RURAL INDUSTRIES RESEARCH
& DEVELOPMENT CORPORATION

OSTRICHES

Their Nutritional Needs under Farming Conditions

A report for the Rural Industries Research and Development Corporation

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Foreword

This project arose out of the recognition that the economic future of the ostrich industry relied heavily on providing cost-effective diets. Reliance on grazing birds was seen to be an important avenue of research. It is extremely difficult to quantify pasture intake and to distinguish its intake from that of concentrate feed, normally given as a feed supplement.

Since this project commenced, emphasis appears to be changing from meat to leather production. This means that for the best quality hide, growth rate and slaughter weight may now differ from those originally targeted. Nevertheless, overall results suggested that substantial amounts of concentrate feed can be replaced by grazing if the pasture is of good quality.

Other outputs from the project included the design and use of low cost portable breeding paddock shelters and a 'no frills' feeding system for the breeding ostriches during maintenance and reproduction and for producers who can access raw ingredients such as whole grain, and legume seeds such as peas and lupins.

The project was funded from RIRDC Core Funds which are provided by the Federal Government.

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Peter Core
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We also wish to thank Neil Reilly, Ron Scott, John Scott and Darren Plowright at Lagoon Park for providing facilities and the day to day operations in conducting the free choice experiments.

Contents

Executive Summary

A series of experiments was undertaken at the Queensland Poultry Research and Development Centre (QPRDC) and on-farm to gain further information on the nutrition and dietary needs of ostriches as well as their ability to utilise fibre sources and pasture.

Before any experiments were undertaken, a survey of ostrich producers was conducted in early 1997. These were located mainly in northern New South Wales and Queensland, and 160 out of 618 producers responded. Much information was gained, analysed and interpreted. The outcome was that ostrich farmers were cautiously optimistic about the future. Subsequent changes in the industry indicated that if the survey had been undertaken today, many of the results would likely be different. At that time, the survey outcomes formed a useful basis for research and research direction, since responses did highlight where information, particularly on nutrition, was lacking.

The first experiment was conducted in order to measure the apparent metabolisable energy (AME) of diets high in fibre. There was a conventional basal diet, and 200 g/kg of this was replaced either by wheat pollard, milled lucerne meal, milled Rhodes grass or milled wheat straw. These were fed to five individual ostriches, five individual emus at two ages and five individual adult cockerels. An inert marker was used to determine dry matter digestibility of the five diets. It was found that there was no significant ($P>0.05$) difference in AME of the diets between the old (21 kg) and young (11 kg) emus, nor between these and adult cockerels. AME generally declined as the fibre content of the diets increased. For ostriches, mean AME values were higher ($P<0.05$) than for the cockerels and emus. They were similar for those diets with pollard or lucerne. These were similar to AME of the basal diet and higher than those on the Rhodes grass and wheat straw based diets. These had similar fibre contents. Ostriches were observed to recycle their excreta. This would have increased the dry matter digestibility and AME of diets.

A series of experiments was conducted on producers' farms in order to determine whether ostriches can choose between two diets which varied in energy and protein (amino acid) levels. Feeders were designed and tested to prevent feed spillage. In the first experiment, which was preliminary, diets were either 10.2 MJ AME/kg or 7.6 MJ AME/kg and were fed to three groups of six ostriches on each of two farms. The experiment ran for 77-84 days. Growth rate was excellent with one group achieving almost 500 g/day. Average growth rate was 458 g/day on Farm 1 and 440 g/day on Farm 2. With one exception, ostriches selected the high energy diet in a ratio of about 1.5:1.0. Feed conversion ratio (FCR) was about 3:1. The producer on Farm 2 used his commercial formulation and ostriches gained only 362 g/day.

In the second free-choice experiment, four diets were formulated. These were (1) high protein-high energy; (2) high protein-low energy; (3) low protein-high energy; and (4) low protein-low energy. There were six combinations of the four diets. Three on-farm collaborators were identified, but only one was prepared to undertake the trial work. The diets contained either 12.l5 or 8.5 MJ/AME/kg, and 200 or 130 g crude protein/kg. The results in Table 4 show that ostriches with access only to low-protein diets grew slowly, while those offered combinations of the two high-protein diets grew the fastest. The most economical group was birds on the combination of high protein high energy – low protein high energy diets. The high protein-high energy diets were consumed in highest amounts.

