produced in 2002. Since the emphasis at that time was to institute a single management, the literature was searched to find a grazing management to control internal parasites. No research based recommendations were found that did not depend ultimately on prohibited anthelmintics. To find original research on internal gastrointestinal nematode life cycles we went back to work of Veglia (1915). The key findings from Veglia's (1915) work was that upon excretion in the feces *H. contortus* eggs hatch and develop to the L₃ stage, the infective stage, within no less than 4 days under lab conditions. Consequently we decided upon a grazing management employing rotational grazing to determine whether Veglia (1915) findings would apply under field conditions. This management consists of dividing the grazing area into paddocks, allowing animals to occupy one paddock for no more than 3 days and not returning them for 56 days. In this way we hoped to keep the lambs from acquiring a heavy infection of parasitic nematodes. There were no problems with the first and second lamb crops. However, in the third and fourth crops we had to use synthetic anthelmintics, once, for less than one quarter of the animals. We found that more lambs on one of our experimental treatments had to be dosed than the others. These treatments differed in stocking density that was calculated to attain a certain level of soil fertility i.e. high = 10 ewes/16 lambs and low = 8 ewes/12 lambs per ha; more lambs were dosed in the high stocking density group compared to the low density. In addition, in both 2004 and 2005 when we had to treat some lambs for internal parasites we did not follow our grazing management i.e. 3 days paddock occupancy and >56 days pasture rest all season long. Thus, some of the problems in those years might have been prevented by grazing management.

We completed, in 2005, a field trial on just one aspect of grazing management. This aspect was a comparison of days of paddock occupancy. If animals could be allowed to remain in a paddock for more than 3 days, labor and fencing costs would be reduced. We compared 3-, 4-, 5-, and 6-day paddock occupancy during the spring. We found no treatment effects on fecal egg counts, however, weight gain of lambs was lower ($P = 0.07$) in the 6-day occupancy than in the other lengths of occupancy. We concluded that paddock occupancy of up to 5 days would not have much effect on parasitism, but that a 6 or more day occupancy could lead to infective larvae being present before the end of the occupancy period.

In 2006 we supplemented periparturient ewes (2 wk before and 1 wk after lambing) with a high (18%) or low (12%) protein diet (fed at the rate of 270 g per head per d on a DM basis), introduced a creep gate and reduced the stocking density to 8 ewes/13 lambs for high and 7 ewes/10 lambs per ha for low stocking density. We continued to rotationally graze with a 3 day occupancy followed by at least 56 day pasture rest. In spite of the fecal egg count being relatively high (>1000 egg/g), creep-grazed lambs showed no signs of nematode parasitism and other parameters measured. The packed cell volume was within range for a normal lamb (30 - 33%), daily gain was >150 g/d at weaning. The FAMACHA scores were between 2 and 3, with $>50\%$ of the lambs scoring a 2 or better (indicating that the lambs were resilient to *H. contortus* parasitism; if score is greater than 3, dosing is recommended for lambs). The name of the chart, FAMACHA, is derived from the acronym of the originator of the idea, Dr. FAffa MAIan CHArt (Bath et al., 1996). The chart is based on the principle that the color of mucous membranes is correlated with the anemia situation of an animal. The five eye-color categories (1 to 5) depict varying degrees of anemia i.e. from non-anemic (red = 1) through anemic to severely anemic (pale = 5).

In the present proposal we will test two aspects of grazing management that could reduce the number of infective larvae ingested by grazing lambs, herbage allowance and creep grazing. Neither of these approaches has been adequately covered in recent literature. Since our preliminary observations are encouraging we wish to carry out replicated experiments which are the subject of this proposal. Our approach is to develop a grazing management that will allow lambs to attain resilience and build up resistance against *H. contortus*. We propose to accomplish this using a grazing management which will result in the presence of some infective larvae. We propose to limit ingestion of large numbers of these larvae by allowing lambs to graze just the upper portion of the sward by adjusting herbage allowance and using a creep gate. A second and equally important aspect of management to control internal parasites is to maintain the immune system of both ewes and lambs. We propose to do this by assuring that periparturient ewes have an adequate supply of protein in the diet. Lambs will benefit from increased passive immunity and will build up their own immunity with a high level of nutrition (by allowing them to selected high quality forage ahead of the ewes).

