Australian Government

Rural Industries Research and Development Corporation

Travel Report: 10th International Congress of Asian-Australasian Association of Animal Production (AAAP) and the 2nd International Symposium on Recent Advances in Animal Nutrition

in New Delhi, India
September 20 – October 1, 2002

by Y. J. Ru

Presented to the Rural Industries Research and Development Corporation

September 2003

RIRDC Web Publication No: W03/117
RIRDC Project No: TA012-51

ISBN 0642 58683 7
ISSN 1440-6845

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Published on the web in September 2003

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TRAVEL REPORT SUMMARY

Yingjun Ru attended the 10th International Congress of the Asian-Australasian Association of Animal Production (AAAP) in New Delhi, India from the 23– 28 September 2002, and contributed 2 papers as a keynote speaker and chaired one session on less developed livestock species. The papers submitted were;

- Ru, Y. J., Peng, W. K., Kruk, J. A., Glatz, P. C., Fischer, M. and Swanson. K. (2002). Predicting crude protein content and *in vitro* digestibility of pastures for fallow deer using near infrared spectroscopy (NIR).

- Ru, Y. J., Glatz, P. C. and Wyatt, S. (2002). Energy requirements of 28-32 kg fallow weaner deer in southern Australia.

Yingjun Ru also attended the 2nd International Symposium on Recent Advances in Animal Nutrition prior to the conference on 22nd September 2002.

The main reasons for Yingjun Ru to attend the conference was to obtain information that would benefit the progress of his current RIRDC projects. In particular;
Communicate with international researchers on deer nutrition research to develop a better understanding of the differences in digestion physiology between deer and other ruminants.
Evaluate the potential to develop rapid feed evaluation systems for deer.
Discuss the current progress in the application of herbs, spices and botanicals for monogastrics to replace antibiotics in the feed.
Assess the current development in village poultry production systems in Asia.

The major benefits gained by Yingun Ru from attending the conference were as follows;
Outcomes of the deer nutrition research in Australia were discussed at length with overseas researchers. A number of areas have been suggested for further studies, including comparison of nutrient requirement between animal species, evaluation of alternative feed resources and the development of rapid feed evaluation systems.

Understanding of the digestive physiology of deer is essential for the development of feeding strategies. Research in this area is very active in India, but experimental protocols need to be improved.

Enzymes are used widely by the pig and poultry industries to improve feed utilisation efficiency. However, the application of enzymes is a hit or miss strategy. A great understanding is needed on the substrate of different enzymes and the chemical characteristics of feed grains for the successful application of enzymes in pig and poultry rations.

Despite years of research on natural products to replace the antibiotics, the animal responses to these products are inconsistent. Researchers agree that more materials, especially local materials should be further tested.

It has been demonstrated by overseas researchers that free range poultry or village poultry plays a significant role in the supply of animal protein to humans. There is a demand for free range products, especially these produced by local breeds. There is potential to improve the production of free range chickens by developing feeding strategies, assessing potential pastures and stocking rate and selecting proper breeds.

The variability in nutritive value of feed ingredients, especially by-products makes it hard to formulate ration to meet the nutrient demand by pigs and poultry. While Australian researchers are focusing on the development of rapid feed evaluation assays for cereals for pigs and poultry, overseas researchers are developing rapid feed assay for by-products such as soybean meals. However, more data is required before robust feed evaluation method can be developed.

SCHEDULE

September 20, 2002	Travel from Adelaide to New Delhi, India via Singapore
September 22, 2002	Attend the 2nd International Symposium on Recent Advances in Animal Nutrition
September 23–28, 2002	Attend 10TH International Congress of Asian-Australasian Association of Animal Production (AAAP) Present papers, chair a symposium on less developed livestock species, discuss feed evaluation, deer nutrition and monogastric nutrition research with colleagues
September 30, 2002	Travel from New Delhi to Adelaide via Singapore

REPORT OF TRAVEL

Purpose

Attend the 10th International Congress of Asian-Australasian Association of Animal Production (AAAP) in New Delhi, India from the 23– 28 September 2002

Attend the 2nd International Symposium on Recent Advances in Animal Nutrition prior to the conference on 22nd September 2002.

Present papers on current RIRDC projects; re nutrient requirement of fallow deer, and predicting nutritive value of pastures for deer.

Discuss deer nutrition research with overseas colleagues

Discuss with international researchers the current progress in the application of herbs, spices and botanicals for monogastrics to replace antibiotics in the feed.

Major Achievements

Yingjun Ru met with overseas colleagues and discussed issues associated with deer nutrition and feed evaluation. Asian colleagues agree that there are differences in feed utilisation efficiency between deer and other livestock species. Further development of rapid feed evaluation assays is required. Roseworthy research has already showed that potential of using near infrared respectroscopy (NIR) to predict nutritive value of annual pastures for deer and it has been suggested to validate this NIR assay with *in vivo* data.

Defining the nutrient requirements of these less developed livestock species is one of the key strategies for managing these animals under grazing conditions or in the village farming system. Research on energy requirement of deer in Roseworthy showed that caution needs to be used in the use of data generated from other countries or under different feeding conditions. The colleagues suggested that further comparisons between deer and other animal species such as sheep should be carried out.

With the EU ban of antibiotics in animal feed, European colleagues highlighted the use of herbs, spices and botanicals in monogastric feed as a replacement of antibiotics. The research in Europe and Asia showed inconsistent results with these natural herbs, spices and botanicals. More assessment of local materials needs to be conducted.

Yingjun Ru chaired a session on the genetics of less developed livestock species. This session covered deer, mithun, yak, donkeys, camel, jack and jannies. Delegates from a number of countries discussed; 1) present status and future prospects of conservation and management of yak and camel genetic resources, 2) the biochemistry of semen for jack and mithun and 3) the relationship between mineral concentration and infertility of jannies.

Free range poultry is playing a significant economic role in the economic in Asia due to its low operating cost. More importantly, consumers are demanding high quality chicken meat and egg from village poultry, where local breeds are dominant. In Australia, integrating poultry into farm cropping/pasture program was thought to be a useful approach to enhance free range production systems.

ISSUES AT THE CONFERENCE

The congress focused on many issues for livestock production. The theme of the congress was "Animal Production for Food and Environment Security".

Alternative feed resources for ruminants

Asian countries are focusing on the development of ruminants instead of pigs and poultry due to the limited supply of feed grains. However, feed resource is one of the key limiting factors for ruminant production in these countries where the pasture production is declining because of the over-grazing. Evaluation of legumes trees as feed for ruminants is under the way.

