cattle. Meta-analyses methods were applied to 15 experiments with Nellore cattle. All trials recorded daily DMI from Nellore bulls and steers fed in individual pens, group pens or electronic Calan gate feeders. Only trials conducted in research centers were used to ensure an adaptation period that would minimize compensatory growth effects. Among the 176 experimental units, feeding periods varied from 62 to 277 d and NE_m concentration ranged from 1.01-1.77 Mcal/kg (51.2-74.5% TDN). NE_m intake per unit of shrunk $BW^{0.75}$ was analyzed using mixed model procedure from SAS. Random experiment effect, fixed sex effect (castrated and intact), and continuous variables (dietary NE_m concentration, NE_m^2, and days on feed) were included in the model. The suggested new equation is:

$$DMI (kg/d) = (SBW^{0.75} * (0.2068 * NE_m - 0.03958 * NE_m^2 - 0.07553)) / NE_m$$

The sex effect was not significant (P>0.05), maybe because steers tended to be older than bulls. DMI predicted from the Zebu data and the NRC equations showed that at low dietary NE_m concentrations (1.0-1.4 Mcal/kg), *B. indicus* have higher intakes than *B. taurus*. Conversely, *B. taurus* cattle showed increasingly greater DMI than *B. indicus* when NE_m was above 1.4 Mcal/kg. Using an independent data set from Nellore young bulls to validate the new equation, we obtained less overprediction bias than the NRC 1984 and 1996 equations (1.3% vs. 6.1 and 3.2%). Also, actual intakes and the predicted estimates did not differ using *t* test (P>0.10). We conclude that our equation predicted DMI from *B. indicus* more accurately than NRC equations.

Key Words: Beef Cattle, Dry Matter Intake, Nellore

221 Use of chromic oxide and alkane controlled release capsules to estimate intake and digestibility by beef steers. I. Lopez-Guerrero*, J. Fontenot, and G. Scaglia, *Virginia Polytechnic Institute and State University*, *Blacksburg*.

Two digestion trials were conducted to evaluate chromic oxide and alkane controlled release capsule (CRC) technique to estimate DM fecal output (DMFO), intake (DMI), and digestibility (DMD) by steers. For the first trial, six Angus crossbred steers (BW = 328 ± 31 kg) were allotted at ramdom to individual pens and fed tall fescue hay at a level of 1.5% BW. Seven days before the collection period, the steers were dosed with two intraruminal CRC, one containing Cr_2O_3 and another containing a mixture of C_{32} and C_{36} alkanes. During the 7 d collection period, hay samples and feces were collected, mixed, and sampled twice per day. Statistical analyses were conducted using the mixed procedure of SAS. The results show that, actual DMI, DMFO, and DMD were 4.74 kg/d, 1.85 kg/d, and 61%, respectively. No differences were found among days in the recovery rate (RR) of alkanes (P ≥ 1.106) or Cr_2O_3 (P = 0.341). There was no difference between the actual and the estimated values of DMFO (P ≥ 0.315), DMI (P ≥ 0.381), and DMD (P ≥ 0.161), provided the RR of the respective marker was used as correction factor for the estimated values. However, estimates using Cr_2O_3 were more reliable than those obtained with alkanes. The second trial was conducted under grazing conditions. The procedures were basically similar to those used in the first trial. The main differences were that the steers (n = 5) were heavier (BW = 382 ± 16 kg) and grazed low-endophyte fescue pasture, and only Cr_2O_3 CRC was used to estimate DMFO and DMI. Forage allowance was between 12.48 and 14.81 kg of forage DM/100 kg BW. The RR of Cr_2O_3 was not different among days during the collection period, but the mean was unusually high (189%). Nevertheless, actual and estimated DMFO and DMI were not different (P ≥ 0.846) when the RR was used to correct the calculations. Under the conditions of these trials, DMFO, DMI, and DMD can be reliably estimated using Cr_2O_3 CRC if an accurate RR can be obtained.

Key Words: Beef Steers, Markers, Dry Matter Intake

222 The effect of silage microbial inoculant with and without additional preservatives on the aerobic stability of maize silage. S. Hall[1], P. Moscardo Morales[1], J. K. Margerison*[1], D. Wilde[2], P. Light[2], M. Smith[2], and N. Adams[2], [1]*University of Plymouth*, *Plymouth, Devon, UK*, [2]*Alltech (UK) Ltd*, *Stamford, Lincs, UK*.