Justification:

Sheep production is ideally suited to small hill land farms where grassland is an appropriate land use. In the US northeast, demand for lamb and mutton is increasing, due, in part to an increase in ethnic populations (Stanton, 2000; Jones, 2004). This demand will persist for the foreseeable future because lamb production will continue to

be limited by gastrointestinal nematode infection. In conventional systems, the universal and the primary method of dealing with such infection is the use of anthelmintics; synthetic products are prohibited in organic production. However, buildup of resistance to synthetic anthelmintics is a critical emerging issue. Therefore, internal parasite control using management alone, the goal of this proposal, will not only have a major impact on conventional and organic sheep production but also benefit the environment because use of synthetic products would considerably decrease.

The long-term goal of research on sheep parasites at the WVU Organic Research Farm is to develop effective grazing management practices for satisfactory control of internal parasites without use of synthetic anthelmintics. Supplementation of ewes before and after lambing, rotational grazing of sheep with proper stocking rate and creep grazing are readily adoptable managements for sheep producers. Recommendations of this study will be disseminated to sheep producers and other stakeholders at our Field Days, internet web pages, and research and extension publications.

(ii) Objectives and Anticipated Impacts.

Objectives:

Continued use of anthelmintics to control gastrointestinal nematodes in sheep may not be sustainable in the long run due to development of resistance. In addition, the National Organic Program prohibits the use of synthetic anthelmintics for control of gastrointestinal nematode parasitism in sheep. Our experience indicates that using rotational grazing (3-day occupancy and >56 day pasture rest) alone to achieve such control may be too expensive for profitable lamb and wool production. We propose to use protein supplementation and grazing management to reduce the anthelmintic doses to a minimum in conventional systems and make organic lamb production profitable on Appalachian grassland. Consequently our proposal will address two objectives:

- a. Determine the effect of a supplemental protein diet fed to ewes during the periparturient period (3 wk before and 2 wk after lambing) on the immune status of ewes and their lambs during the subsequent grazing season.
- b. Determine the effect of creep grazing of lambs and herbage allowance on lamb performance (weight gain, immune status) and fecal egg count of *H. contortus*.

Anticipated Impacts:

Safeguarding human health and environment:

Ivermectins are relatively safe compounds as indicated by their widespread use for treatment of livestock, pet, and human parasites. The incidence of adverse reaction in sheep reported to the manufacturer after sale of hundreds of millions of doses has been 0.00002 % (Pulliam and Preston 1989). Nevertheless, adverse environmental effects have been reported. Ivermectin has a short half-life in the animal and the bulk of the drug leaves the body and enters the environment via fecal excretion. Some fresh water invertebrates and fish are highly sensitive to Ivermectins, as are certain species of dung-feeding insects which are important in breakdown of fecal pats in pastures (Halley et al. 1989; Roncalli, 1989; Errouissi, et al. 2001). The increased persistence of fecal pats from treated animals increases the risk of erosion and transport to surface waters.

Pasture management to control internal parasites will also be good practice for soil conservation. Sheep producers will be encouraged to pay more attention to how pastures are managed, overgrazing will be reduced.

Economic benefits:

Much of the northeastern US has small farms and grassland. There is potential for increased sheep production to meet expanding demand from ethnic groups. The most rapidly expanding aspect of organic food production is in livestock. Our research will provide economic benefits to small grassland farmers producing sheep conventionally and organically. Conventional producers will be able to produce with reduced pesticide use. Many sheep producers are skeptical of being able to produce organic lamb because they believe anthelmintic use is unavoidable. Our results will give them a less-cost alternative.

Contribution to IPM strategies:

Our objective is to develop integrated management of pasture and animal without use of pesticide to control internal parasites. On the one hand we propose to increase natural immunity of the animals and on the other to reduce the exposure to the parasite such that the animals develop natural immunity.

(iii) Approach and Procedures.

Experimental Design:

The experimental design will be a randomized complete block with two factors during the periparturient period (high and low CP) and four factors during the spring grazing period (high and low forage allowance; creep and no creep). During the periparturient period, 64 pregnant ewes will be divided at random into two treatment groups, replicated four times. One group will receive a high protein (18%) and the other a low protein (12%) supplement diet fed at the rate of 275 g.head⁻¹.d⁻¹ on a DM basis for a period of 5 wk (3 wk before and 2 wk after lambing). During the spring grazing period, the 64 ewes that were protein-supplemented and their approximately 96 lambs will be assigned at random to 4 treatment groups factorially arranged and replicated four times with equal numbers of ewes and lambs. Each treatment/replication will have 2 high protein- and 2 low protein-supplemented ewes, and their lambs. Two forage allowances (2.5x or 1.5x the daily DM intake) will be compared with and without creep grazing.