Researchers in Bangladesh assessed three legume tree forages, *acacia nilotica, albezia procera and sesbania acculeata*. The preliminary results showed that total tannins ranged from 2.6% to 13.6% and condensed tannins ranged from 0.07% to 11.8%, depending on the dry methods. More importantly the potential degradability measured using an *in vitro* method varied from 52% (*albezia*) to 85% (*sesbania and acacia*). However, the palatability of these legume tree forages remains unknown.

Although plant tannins have a negative effect on the palatability of feed, the literature suggests that condensed tannins can overcome the detrimental effects of internal parasites in ruminants. Indian research further assessed the potential of using tanniniferous top feed (oak leaves) to reduce the parasite load in calves. It revealed a decreasing trend in parasite load in groups fed on oak leaves compared to the control group. While the researchers suggested that the condensed tannins might have induced an antagonistic effect against parasitism in calves supplemented with oak leaves, other factors may contribute significantly to the variation in the parasite load of the experimental animals. Therefore there was no significant difference between treatments.

Legume tree leaves viz glyricidia, subabul and sesbania were also evaluated in lambs by replacing 30% groundnut haulms in isonitrogenous complete rations. Data on intake, feed efficiency and nutrient digestibility revealed that inclusion of legume tree leaves in the ration considerably improved the growth performance and nutrient utilisation of lambs. There was a large variation in the nutritive value among these legumes tree leaves.

Japanese researchers conducted a large experiment to examine the potential and limitations of 14 indigenous multipurpose trees and shrubs, *Acacia brevispica, A. mellifera, A. tortilis, A. hockii, A. nilotica, A. abyssinica, A. elatior, Acacia senegal, Albizia amara, Albizia coriria, Balanites aegyptiaca, Bridelia micrantha, Grewia bicolor,and Zyziphus micronata*. The total nitrogen levels in leaves ranged from 12.1% for *Acacia nilotica* to 25.6% for *Bridelia micrantha*. The neutral detergent fibre content varied from 21.8% in *Acacia hockii* to 60.1% in *Albizia amara*. A palatability study with goats showed the following preference order; *A. tortilis> Balanites aegyptiaca> Zyziphus micronata> Albizia coriria> Acacia senegal> A. abyssinica> A. mellifera> Albizia amara> Acacia brevispica> A. elatior> Albizia amara> Grewia bicolor> A. nilotica> Bridelia micrantha> A. hockii.* These results indicate the nutritive value and palatability of indigenous browses is variable. Presence of phenolic compounds could have contributed towards low palatability. Long-term feeding trials are required to assess the responses in animal performance of the best ranking species when using them as a protein supplement.

<u>Deer nutrition research</u>

Yingjun Ru delivered two papers as keynote speaker in two sessions, 1) feed and feed technology and 2) genetic resources of less developed livestock species. The research in deer nutrition on Roseworthy and India was well discussed in each session. Overseas colleagues believed that the following research issues need to be followed up;

Further establishment of *in vitro* rapid feed evaluation assay, especially the NIR method assessed by Yingjun Ru. It has been also suggested to validate this method with *in vivo* data so that the industry can use this service with greater confidence.

The nutrient requirement of deer is influenced by the environmental conditions. The direct application of data from other countries or determined from other animal species is questionable until the difference in nutrient requirement between animal species has been well demonstrated. Based on Roseworthy research, the colleagues suggested to make further comparisons of the nutrient requirements for maintenance between deer and sheep.

Research conducted on Roseworthy and overseas has shown the difference in feed utilisation between deer and other ruminants. Apart from the difference in anatomical structure of digestive tract, researchers in India compared the difference in microbial biology in rumen between sheep and wild ruminants including deer. Thirty-two strains of anaerobic fungi have been isolated and evaluated for their ability to produce fibre-degrading enzymes in a medium containing wheat straw, wheat bran and cellobiose. The acetyl esterase activity of different strains ranged from 10.4 to 51.2 mIU/ml, ß-glucosidase from 1.87 to 508 mIU/ml. The results indicate that the efficient strain of fibrolytic anaerobic fungi from wild ruminants including deer may be a potent candidate for rumen manipulation to increase fibre degradation in domestic animals such as sheep and cattle.

<u>Assessment of herbs, spices and botanicals as replacement of antibiotics</u>

A ban of antibiotics as feed additives in animal nutrition has been in place since 1986 in Sweden and since 1999 in Switzerland. Today in the EU only three antibiotics are still permitted as growth promoters (Salinomycin-Na, Flavophospholipol, Avilamycin). A general ban is foreseen in some years from now, because of the increased occurrence of pathogens resistant against therapeutic antibiotics used in animals and humans. Now the world is looking for friendly supplements with higher acceptance by consumers. Herbs, spices and botanicals are being assessed by many researchers although the responses in animal performance are not consistent. Whether herbs, spices or botanicals are practical for use as an alternative antibiotics still needs to be resolved. they have to be considered in each practical.

Development of enzymes for pigs and poultry

With limited feed grains available for pigs and poultry in Asia, a large proportion of ration for village pigs and poultry are fibrous materials. Even in the intensive pig and poultry production systems, agriculture by-products (canola meal, cotton seed meals etc) account for significant part of pig and poultry rations. The application of enzymes in pig and poultry diets to improve feed utilisation is a key strategy for improving animal production in this region. However, the animal response to enzyme application is variable and the application of enzymes is a hit or miss strategy. For example, researchers in India showed that addition of multiple enzymes to a corn-soy or sorghum based diet did not improve broiler performance, but feed efficiency was improved for a finger millet based diet. A layer trial also demonstrated no benefit of enzyme supplementation in the corn-soy-rice bran based diet for egg production. Korean research also showed no improvement in animal performance by applying multiple enzymes. These results further suggest that a better understanding of the substrate of different enzymes and the chemical characteristics of feed grains is essential for appropriate application of enzymes in pig and poultry rations.

Phytase is widely used in pig and poultry rations to improve P utilisation and reduce the pollution of soil by P excreted by animals. Most phytase is produced by bacteria, but research conducted in Korea showed that plant phytase content in feedstuffs varies from 0 in corn to 2395 U in wheat bran. Wheat bran can be used in a low nonphyrate P broiler diet to prevent the depression of performance and to reduce the P excretion. The phytase activity in different feed resources needs to be explored and this information will be useful to develop pig and poultry diets for better utilisation of P.

Development of rapid feed assay for pigs and poultry

Many overseas researchers are assessing the nutritive value of feed ingredients for pigs and poultry. In Asia, the utilisation of feed grains in pigs and poultry industry strongly competes with human consumption. Thus researchers are focusing on the by-products such as canola meal, wheat bran and rice bran etc, and revealed a large variation in nutritional quality of these products. These variations are dependent on the supplier, processing method and origin of the product. Thus the feed industry need a rapid assay to evaluate the nutritive value of these products prior to including it into the pig and poultry rations.