In the third free choice experiment, diets differed from previously. The four diets, either low or high energy, had protein levels that contained high or low lysine with other essential amino acids adjusted accordingly. Ostriches with access only to the low-lysine diets grew the slowest (355 g/day) while those with access only to the high-lysine diets grew most rapidly (410 g/day). When given a choice, birds consumed over twice as much of the high protein-high energy diet than the other choice. The choice-feeding approach offers opportunity for two diets to be offered in practice, one cheap and of low nutritional value, the second more expensive, and in this way the birds would select, allowing total feed costs to be kept to a minimum, yet giving acceptable growth.

A fourth free-choice experiment replicated the previous one. Results were generally similar and growth rate varied from 290 to 342 g/d. Again feed costs/kg weight gain varied widely, giving opportunity to provide birds with a choice of high- and low- quality diets that would reduce feed costs overall. Lysine (g/kg gain) fluctuated considerably from as low as 31 to a high of 54, again giving considerable opportunity to make savings.

Low cost portable paddock shelters for ostriches were designed and constructed at QPRDC. These proved to be highly successful.

Because emphasis has changed from more intensive production systems, focussing on meat production and rapid growth, to more extensive slower-growing systems to provide quality hides, greater reliance on grazing becomes a more attractive option. There was a preliminary trial and a more detailed experiment. In both, a high-quality diet was offered in various amounts from appetite to 50-60% of appetite (*ad libitum*) to 100%.

Dry matter was measured using a pasture probe. In the preliminary trial, pasture intake was estimated to be 648-858 g dry matter/day. Average daily gain was 300 g/bird day^{-1} for those fed to appetite to 248 g/day for those given concentrate feed at 50% of appetite. The results suggested that substantial amounts of concentrate feed can be replaced by grazing if the pasture is of good quality. In the second trial, pasture growth and grazing area were measured. Quality of pasture was poor; low in crude protein and high in fibre. Pasture intake was highly variable (185-315 g/bird d^{-1}). Growth rate was slightly higher than in Trial 1. One group reached 95 kg after 140 days on experiment. The weather was inclement and this may have interfered with normal grazing behaviour. Intake of concentrate feed suggested that although pasture intake was sometimes over 300 g/bird, the quality was such that it may not have been well utilised. This may explain differences in performance between the two grazing experiments.

In the last part of this study, we examined the concept of “no frills” feeding. This was aimed at mature ostriches during maintenance and reproduction and at producers who could access raw ingredients such as whole grains, and legume seeds such as peas and lupins. A supplement containing a low-cost mineral and vitamin premix was designed according to whether the hen was in lay or not. The feed costs were reduced greatly, and although very long term trials could not be undertaken, farmers who trialed the “no frills” feeding system were pleased with the outcomes.

The original objectives of the research program were met, with some additional work undertaken and specialised equipment constructed and tested on-farm.

1. Introduction

A history of the early ostrich industry and ostrich systems and practices in Australia was described by Hastings (1994). Very recently the ostrich industry has undergone dramatic changes, and in some cases causing severe hardship to producers. Initially the industry went through a stage of rapid expansion during which time breeding stock commanded enormous prices and some producers became wealthy. Those that bought stock generally fared badly, particularly when the industry changed from the breeding to the production phase. Prior to this the industry could afford very expensive diets and feed manufacturers and others used generous specifications based on poultry species. Additives designed to boost performance and reduce some metabolic diseases and nutrition-related disorders were included, often with little evidence of their effectiveness.

It was soon recognised that feed costs for growing birds were as high as 70% of total production costs and it would be necessary to reduce feed costs if the industry was to remain viable.

During the past six years, the main focus of the industry has been on meat production, with little attention being paid to leather. In South Africa, meat and feathers account for much less than half of product income and leather provides the major share.