Methods:

The experiment will be conducted at the West Virginia University Organic Research Farm, Morgantown, WV. The experiment will start in March 2007, be carried out for one growing season and repeated in 2008. Soils in the experimental area are in the Clarksburg, Dormont and Holly series. The topography is rolling with a slope of 0 to 20%. Pastures on this farm are mixed swards of tall fescue (*Festuca arundinacea* L.), orchardgrass (*Dactylis glomerata* L.), Kentucky bluegrass (*Poa pratensis* L.) and other cool season grasses; legumes present are predominantly red clover (*Trifolium pretense* L.) and white clover (*T. repens* L.). All pastures contain some forbs.

During the periparturient period, supplementation will start 3 weeks before

expected lambing date. Both the high and low protein diets will provide 120% and 80%, respectively, of daily requirements of metabolizable protein (MP), that part of protein that is absorbed and is available for use at the tissue level. The MP amounts, calculated using Burroughs' metabolizable protein system (Burroughs et al., 1974), will be determined on the assumption that the pregnant ewe will have a litter weight of 7 kg (lambing rate = 150), no maternal body weight (BW) gain and 14.3 g MP per day for wool growth. In addition, it is assumed that the lactating ewe will produce 2.5 kg milk per day, have mean BW loss of 100 g per day and require 10.2 g MP per day for wool growth. The basis for the foregoing assumptions is the recommendations of Agricultural and Food Research Council (1993).

The forage allowance treatments will be provided by varying the area available at the start of grazing each paddock. Height of the forage will be measured and the required area of pasture calculated to provide the treatment forage allowance. The creep treatments will have a creep gate in the fence to the next paddock to be grazed. This will allow lambs to pass through but not the ewes.

During the spring grazing period, animals will be moved every seven days from one paddock to the next. After 2 grazing cycles in spring each paddock will be mown at 10-15 cm to remove reproductive tillers. Cut material will not be removed. The grazing system will be 7-day occupancy and 35 days rest. This should provide conditions for presence of infective stage worms to test the treatments. The experiment will start April 15 and continue for two grazing cycles. At the end of the second cycle lambs will be weaned (approximately 90 days of age) and removed to aftermath hayfields, and pasture fields with rest days >56, where they will be on 3-day rotations until removed from the experiment in late October. On pasture fields rested for >56 days, lambs will graze ahead of the ewes to ensure that lambs have opportunity for selective grazing. The latter management will ensure lambs have access to relatively high quality forage to maximize weight gain, and clean forage to prevent acquisition of new loads of parasites.

Ewes will be weighed at day 21 before lambing, day 0 (within 12 hr of lambing), at start of grazing cycles (Apr 15), at weaning and at breeding (late Oct). The lambs will be weighed at day 0 (within 12 hr of birth), at start of grazing cycles (mid Apr), at weaning (late June), late Aug and when they are taken off experiment (late Oct). Ewes will be scored for body condition by lumbar palpation at weighing. Fecal samples will be taken directly from the rectum of each ewe weekly during the periparturient period; lambs will be sampled for fecal eggs to coincide with weighing, starting Apr 15. Fecal egg count will be determined using a modified floatation method (Christie and Jackson, 1982).

Blood samples will be taken weekly during the periparturient period and thereafter when BW measurements are taken, from the jugular vein into heparinized tubes that will be centrifuged for 20 min at 2000 x g and hematocrit count (packed cell volume) conducted.

The anemic status of animals will be monitored using a FAMACHA[®] chart at weighing. The name of the chart, FAMACHA, is derived from the acronym of the originator of the idea, Dr. FAffa MAlan CHArt (Bath et al., 1996). The chart is based on the principle that the color of mucous membranes is correlated with the anemia situation of an animal. The five eye-color categories (1 to 5) depict varying degrees of anemia i.e. from non-anemic (red = 1) through anemic to severely anemic (pale = 5). Those animals

considered severely anemic or in danger of succumbing to the effects of haemonchosis will be treated.

Herbage mass will be determined immediately before and after grazing each paddock using a pasture plate (Rayburn and Rayburn, 1998). Herbage nutritive value will be determined on hand plucked samples (to simulate what animals are eating) on each paddock before and after each grazing. These samples will be dried at 80°C for 48 hrs, ground to pass through a 1 mm screen and analyzed by NIRS (Windham et al., 1989).