Researchers in Asia and Europe developed prediction equations of true amino acid digestibility and amino acid content of soybean meal. These equations are based on chemical composition of the soybean meal and require intensive laboratory analyses. Thus the prediction is a slow and expensive process. An Australian study has already proven that near infrared spectroscopy (NIR) can be used for rapid feed test. Some NIR calibrations are offered as commercial service by a number of laboratories. However, these calibrations are for cereals. The potential of using NIR systems to predict the nutritive value of by-products requires urgent assessment.

Using extracts from natural spices to preserve chicken meat

Red chilli extract was assessed for the extending the storage quality of chicken meat cutlets. Anaerobes, yeast and moulds were measured over a 28-day period of storage. Sensory evaluation and microbiological assessment suggested that incorporation of red chilli extract at 0.05% was able to offer cost effective shelf life for chicken meat cutlets up to 14 and 28 days of refrigerated and frozen storage, respectively.

Black pepper and turmeric extracts were added to a shami chicken kabab. Microbial counts declined with the increasing level of extract added in the kabab. It has been concluded that shami chicken kebab prepared with 0.1% black pepper extract or 0.2% turmeric extract could be safely consumed before 14 days of refrigerating and 28 days of being frozen.

Aeromonas hydrophila is an emerging food-borne pathogen. It has been frequently isolated from chicken meat. Due to its psychrotropic nature, it can spoil chicken meat both at refrigeration and ambient temperature. Spices such as garlic impart flavour to food and possess anti-microbial property against many pathogens. Anti-microbial effect of garlic extract against *Aeromonas hydrophila* in raw chicken meat mince was studied by Indian scientists. The results showed that garlic extract can be used as bacteriostatic agent in chicken mince to control the growth of spoilage organisms.

Free range poultry production

There is an increasing demand for free range eggs and meat in Asia and Europe. Free range poultry (backyard poultry) production is one of the major protein supplies for the rural population. Indian researchers showed that for free range poultry, the feed cost accounted for 40.3% total production cost, and vaccination and medication accounted for 7.1%. The labour cost was not considered. The mortality was 9.7%, of which 47% was caused by predators. The overall benefit cost ratio was about 3:1.

Consumers in Asia demand chicken meat from local breeds which have low productivity, but produce a high quality product. Indian researchers are focusing on the assessment of their local breeds and the development of new lines for free range production system. It was found that indigenous breed CARI Nirbheek has better performance than Shyama and Hitkari breeds. CARI Nirbheek matures at the age of 175 days with an annual egg production of 198 eggs. Guinea fowl is a potential poultry breed for low input production system and well adapted to diversified agro-climatic conditions in arid and semi-arid regions. It possesses an excellent foraging potential and inherent hardiness. Three varieties (Pearl, Leavender, White) were assessed under different farming systems. The results revealed that these birds under free range did not show any difference in production performance from those reared under intensive system. More importantly, these birds showed better disease resistance against Newcastle disease and bursal disease.

BENEFITS AND SIGNIFICANCE OF TRAVEL TO GRANTEE

Yingjun Ru was able to meet with overseas colleagues and discuss issues associated with deer nutrition, free range poultry production systems and feed evaluation for ruminants and monogastrics. This has provided him with numerous ideas which could be tested in Australia.

Asian colleagues brought Yingjun Ru up to date with the latest studies being undertaken on microbial research on deer and other ruminants. These studies encouraged further understanding of the digestive physiology of domestic and wild ruminants. The outcomes of this type of research will be important for both Australia and overseas to improve feed utilisation efficiency of farmed animals.

Integrating poultry into farm cropping/pasture program was considered a useful approach to enhancing free range production systems, but the production system is different for Europe and Asia. European researchers are designing alternative layouts for free range systems and Asian scientists are focusing on the utilisation of local poultry breeds in the village farming systems.

The impact of the ban of antibiotics on the pig and poultry production is uncertain for most Asian countries. It has been suggested that herbs, spices and botanicals can be used to maintain the health of animals without use of antibiotics through the regulation of feed intake and stimulation of digestive secretions. The assessment of these materials, especially local ones is essential.

BENEFITS TO RURAL INDUSTRY

The research on nutrient requirement of deer in Australia was discussed with overseas colleagues and a number of research areas were suggested. These include 1) comparison of the nutrient requirements between deer and sheep, 2) further validation of rapid feed evaluation method for deer with animal house research and 3) evaluation of alternative feed resources for deer. Outcomes of research in these areas will enable us to develop nutritional management strategies based on animal demands and the seasonal changes in nutritive value of forages. While overseas researchers have obtained a large amount of data in these areas, caution should be applied by Australian deer producers when applying such information under Australian conditions.

The ban of antibiotics in animal feeds has led to research into natural products as replacement of these antibiotics. Herbs, spices and botanicals have been examined but none has demonstrated a consistent antibiotic effect.

Considerable potential exists to improve the free range poultry production system by using some local breeds which are capable of utilising forage, are more resistant to diseases and can produce high quality of meat. The supplementation strategies, suitable forages and other management issues should be examined.

RECOMMENDATIONS TO RIRDC AND INDUSTRY

Results of RIRDC funded research on deer nutrition in Australia should be made available for key nutritionists in Asia and other countries (e.g. New Zealand). This will allow us to understand the difference in nutrient requirement of deer determined under different environments.

Assessment of alternative feed resources for deer is needed, especially when the deer farming is expanding to the areas where salinity is a problem. In these areas, bushes (e.g. saltbushes, bluebushes) are the dominant feed resource for grazing animals, particularly in summer. The feeding value of these bushes should be examined.

Rapid feed evaluation for deer needs to be further developed. These *in vitro* methods need to be validated using *in vivo* method before using for commercial services.

The difference in digestive physiology between deer, sheep and wild animals should be investigated. The outcomes of this type of research will give us a better understanding why some wild animals can utilise fibrous materials better than sheep. The application of these research findings will result in an improved feed utilisation efficiency of farmed animals.

The free range production system needs to be further developed. These include the development of feeding strategies for free range birds, and the assessment of pasture species, stocking rate and welfare issues of foraging birds.

The variability in nutritive value of feed ingredients limits the nutritionist in formulating a proper diet to match the nutrient requirement of pigs and poultry. A rapid feed assay is required for pigs and poultry so that the ingredients can be assessed prior to including in the diet formulation. Most researchers are focusing on rapid assays of cereals, but rapid assays for vegetative proteins and agriculture by-products are urgently needed by the industry.