The effect of inoculating maize silage with Maize-all GS (inoculant) and Sil-all Fireguard (inoculant and preservative) on silage aerobic stability was measured. Forage maize (DM 29 (±1.29)) was divided into sub-samples (300 kg FM) and treated with; No additive (0), Sil-All fireguard (0.5g/100kg FM (SAFS), Maize All GS 1g/100kg FM (MAS). Nine experimental silos lined with polythene had 75 kg/m2 applied and were stored (17 to 20 ° C) for 30 days. On opening 20 holes were made (0.5 cm d), samples were wrapped in polystyrene. Lactic acid (g/kg) at 48 to 168 h 0 -37.2 b,SAFS -78 a, MAS -52.5 a (11.9) and 0 to 168 h -0 53.2 b,SAFS -72.4 a, MAS -64.2 a (5.56) reduced significantly more (P<0.05) with SAFS and MAS, while acetic acid (AA) (g/kg DM) at 0 to 48 h) declined more in 0 -8.2 c, least in SAFS 0.6 a, and -2.2 b in MAS (2.6) (P<0.05), but between 0 to 168 h AA were lowest in SAFS, 0 -14.6 b, SAFS -23.8 a, MAS -18.4 b (2.67) (P<0.05). Maximum pH was lowest in MAS, and not sigificatly different between SAFS and 0 (0 7.3 a, SAFS 6.7 b, MAS 7.4 a (0.22) and pH change 48 to 168 h was greatest in MAS, 0 3.3 b, SAFS 3.0 c, MAS 3.6 a (0.17) (P<0.05). Time to max. temp. (h) was greatest in SAFS (0 83.1 a b, SAFS 109.1 a, MAS 74.5 b (10.4) (P<0.05). Silage additives increased lactic acid and silage aerobic stability.

Sheep Species: Management of Gastrointestinal Nematodes in Sheep

223 Epidemiology of sheep gastrointestinal nematodes in the U.S. R. Kaplan*, *University of Georgia*, *Athens*.

There are many important diseases of sheep, but none are as ubiquitous or present as direct a threat to the health and productivity of sheep as gastrointestinal nematode (GIN) parasites. Control of GIN is therefore of primary concern in any sheep health management program. Well designed worm control programs must take into account many factors, the most important of which is the epidemiology and transmission dynamics of GIN in the particular locale of the farm. Because epidemiology differs greatly between regions, it is not possible to formulate broad-scale recommendations that are valid in all regions of the United States. In order to develop rational control plans for GIN, it is important to appreciate that there are numerous worm species that can cause disease in sheep, and optimal control strategies will differ among species. Fortunately, only a few species are highly pathogenic and of primary concern. Major pathogens include *Haemonchus contortus*, *Trichostrongylus colubriformis*, and *Teladorsagia (Ostertagia) circumcincta*. Other less common and usually less important species/genera include *Trichostrongylus axei*, *Nematodirus*, *Cooperia*, *Oesophagostomum*, *Trichuris* and *Bunostomum*. In virtually all instances infections will be mixed, with climate and season being the major factors influencing the relative percentages of the different species. In the warmer regions of the country, *H. contortus* is by far the predominant species with *T. colubriformis* the next most important. In cooler regions, *T. circumcincta* will be more of a problem, and there is a greater potential to have a mixture of all 3 primary pathogenic species. The less common species usually are not present in numbers sufficient to cause disease on their own; however, in certain situations conditions may allow large infection levels to develop which can produce serious outbreaks of disease. In the cooler regions of the country, GIN transmission is highly seasonal, whereas in the warmer regions, transmission of GIN may occur year-round. In this presentation, epidemiology of the major GIN pathogens will be discussed in relation to how this impacts the development of worm control programs.

Key Words: Gastrointestinal Nematodes, Epidemiology

224 Immunological aspects of nematode parasite control. J. Miller*[1] and D. Horohov[2], [1]*Louisiana State University*, *Baton Rouge*, [2]*University of Kentucky*, *Lexington*.

Gastrointestinal nematode parasitism is arguably the most serious constraint affecting sheep production world-wide. Economic losses are caused by decreased production, cost of prophylaxis, cost of treatment, and the death of infected animals. The nematode of particular concern is *Haemonchus contortus*. Severe blood loss can occur, resulting in anemia, anorexia, depression, loss of condition, and eventual death. The control of nematode parasites traditionally relies on anthelmintic treatment. The evolution of anthelmintic resistance in nematode populations threatens the success of drug treatment programs. Alternative strategies for control of nematode infections are being developed and one approach is to take advantage of the host's natural and/or acquired immune response. The host's innate natural immunity can be used in selection programs to increase the level of resistance in the population. Vaccination can also be used to stimulate/boost the host's acquired immunity. The induction of protective resistance is dependent on the pattern of cytokine gene expression induced during infection by two defined CD4+ T-helper cell subsets which have been designated either Th1 or Th2. Intracellular parasites most often invoke a Th1 type response and helminth parasites a Th2 type response. Breeds of sheep resistant to infection have developed resistance over a much longer host-parasite relationship term than short-term genetically selected resistant lines within breed. The immune components involved in these (similar/different) will be reviewed. The potential for using vaccines has been investigated, with variable results, for several decades. The few successes and potential new antigen candidates will also be reviewed.

Key Words: Sheep, Nematode, Immunology

225 Use of QTL to determine parasite resistance in sheep. N. Cockett*[1], S. Bishop[2], G. Davies[2], T. Hadfield[1], S. Eng[1], and J. Miller[3], [1]*Utah State University*, *Logan, UT*, [2]*Roslin Institute*, *Midlothian, UK*, [3]*Louisiana State University*, *Baton Rouge*.