Statistical Analysis:

Ewe data will be analyzed as a randomized complete block design, using analysis of variance (ANOVA). The treatment will consist of two levels of CP, and the response variable will be ewe immune status. Lamb birth weights will be analyzed as a split plot within a randomized complete block, also using ANOVA. Main plot treatment will be the two levels of CP, and subplot factors will be forage allowance and creep, with two levels each. Lamb body weights, packed cell volume, anemic status, and nematode egg counts will be analyzed in similar fashion to birth weights, with the exception that each of these variables will be measured 4 times throughout the study. These multiple measurements will be analyzed using a repeated measures component with the split plot design.

The results of this experiment, combined with our on-going crop/livestock systems research will allow us to make budgetary analyses. Our recommendations for economic conventional/organic lamb production will be readily implemented on the region's farms.

Timeline:

The experiment will be conducted at the West Virginia University Organic Research Farm starting in March, 2007 and will be repeated in 2008.

(iv) Evaluation Plans.

The objective will be evaluated using the sheep and lamb weights, and fecal egg counts. All management aspects of our research will be directly applicable in our own and farmer production systems in the northeast. Our recommendations can be implemented on both organic and conventional lamb producing farms. Organic sheep producers must have their sheep on pasture in order to meet the requirements of the National Organic Program rules and most conventional producers do likewise. Our recommendations will be easily implemented on the region's farms. The main issues will be costs and effectiveness. Our research will address both. The field work will be completed at the end of the growing season (October 2008). Results of the first year will be available by March 2008 and recommendations will be made by March 2009.

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Appendix

Results of CRIS Assisted Search on Immune Status of Protein-supplemented Periparturient Ewes and Creep-grazed Lambs against *Haemonchus contortus*

We used CRIS Assisted Search, search CRIS Full Text and entered phrases such as: protein supplementation of periparturient ewes relative to parasite control retrieved 0 records; creep grazing of lambs to control parasites in lambs retrieved 0 records; parasite control in sheep retrieved 2 records; *Haemonchus contortus* and *Teladorsagia circumcincta* retrieved 41 records, etc. The CRIS assisted search yielded summaries of on-going research work in the area of parasite control in sheep at various research institutions across the US. Some of the subjects are related to this proposal including the extent of anthelmintic resistance to *Haemonchus contortus*, test of breeds of sheep with marked resistance/immunity, test of non-anthelmintic products e.g. herbal plants, diatomaceous earth, etc. as alternative dewormers, discovery of parasite antigens that can induce immunity, identification of genetic markers associated with parasite resistance/susceptibility. There is also research investigating how to characterize and expand certain compounds exhibiting activity against nematodes leading to development of anthelmintics with a new mode of action. In addition, there are projects investigating integrated control programs using both traditional and novel approaches (sustainable agricultural systems) to control animal parasites. There are projects incorporating the FAMACHA system in clinical studies under various sheep managements, we propose to test the applicability of this system under our proposed management system (organic) during the first year of the experiment before reaching out to producers with our recommendations. There is no on-going research addressing the role of protein nutrition and creep grazing of periparturient ewes and lambs, respectively, on immune status against *Haemonchus contortus* in sheep as this proposal seeks to investigate. It is concluded from the CRIS search that the possibility or likelihood of our proposal duplicating any existing work is nil.

IPM
Regional Integrated Pest Management
Competitive Grants Program
Research Relevancy Statement

Name of PD: William B. Bryan

Institution: West Virginia University

Project Title: Immune status of lambs, born of protein-supplemented periparturient ewes and creep-grazed in spring, against *Haemonchus contortus*