DISSEMINATION OF REPORT

Circulate to RIRDC deer, egg, chicken meat, new animal products, resilient farming systems and organic farming.

ACKNOWLEDGEMENT

The author of this report is very grateful for the funds provided by RIRDC to undertake this travel.

PUBLICATIONS

Ru, Y. J., Peng, W. K., Kruk, J. A., Glatz, P. C., Fischer, M. and Swanson. K. (2002). Predicting crude protein content and *in vitro* digestibility of pastures for fallow deer using near infrared spectroscopy (NIR). Asian-Australasian Journal of Animal Science, (in press).

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COPIES OF PUBLICATIONS

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Predicting crude protein content and *in vitro* digestibility of pastures for fallow deer using near infrared spectroscopy (NIR)

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ABSTRACT

Information on nutritive value of pastures is essential for the development of supplementary feeding strategies for deer in summer and early winter in southern Australia. The traditional methods for feed evaluation are slow and expensive. For example, determination of dry matter digestibility involves feeding animals and collecting faeces for at least 14 days, a task more difficult for deer because of their fractious behaviour. Ru *et al* (2002) [12] demonstrated that the Tilley–Terry method can be used to estimate dry matter digestibility and digestible energy content of pastures, but the maintenance of fistulated deer is a difficult animal husbandry task. Near infrared spectroscopy is currently used to estimate *in vitro* digestibility for sheep at a low cost and rapid turnover. An experiment was conducted where 40 pasture samples (mixture of medics, ryegrass and others) were collected during 2000 and 2001 and *in vitro* digestible energy (DE) content and dry matter digestibility (DMD) were measured using Tilley-Terry method and crude protein using a Leco machine. The NIR calibrations were developed for DMD, DE and crude protein content. The correlation analysis showed that R^2 was 0.93, 0.99 and 0.97, and standard error of calibration (SEC) was 0.30, 0.42 and 1.07 for DE, crude protein content and DMD calibrations, respectively. These results show there is potential for using NIR to predict protein content and *in vitro* digestibility of pastures, but more samples are needed to further validate the calibrations.

Key Worlds: Annual Pasture, Dry Matter Digestibility, Digestible Energy, Grazing Deer

INTRODUCTION

In southern Australia, the nutrient demand of grazing deer is not matched by the seasonal feed supply. An effective supplementary feeding and grazing management strategy during the season is the key to ensure that weaner deer reach market body weight at the end of the season. To develop a nutritional management strategy for producing quality venison, deer producers need information on the nutritive value of pastures during the season. However, such information is limited and most Australian deer farmers are using the nutritive value of feed ingredients determined in sheep as a guideline. The application of nutritive values of feeds determined by sheep for deer feeding is questionable given deer digest fibre better than sheep in summer [5] and *in vitro* DMD of some feed ingredients is higher in deer compared to sheep [8]. The interaction between animal species and pasture species in digestibility was also reported by Milne et al. (1978) [9]. More importantly, it is well known that the determination of nutritive value of feed using deer is expensive and time-consuming due to the difficulty of handling deer. Ru et al. (2002) [12] determined the *in vitro* and *in vivo* digestibility of 11 ingredients in red and fallow deer and found that *in vitro* digestibility was lower than *in vivo* digestibility, but significantly correlated with *in vivo* digestibility for red and fallow deer. The *in vitro* method for digestibility estimation has potential as a rapid feed evaluation system for deer. However, maintaining deer with rumen fistula is difficult and expensive due to the cost of feed, housing facilities and labour requirement.

Near infra-red spectrophotometer (NIR) has been used for rapid analyses of nutritional components of feedstuffs [7]. In 1976, Norris et al. (1976) [10] successfully predicted forage digestibility *in vitro* and *in* *vivo* using a scanning monochromator instrument. They found R^2 values of 0.78 and 0.90 for the prediction of DMD *in vivo* and *in vitro*, respectively. In the early 1990's, a number of calibrations were developed to predict *in vivo* digestibility of forage for sheep and cattle [3, 4, 6,11]. However, these NIR calibrations cannot be used to predict the *in vitro* or *in vivo* digestibility of forage for deer because Ru et al. (2002) [12] demonstrated a difference in both *in vivo* and *in vitro* digestibilities between sheep and deer. The difference in digestion capacity between deer and sheep warrants the development of NIR calibrations specifically for deer. The objective of this study was to explore the potential of using NIR to predict crude protein content, *in vitro* DMD and DE content of annual pastures for deer.

MATERIALS AND METHODS

Pasture samples and in vitro digestibility measurement

Pasture samples were obtained over two years from two grazing experiments conducted at Roseworthy Deer Farm, University of Adelaide, South Australia. Each year mixed pastures (ryegrass, medics and others) were grazed by fallow deer during the season at a stocking rate of 12 weaner deer/ha. Pasture was sampled monthly from May to October by cutting to 3 cm above the ground. The samples were freeze dried and milled through a 1 mm sieve for chemical analyses, *in vitro* DMD and DE measurement, as well as NIR scanning. Crude protein content was measured using a LECO-CHN 1000, combustion system [1] .

In vitro digestibility was estimated using Tilley-Terry method [14]. In brief, fallow deer (male, 8-10 months old) were obtained from Farm Services, Adelaide University, Roseworthy Campus. For each batch, two deer were slaughtered and the rumen fluid collected for *in vitro* digestibility estimation. CO_2 was passed through the rumen fluid to maintain anaerobic conditions and the container was sealed and kept in a water bath at 39 ^oC before adding to the incubation tubes. The time from collection to completion of the inoculation process was less than 2 hours as recommended by Schwartz and Nagy (1972) [13].

A sample of the feed (0.5 g) was weighed into incubating tubes and 10 mL of rumen fluid and 40 ml of buffer (pH=5.8) were added. Tubes were flushed with CO_2 and capped immediately. Ten replicates of each sample were incubated in a shaking water bath at 39 ^oC for 48 hours. After the samples were centrifuged at 3000 rpm for 15 min. and washed with distilled water, 50 mL of pepsin solution was added to each tube and incubated for another 48 hours at 39 ^oC. After incubation, the samples were centrifuged (3000 rpm) and the residues dried at 60 ^oC over night. Dry matter and gross energy in the residue were determined using the standard procedure [2] . In each batch, a quality control lucerne sample was included.