Gastrointestinal parasites have a profound effect on sheep production. The identification of genetic markers for parasite resistance in sheep will be useful for establishing breeding schemes that select for parasite-resistant animals. A genome-wide QTL scan was implemented as part of a collaborative project with Louisiana State University, Utah State University and Roslin Institute, in order to identify chromosomal regions in the ovine genome that play a role in resistance to gastrointestinal parasites. A sheep population segregating for parasite burden (measured by fecal egg count or FEC for *Haemonchus contortus*) was constructed and included F2 offspring of F1 parents produced from Gulf Coast Native (resistant) and Suffolk (susceptible) crosses. Using selective genotyping of 50 microsatellite markers on the upper and lower 20% of the lambs, suggestive QTLs were identified on ovine chromosomes 1, 3 and 19. Additional markers in these regions were then genotyped across the full population. The most significant results were detected on chromosomes 1 and 19. A study conducted by Roslin Institute and Glasgow University using Scottish Blackface lambs identified several QTL associated with parasitic infection across four ovine chromosomes (2, 3, 14 and 20). These QTL were within chromosomal regions previously associated with immune function and cell growth and specialization. A study by AgResearch, New Zealand using a Romney sheep line selected for parasite resistance identified a QTL near the *IFN* locus. Using a population of feral, naturally infected Soays, a significant association was found between FEC for *Teladorsagia circumcincta* and alleles of the *IFN* microsatellite but not with alleles of flanking markers. These results provide additional support that a QTL for reduced FEC is segregating near *IFN*. QTLs associated with *Trichostrongylus colubriformis* resistance were reported by CSIRO, Australia on ovine chromosomes 1, 3, 6, 22, and 23, and QTLs associated with resistance to *H. contortus* were identified on chromosomes 1, 3, 6, 14 and 23.

Key Words: Sheep, Parasite Resistance, QTL

226 The effects of forages/plants on *Haemonchus contortus* infection. T. Terrill*, *Fort Valley State University*, *Fort Valley, GA*.

Parasitic nematode diseases of domestic livestock are economically important throughout the world. The use of medicinal plants to control parasitic infections in animals is a common practice with resource-poor farmers in Africa, India, Asia, and other regions. In areas where chemical anthelmintics are readily available, there has been a world-wide increase in anthelmintic resistance in sheep and goats, and this is fueling increased interest in use of medicinal plants to control parasites. Haemonchosis, caused by the blood-sucking activity of *Haemonchus contortus*, is widespread in the tropics and subtropics and is the primary contraint to profitable small ruminant production in these regions. Despite a large amount of anecdotal information on plants with anti-parasitic activity, there are relatively few scientific reports on efficacy of plants or plant compounds against *H. contortus*. There is growing evidence that some condensed tannin-containing forages in fresh and dried forms have activity against eggs, larvae, or adult forms of this parasite, but the mechanism of action is still uncertain. Incorporating medicinal plants into grazing/feeding systems to effectively control parasitic nematodes in sheep and goats is an elusive challenge, but positive strides in this direction are being made.

Key Words: Sheep, Goats, Gastrointestinal Nematodes

227 Biological control of nematode parasites in sheep. M. Larsen*, *Danish Center for Experimental Parasitology, The Royal Veterinary and Agricultural University*, *Frederiksberg C, Denmark*.

This short review will present data from the last 10-15 years on biological control of nematode parasites in sheep. These nematodes cause serious infections and production losses in sheep production worldwide. Together with other, sustainable tools (e.g. FAMACHA, grazing management strategies, smart use of drugs) to combat the parasitic nematodes, biological control (BC) by means of the fungus, *Duddingtonia flagrans*, has been investigated. The fungus produces a large number of spores (chlamydospores) that can survive through the gastrointestinal tract of ruminants. The principle behind BC is to manage the level of infective larval stages of the nematodes (e.g. *Haemonchus contortus*) on pasture to an extent that the impact on the animals is minimized. The effect of daily supplementation of fungal spores to grazing young sheep has successfully been investigated world-wide (Australia, USA, Europe, Asia) and in different climatic zones (temperate to tropical). Researchers have found significantly lower levels of larval development in fecal cultures, as well as larvae found on pasture in field trials where animals received spores from start of grazing and onwards for 2-3 months in temperate climate, and even up to three quarters of a year under tropical conditions. Besides the reduction in number of larvae, worm burden of tracer lambs has been significantly reduced, and not least, the productivity of lambs receiving fungus was significantly higher than the controls. Some parasites (lungworm and *Nematodirus* spp.) seem to be refractory to control by this fungus. Although daily supplementation would be possible for dairy producers, it is imperative for a more advanced formulation of the fungal spores to become available. One such solution could be a slow release device, by which one would overcome the potential difficulties in securing daily uptake by individual animals over an extended period. Also, such a technology would be user friendly and very flexible with respect to implementation in different management systems and climates.

Key Words: Biological Control, Sheep, Nematophagous Fungi