Project Type: Research

Project Summary: Anthelmintics have been used for pasture lamb production for many years. Resistance to these anthelmintics is now common. There is rapid growth in the ethnic populations in the NE that demand lamb. The NE has many acres of pasture. Both from a cost and efficacy point of view pasture management needs to be reevaluated for parasite control. Sheep producers have become so dependent on synthetic dewormers that most believe pasture lamb cannot be produced without their use. However, experience over the past 6 years with our organic sheep flock has encouraged us to believe that grazing management alone can be used successfully to control internal parasites. Our research up to this point has been a comparison of crop livestock systems using the same pasture management. After the first two years we have had to treat about one quarter of our lambs each year with anthelmintics. However, in 2006 we used creep gates and did not dose any experimental lambs. Based on our experience we now propose to carry out an experiment comparing four grazing management systems for lambs. We plan to compare creep grazing and control at two levels of herbage allowance. These two aspects of grazing management have potential to reduce exposure of lambs to infective nematode larvae. In addition, we propose to feed ewes two levels of supplemental protein, 3 wk before and 2 wk after lambing. Increasing protein in the feed may increase immune status of both ewes and suckling lambs. Sixty four ewes and their approximately 96 lambs will be assigned at random to four treatments, two forage allowances (2.5x or 1.5x the daily forage DM intake) with creep- or no creep-grazing in a replicated study. Animals will occupy a paddock for 7 days and each paddock will be rested for 28 days. This grazing management will assure that the pasture will have infective stage larvae. All animals will be weighed, sampled for feces and blood, and scored for body condition (ewes only) and anemic status, at the start of the experiment (early April), at weaning (late June), in August and late in October. Treatments will be compared using body weight changes, fecal egg counts, packed red-blood-cell volume, body condition score (ewes) and FAMACHA scores. Paddock area will be adjusted weekly to maintain herbage allowance. This field experiment, will result in grazing management recommendations for both conventional and organic sheep producers in the northeastern US. We expect to provide an integrated animal-pasture management solution to *Haemonchus contortus* parasitism without anthelmintics.

Description of the problem, background, and justification: The most common and most important gastrointestinal parasite of economic importance for sheep in the northeastern region of the US is *H. contortus*, the “barberpole worm” also referred to as “stomach worm”, “wireworm” or “bankrupt worm”. This blood-sucking parasite pierces the lining of the gastrointestinal tract, causing blood loss, anemia, and poor growth. Monitoring programs rely on clinical symptoms e.g. pale color of mucous membrane, edema or bottle-jaw, severe loss of condition, diarrhea or by fecal egg counts. Young lambs are highly susceptible whereas older sheep can develop immune system responses that allow them to tolerate low levels of infection. Sheep exposed to parasites will, to a certain degree, be able to inhibit parasite development and egg-laying. A non pesticide approach to internal parasite control in sheep is to expose young lambs to low levels of infective larvae while boosting their immune response. Management and diet can be used in this integrated approach. Protein supplementation of ewes before and after lambing can improve the immune status of their lambs. Herbage allowance and creep grazing are pasture management strategies to reduce exposure of young lambs to infective larvae.

Sheep production has potential in the NE because it relies on grassland. Not only are large areas of grassland available in the region but, in addition, there is an emerging appreciation for grass fed animal products and ethnic demand for lamb, mainly from Middle Easterners, Hispanics, Greeks and Caribbean Islanders. In the Livestock and Field Crop Working Group IPM priorities for 2006 integrated management of significant pests affecting pastures was given high priority. Most grazing management research for parasite control does not control forage allowance. Simply rotating pastures is not adequate. Since gastrointestinal nematode infection in grazing sheep is universal most producers use anthelmintics on a routine basis, adding to yearly costs. Of greater concern, routine dependence on synthetic anthelmintics has resulted in buildup of resistance. Most sheep producers are skeptical when we present our experiences with organic lamb production. They are so accustomed to using anthelmintics that it will take some well controlled experiments to show that management alternatives are available.

We are not seeking multi-state involvement now. This is partly due to skepticism on the part of potential collaborators. It should be noted, however, that, as far as we know, the only organic experimental flock in the northeast is at WVU. We think that our proposed experiment needs to be carried out first to establish our theories. If successful our results will be applicable throughout the NE, both for conventional and organic producers.

Project objectives and anticipated outcomes

- a. Determine the effect of a supplemental protein diet fed to ewes during the periparturient period (3 wk before and 2 wk after lambing) on the immune status of ewes and their lambs during the subsequent grazing season.
- b. Determine the effect of creep grazing of lambs and herbage allowance on lamb performance (weight gain, immune status) and fecal egg count of *H. contortus*.

This project will provide integrated non chemical systems of internal parasite control of lambs. It will facilitate production of organic lamb and wool which has potential in the northeast US. Recent market surveys show that the fastest growth in organic food production is in livestock products. Organic sheep production is ideally suited to small grassland farms, predominant in the northeast. Integrated use of pasture

will contribute to sustainable rural communities. For producers wishing to continue using anthelmintics we will be able to recommend reduced frequency of their use, contributing to a reduction in buildup of parasite resistance.