NIR calibration development

NIR reflectance spectra of all available samples were recorded using a Foss NIRSystem Model 6500 Spectrophotometer (FossNIRSystem Inc., Silver Spring, MD, USA) and Intrasoft International (ISI) WINISI software (FossNIRSystem Inc., Silver Spring, MD, USA). Scanning was performed via a transport module in reflectance mode over the wavelength range of 400-2500 nm at 2 nm intervals using a small ring cup. Examination of final spectra was conducted in second derivative using SNV and Detrend scatter correction.

Samples were also examined using the population structuring software in order to identify spectral outliers. To identify patterns in the group of spectra that contribute the most to the variation among the spectra, Principal Component Analysis (PCA) was used. An average Mahalanobis distance (Global H) was calculated and H values for individual samples were standardised by dividing by the average H value. Any sample with a spectrum more than 3.0 standardised units above the mean of the sample set was regarded as a spectral outlier. An identical population structuring procedure was applied to all samples.

The applied calibration technique involved SNV and Detrend scatter correction method and modified partial least squares (MPLS) regression of derivatised spectra. The superlative math treatment was

2,5,5,1. The same calibration procedure was used for both calibration sample sets. The calibration equations were produced for the 1,100 – 2,500 nm segment of wavelengths. The Standard Error of Cross Validation (SECV) was used as a measure of accuracy of calibrations in each case. Final equations were chosen according to a combination of the lowest SECV and the highest 1-VR value (coefficient of determination for cross validation). Calibration equations were developed for each of the three analysed constituents for these pasture samples.

RESULTS

No spectral outliers were found for pasture samples, so all samples were included in the calibration set. The *in vitro* DMD and DE content of pastures varied significantly in both years (Table 1). The crude protein content of pastures was higher ($P<0.05$) in 2001 than 2000. These variations in nutritive value of pasture samples enabled us to develop calibrations to cover samples with a wide range of quality.

Table 1. Nutritive value of annual pastures for the development of NIR calibrations for deer

Parameter	Means	Maximum	Minimum
	2000 (n=20)		
DMD (%)	61.7	69.3	50.6
DE (MJ/kg as fed)	9.9	11.2	7.9
CP (% dry matter)	22.3	29.9	11.8
	2001 (n=20)		
DMD (%)	67.8	80.9	53.9
DE (MJ/kg as fed)	10.6	13.1	8.8
CP (%)	27.8	34.9	17.1

DMD, dry matter digestibility (*in vitro*); DE, digestible energy content (*in vitro*); CP, crude protein content

The 1-VR and R^2 values for NIR calibrations were > 0.99 for crude protein content and >0.9 for *in vitro* DMD. The R^2 was 0.93 for *in vitro* DE content, but the 1-VR was relatively low (0.79). The standard errors of calibration were low for all nutritional components (Table 2).

Table 2. NIR calibration equations statistics developed for determination of nutritive value of annual pastures for deer.

Parameter	Mean	SD	SEC	R^2	SECV	1-VR
DMD (%)	64.3	6.67	1.08	0.974	1.959	0.914
DE (MJ/kg as fed)	10.3	1.13	0.30	0.930	0.516	0.790
CP (%)	24.9	6.40	0.42	0.996	0.608	0.991

DMD, dry matter digestibility (*in vitro*); DE, digestible energy content (*in vitro*); CP, crude protein content; SD, standard deviation; SEC, standard error of calibration; SECV, standard error of cross validation; 1-VR, coefficient of determination for cross validation

DISCUSSION

This preliminary research shows that NIR has the potential of predicting the nutritive value of annual pastures for deer. The crude protein content, *in vitro* DMD and DE content of annual pastures could be predicted with acceptable errors. However, these calibrations cannot be commercially utilised without further development. It should be noted that these calibrations have been developed with limited number of samples, and the pasture samples included a few pasture species. Under actual grazing conditions, pasture species varies between properties and regions. Thus, more samples with a range of pasture species at different maturity stages should be evaluated and included in the calibration set. More importantly, as a part of the NIR calibration development, the validation of NIR calibrations should be performed to further assess the predicting errors in comparison with the traditional methods.

It is highly desirable to develop NIR calibrations for predicting *in vivo* digestibility of pasture. However, the task is difficult for deer because of the difficulty of animal handling. Although Ru et al.

(2002)[12] successfully trained deer and evaluated some common feed ingredients using total faecal collection, the process is time-consuming, labour-intensive and expensive. These factors restrict the short turnover time required by the deer producers for the rapid adjustment of their grazing strategy based on the nutritive value of forage and intake of grazing deer. Ru et al. (2002)[12] studied the relationship between *in vivo* and *in vitro* digestibility of some common feed ingredients for red and fallow deer. The outcomes of their research show that *in vitro* assay can be used to predict *in vivo* nutritive value of feeds for deer, but the conduct of *in vitro* experiment is also a difficult task. Thus, there is an urgent need to develop a rapid laboratory assay to predict *in vitro* digestibility of pastures for deer. Given the potential of NIR shown in this study, the development of NIR calibrations is more likely to be successful. It is envisaged that the development and application of robust NIR calibrations for rapid nutritive value assessment will enable deer producers to measure the nutritive value of their pasture more frequently at a low cost for the development of grazing and feeding strategies during the season.

ACKNOWLEDGMENTS

The authors would like to thank the staff of the PPPI Nutrition Research Laboratory, SARDI Livestock Systems and Farm Services, Adelaide University for their technical support. The authors are also grateful for the financial support provided by the Deer Program of Rural Industry Research and Development Corporation (RIRDC).

REFERENCES

1. Anon. 1991. 'Instruction Manual for CHN 1000', (LECO Corporation, USA).
2. AOAC. 1980. Official Methods of Analysis. 13th edn. Association of Official Analytical Chemists, Washington, D.C.

Baker, C. W., D. I. Givens and E. R. Deaville. 1994. Prediction of organic matter digestibility *in vivo* of grass silage by near infrared reflectance spectroscopy. Effect of calibration method, residual moisture and particle size. Anim. Feed Sci. Techn. 50:17-26.

3. Barber, G. D., D. I. Givens, M. S. Kridis, N. W. Offer and I. Murray. 1990. Prediction of organic matter digestibility of grass silage. Anim. Feed Sci. Techn. 28:115-128.
4. Francois Domingue, B. M, D. W. Dellow, P. R. Wilson and T. N. Barry. 1991. Comparative digestion in deer, goats, and sheep. NZ J. Agric. Res. 34:45-53.
5. Givens, D. I., C. W. Baker, A. H. Adamson and A. R. Moss. 1992. Influence of growth types and season on prediction of metabolisable energy content of herbage by near infrared reflectance spectroscopy. Anim. Feed Sci. Techn. 37:281-296.
6. Givens, D. I., J. L. de Boever and E. R. Deaville. 1997. The principles, practices and some future applications of near infrared spectroscopy for predicting the nutritive value of foods for animals and humans. Nutr. Res. Rev. 10:83-114.

Latupeirissa, C. and G. Dryden. 1998. Comparative *in vitro* digestibility of feestuffs by deer and sheep. Proc. Nutr. Soc. Aust. 22: p53

7. Milne, J. A. J. C. Macrae, A. M. Spence and S. Wilson. 1978. A comparison of the voluntary intake and digestion of a range of forages at different times of the year by the sheep and the red deer. Br. J. Nutr. 40:347-357.
8. Norris, K. H., R. F. Barnes, J. E. Moore and J. S. Shenk. 1976. Predicting forage quality by infrared reflectance spectroscopy. J. Anim. Sci. 43:889-897.
9. Offer, N. W. 1993. Background to the new *in vivo* ME silage prediction equation. Proc. Soc. Feed Technologists Ruminants Conference. pp. E1-E7, Reading: Society of Feed Technologists.
10. Ru, Y. J., P. C. Glatz, Z. H. Miao, K. Swanson, S. Falkenberg and S. Wyatt (2002) Comparison of the digestibility of grain and forage by sheep, red and fallow deer. Asian-Aust. J. Anim. Sci. 15: (In Press)

Schwartz, C. C. and J. G. Nagy. 1972. Maintaining deer rumen fluid for *in vitro* digestion studies. J. Wildl. Manage. 36:1341-1343.

11. Tilley, J. M. A. and R. A. Terry. 1963. A two-stage technique for the *in vitro* digestion of forage crops. J. Br. Grassl. Soc. 18:104-111.

Ru, Y. J., Glatz, P. C. and Wyatt, S. (2002). Energy requirements of 28-32 kg fallow weaner deer in southern Australia. Asian-Australasian Journal of Anima Science (in Press).

Energy requirements of 28-32 kg fallow weaner deer in southern Australia

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ABSTRACT

An understanding of the nutrient requirement of fallow weaner deer is crucial for the development of a cost-effective feeding strategy, especially when supplementation is required. In most circumstances, the nutrient requirements of deer are estimated in animal house conditions, but Ru and Glatz (2002) [13] determined the digestible energy (DE) requirement of fallow weaner deer under grazing conditions in South Australia. This paper reports the differences observed in energy requirement of deer in the animal house compared to grazing conditions. As a part of digestibility trial, 6 fallow deer were housed in individual pens from August 1999 to May 2000. The daily nutrient intake, faecal output and daily weight gain were measured during the experiment. It was found that a 28 kg live weight fallow weaner deer required 8.53 MJDE/day to gain 31.7g, while a 32 kg live weight deer required 11.46 MJDE/day to gain 59.3g. The energy requirement for deer housed indoors was 24% lower at 28 kg live weight and 6% lower at 32 kg body weight compared to grazing conditions. This suggests that nutrient requirement measured in animal house can be applied under grazing conditions provided some adjustments to energy requirement is made.

Key Words: Digestible Energy, Body Weight Gain, Weaner Deer

INTRODUCTION

Farmed deer in Australia are limited to six species, including red, fallow, wapiti, rusa, chital and sambar. Of these 50% are fallow deer, a dominant species in New South Wales, Tasmania, Western Australia and South Australia [7]. In southern Australia, fallow deer have been farmed on better-quality grazing pasture, but the seasonality of reproduction of fallow deer means that the peak period of pasture production does not match the periods of peak nutritional demands. Poor pasture availability is the key factor limiting the growth of weaner deer in early winter and a significant proportion of weaners cannot reach the market specifications at the end of the season. These animals have to be carried over to next season, resulting in a significant loss in farm profit. Thus supplementary feed is required during this period , but deer farmers need information on the nutrient requirement of fallow weaners during the season for optimising feed utilisation.

While there have been figures published for seasonal energy requirements for fallow deer [3, 11] based on interpolations from red deer data [8] , there has been no properly designed experiments to measure the energy requirement of weaner fallow deer during the grazing season. Flesch et al. (1999) [9] determined energy intake of fallow weaner deer fed in pens using three groups of weaners with imbalanced gender. The results showed that energy intake ranged from 10-11 MJ ME/day between 12 to 20 weeks of age, equivalent to a metabolic body weight energy intake of 0.95 MJME/kg $^{0.75}$/day. However, more extensive research on energy requirements from weaning to joining or slaughter is required. This paper reports the energy intake of fallow weaner deer at 28 and 32 kg body weight fed in-house or grazed outdoors.

MATERIALS AND METHODS

In-house trial

Six male fallow deer (weaners), 8 months of age, were obtained from a commercial deer farm in South Australia. The average body weight was 26 kg. The deer were housed as a group in a 7 m x 7 m compound constructed in the middle of an animal house, with 1900 mm ring-lock fence strained 100 mm off the floor giving a 2 m high fence, in the Animal Research Centre at Roseworthy Campus, South Australia. After 2 months of training of the deer by hand-feeding with fresh lucerne or grains, the weaner deer were transferred into individual stalls with dimensions of 1200 mm long x 1950 mm high x 900 mm wide. Holes with a diameter of 100 mm were cut in the stalls to allow deer to view each other in the next stall. The feeder was fixed on the door with a drinker next to the feeder. To reduce the stress on deer from fitting and using collection bags, a faecal collection net [10] was placed underneath each individual stall, similar to the faeces collector used in metabolic cages for sheep.

Three diets were used in this experiment with 2 deer/diet. The dietary components were; diet 1: 50% straw, 50% lucerne chaff; diet 2: 70% oaten/wheaten chaff, 30% lucerne chaff; diet 3: 100% lucerne chaff. The deer were fed *ad libitum* and water was available at all times. Total faeces output and feed intake were measured daily for 5 days after deer had been on diets for 14 days. Hair was removed manually from the faeces and 10% of the faeces were subsampled and freeze dried. All samples were milled through a 1 mm screen for chemical analysis.

Field trial

Thirty six fallow deer, age of 8 months, were selected from the Roseworthy deer farm. Deer were allocated into three groups at 12 deer/group with equal males and females. Three groups of deer were supplemented with a diet based on barley and lupins at 434, 340 and 200 g/day, respectively, in July, but no supplement was offered in August. The supplementary diet formulation was 2% mineral premix, 30% lupin and 68% barley. The diet contained 13.0 MJ DE/kg and 168.8 g/kg protein. All deer grazed a medic and ryegrass based pasture. In July and August, the deer were dosed via the oesophagus with a slow-release alkane capsule (produced by Captec Pty Ltd). After 10 days, faeces were collected every second day over 6 days as recommended by Ru et al. (2002)[14]. Faeces were freeze dried and then milled for alkane analysis using a modified method of Dove (1992)[5].

The body weight of deer were measured before dosing alkane capsules and after finishing faeces collection to calculate daily body weight gain. Pasture samples were taken during the faecal collection period by cutting pastures in the exclusion cages at the same level as grazed area. Pasture samples were freeze dried and then milled for alkane analysis. Daily feed intake was estimated using the following equation;

Daily herbage intake (kgDM/day)=(Fi/Fj*(Dj+I*Cj)-I*Ci)/(Hi-Fi/Fj*Hj) [6]; where Fi and Hi are faecal and herbage concentrations of the odd-chain alkanes; Fj and Hj are faecal and herbage concentrations of the even-chain alkanes; Dj is the daily dosed even chain alkane; I is concentrate intake; Cj and Ci are even-chain and odd-chain alkanes in concentrate supplement. The relationship between daily weight gain and digestible energy intake was established using correlation analyses in Systat software [15].

RESULTS

Under grazing conditions, the digestible energy intake (DEI) ranged from 6.8-17.4 MJ/day in July and 8.4-18.7 MJ/day in August. The ranges of body weight gain were -117.6 - 117.6 g/day in July and -16.7 - 166.7g/day in August. DEI was positively correlated with daily body weight gain with the following relationships (Figure 1 and 2);

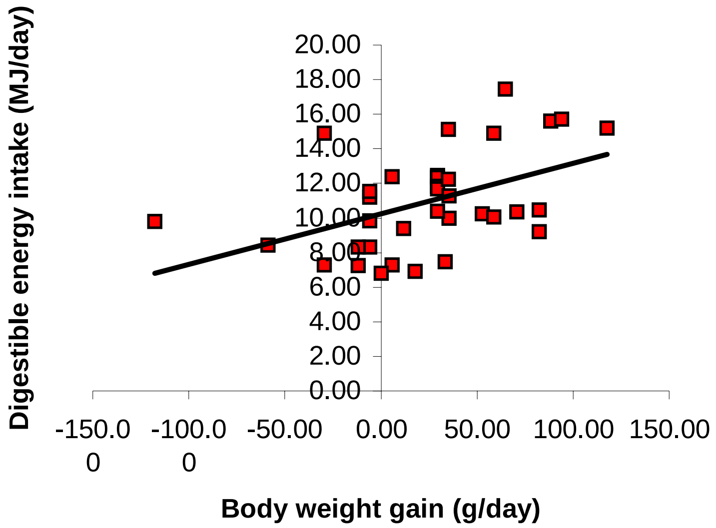

Figure 1. The relationship between body weight gain and digestible energy intake of fallow weaner deer in July

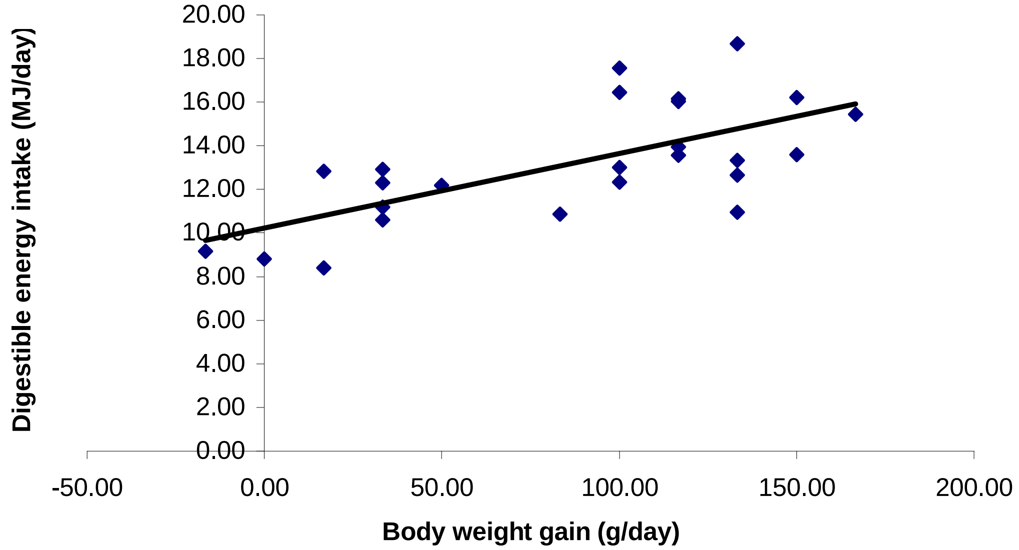

Figure 2. The relationship between body weight gain and digestible energy intake of fallow weaner deer in August

In July when the average body weight of weaner deer was 28 kg

DEI (MJ/day)=10.249+0.029*Gain (g/day), R^2 =0.47, P=0.005, n=36

In August when the average body weight of weaner deer was 32 kg

DEI (MJ/day)=10.227+0.034*Gain (g/day), R^2 = 0.68, P=0.000, n=36

However, in the animal house, the digestible energy intake ranged from 7.8-9.4 MJ/day at 28 kg of body weight, with a body weight gain ranging from 0-57.7 g/day. When reaching 32 kg, the digestible energy intake increased to 10.6-12.0 MJ/day and body weight gain varied between 44.4 and 66.7 g/day. The digestible energy requirement of deer in-house was 24% lower than under grazing conditions at 28 kg of body weight. The difference in energy requirement was lower at 32 kg body weight (Table 1). When assuming that the maintenance requirement is the energy intake at zero body weight gain , there was no difference in digestible energy requirement for maintenance at 28 and 32 kg body weight. When calculated on metabolic body weight basis ($W^{0.75}$), the maintenance requirement was higher in July than in August.

Table 1. Energy requirement of fallow deer in animal house and grazing conditions

Body weight (kg)	28	32
Liveweight gain (g/day)	32	59
Digestible energy requirement		
In-house		
MJ/day	8.53	11.46
MJ/kg $W^{0.75}$	0.701	0.852
Under grazing calculated using equations		
MJ/day	11.17	12.24
MJ/kg $W^{0.75}$	0.918	0.910
Difference (%)	76.4	93.6

DISCUSSION

There was a significant difference in the energy requirement of deer measured in house versus outdoors. This suggests that caution should be taken when applying the nutrient requirement data determined from animal house research to the field conditions, especially in early winter when the temperature in southern Australia is low. It is clear that energy requirement was 24% higher under grazing conditions compared to in-house. It is believed that fallow and red deer can tolerate a wide range of environmental conditions in temperate zones, but generally fallow deer appear to be less tolerant of extreme cold and more tolerant of extreme heat and aridity [4] . While the winters in southern Australia cannot be classified as cold, the difference in energy requirement between red and fallow deer may restrict the direction application of feed standards for fallow deer recommended in New Zealand by interpolating from red deer data. The difference in energy requirement indoors and outdoor was also reported for red deer in New Zealand [1] , where ME requirement for adult hinds at 95 kg were 5 MJ higher for indoors than outdoors for non pregnant, early-mid pregnant and late pregnant hinds (25-29% higher). The outdoor lactating hinds requires 33% more ME per day than those indoors. However, the difference in energy requirement between indoors and outdoors was not significant in August in the current work, presumably due to the mild weather in spring.

The daily energy requirement estimated from the current work is lower than those reported by Asher (1992) [3] and Mulley and Flesch (2001) [12]. Using the conventional ratio of 0.82 (digestible energy/metabolisable energy) suggested by ARC (1980) [2] for ruminant, the predicted ME requirement for fallow weaner deer is 9.2 MJ ME/day in July and 10.0 MJ ME/day in August for at growth rates of 32 and 60 g/day using the model developed in this grazing trial. If the growth rate is 80 g/day, equivalent to Mulley and Flesch's data (2001) [12], the energy requirement in winter is 10.3 MJ ME/day in winter, close to values (10-11 MJ ME/day) reported by Mulley and Flesch (2001) [12] . This value is lower than the value reported by Asher (1992) [3] for male fawns (11.8 MJ ME/day), but close to the value for female fawns (10.4 MJ ME/day). However, the winter growth rate for deer reported by Mulley and Flesch (2001) [12] might not be achieved in southern Australia under grazing conditions.

Due to the lack of data on the growth rate of fawns at the recommended energy requirement, it is difficult to compare the current data with those reported by Asher (1992) [3]. This further indicates the difficulty of the direct application of New Zealand data for the development of supplementary feeding strategy for Australian deer farmers. However, the outcomes of this research will assist farmers to explore the possible pasture and stock management practices to ensure that the genetic potential for growth is not limited by inadequate nutrition under southern Australian conditions.

ACKNOWLEDGMENTS

The authors would like to thank the staff from the PPPI Nutrition Laboratory, Livestock Systems, SARDI and Farm Services, Adelaide University for their technical support. The authors are also grateful for the financial support provided by the Deer Program of Rural Industry Research and Development Corporation (RIRDC).

REFERENCES

1. Adam, C. L. 1994. Management and diseases of deer. A handbook for the Veterinary Surgeon, pp 44-54.
2. ARC. 1980. The nutrient requirements of ruminant livestock. (CAB. England).
3. Asher, G. W. 1992. Growth and Nutrition of fallow deer. In Progressive Fallow Deer Farming. 2nd edition. (Eds. G. W. Asher and M Langridge). pp. 59-68.
4. Asher, G. W. 1993. Intensive husbandry of fallow deer. Proceedings of the first world deer congress. Feb. 1993 New Zealand Deer Farmers Association Wellington NZ. pp. 93-96
5. Dove, H. 1992. Using the n-alkanes of plant cuticular wax to estimate the species composition of herbage mixtures. Aust. J. Agric. Res. 43:1711-1724.
6. Dove, H. and R. W. Mayes. 1991. The use of plant wax alkanes as marker substances in studies of the nutrition of herbivores: a review. Aust. J. Agric. Res. 42:913-952.
7. English, A. W. 1984. The Australian deer farming industry-progress and prospects. In “Deer Refresher Course”. The Post-graduate Committee in Veterinary Science, The University of Sydney. pp. 533-540.
8. Fennessy, P. F., G. H. Moore and I. D. Corson. 1981. Energy requirements of red deer. Proc. New Zealand Soc. Anim. Prod. 41:167-173.
9. Flesch, J. S., R. C. Mulley and P. N. Muley. 1999. The growth rate and metabolisable energy intake of farmed fallow deer (Dama dama) between 12 and 25 weeks of age. Australian Deer Farming. 10:14-17.

Miao, Z. H., P.C. Glatz, A. English and Y. J. Ru. 2001. Managing fallow (Dama dama) and red deer (*Curvus elaphus*) for animal house research. *ANZCART* 14:1-8.

10. Milligan, K. E. 1984. Deer nutrition – feed demands and how to meet them. Proceedings of a Deer Course for Veterinarians. Palmerton North, New Zealand. (Ed. P. R. Wilson). Massey University. pp. 46-58.
11. Mulley, R. C. and J. S. Flesch. 2001. Nutritional requirements for pregnant and lactating red and fallow deer. Deer Research Report. Rural Industry Research and Development Corporation. Canberra, Australia.
12. Ru, Y. J. and P. C. Glatz. 2002. Energy and protein requirement of fallow weaner deer under mediterranean environment. Deer Research Report. The Rural Industry Research and Development Corporation, Canberra, Australia.
13. Ru, Y. J, Z. H. Miao, P. C. Glatz and M. Choct. 2002. Predicting feed intake of fallow deer (Dama dama) using alkanes as a marker. Asian-Aust. J. Anim. Sci. 15:209-212.
14. Wilkinson L, M. Hill, J. P. Welna and G. K. Birkenbeuel. 1992. SYSTAT for Windows: Statistics, Version 5 Edition. Evanston, IL: SYSTAT, Inc.

Attachment. Invitation letter from the AAAP to present two papers and chair a session

Asian-Australasian Association of Animal Production Societies (AAAP)

Address for Correspondence: (India Office): Flat No.205, No.F64-C/9, Sector 40, NOIDA (UP) 201 303.
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AUS-013 24th July 2002

Dr. Yingjun Ru
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Sub: Xth International Congress of AAAP to be held in New Delhi during 22-27 Sept. 2002

Dear Dr. Ru ,

The programme committee of the Congress has decided to request you to accept our invitation to chair and present a keynote paper in Symposium SY 28 – **Less developed species (Mithun, Yak, Deer, etc.)**. We have received your full length papers "**Predicting crude protein content and *in vitro* digestibility of pastures for fallow deer using near infrared spectoscopy (NIR)", "Energy requirement of fallow deer at 28 and 32 kg body weight"** and "**Variability in nutritive value of commercial feed for pigs**" for oral presentation. Your bio data and photograph has also been received.

You are cordially invited to attend the conference and the Exhibition from 22nd to 27th September 2002.

With warm regards,

Yours Sincerely,

P.N. Bhat