Until very recently, rapid growth of meat-type birds has been the main aim of the producer. To meet this objective, diets of high nutritive content were formulated particularly to 50 kg liveweight. The aim was to reach 95 kg by about 9-10 months of age. Invariably this resulted in a carcass that had excess fat, which not only reduced lean meat yield and quality, but also reduced grade of the hide.

In the past 10 years, many countries throughout the world, notably Israel and France, have established ostrich industries. These countries are much closer to markets than Australia. South Africa, the world's largest producer of ostrich meat and leather, has for many years established markets for both products, and has a sound infrastructure in place. The upshot was that the Australian ostrich industry not only had difficulty in penetrating these markets but was unable to produce a constant supply of high-quality meat at a competitive price.

Consumption of ostrich meat in Australia, despite its reputed health benefits, is unlikely to be significant as long as the price of traditional meats remains low. In addition there is increased competition from other newly-emerging species such as kangaroos, crocodiles and emus.

It has recently become clear that the ostrich industry should focus on leather rather than on meat and arrangements have been made to export the ostrich hides to South Africa to have them tanned, since the technical expertise is well established there. This has changed the method of ostrich production in Australia particularly in reducing growth rate and there is greater focus on pasture-based systems.

There is little information on the nutritional needs of ostriches. Basic knowledge was reported by Swart (1987) on the digestive physiology of the ostrich and other aspects.

Du Preez (1991) and more recently Smith *et al.* (1995) have contributed substantially to knowledge of nutritional needs of ostriches. Van Niekerk (1997 a,b,c) provided recent recommendations for the nutritional requirements of growing and adult birds and on nutritional practices (Van Niekerk 1995).

There are still large gaps in our knowledge of how and what we should feed both adult and growing birds in Australia; what forage sources may be substituted for expensive lucerne; and in view of the recent change in emphasis of some producers from meat production to leather production, how and what should we be feeding these birds.

2. Objectives of Study

The original objectives of this research proposal were:

- To survey current management practices that relate to behaviour, grazing and housing of ostriches and to determine the on-farm facilities that will allow collaborative on-farm trials to be conducted with ostrich producers.

- To examine the range of likely feed ingredients and alternative ingredients (particularly roughages) that will be commonly used by the ostrich industry and to determine the nutritive value of some of these feedstuffs using experimental means.

- To test the ability of ostriches to select their nutrient needs from a range of ingredients and to study ostrich behaviour particularly in relation to feeding.

- To test and provide the ostrich industry with practical diet formulations for all phases of production recognising that part of their dietary needs may be obtained from pasture. Attempts will be made to estimate pasture intake of ostriches and separate this from concentrate intake.

- The main objective is to formulate cost-effective diets and recommend best feeding practice for the different phases of production and reproduction and for bird health.

Because of unforeseen circumstances it was necessary to modify some of these objectives. This was due to a rapid and severe downturn in the ostrich industry and to inclement weather which affected proposed on-farm studies as well as planned grazing studies.

The main focus of the research was to:

(i) Obtain current information on all aspects of the ostrich industry from producers in Queensland and Northern New South Wales.

(ii) Determine the apparent metabolisable energy of roughages in the diets of ostriches, emus and adult cockerels.

(iii) To determine the ability of ostriches to select from two diets that varied greatly in their protein and energy content.

(iv) To assess the contribution of pasture to the nutritional needs of growing birds.

(v) To design and test low-cost diets for breeding and non-breeding adult birds.

3. Materials and Methods (General)

Ostrich chicks of mixed breeds and sexes were purchased at 10-20 kg liveweight from producers for the grazing experiments and for the determination of metabolisable energy experiment. Emus and adult cockerels were provided by the Queensland Poultry Research and Development Centre from their on-farm stock.

On-farm, choice feeding trials relied on the producer to provide suitable birds of required liveweight.

Before any on-farm trials commenced, a survey of farmers who would be willing to collaborate was undertaken by a University of Queensland student, Ms Sarah Meibusch. Details of the survey, background information and outcomes are given in Appendix I.

Due to the decline in the industry, it was possible to work with only two producers in the choice-feeding trials.

4. Results of Survey of Ostrich Producers

Details of the survey and original findings as reported are presented here.

The Ostrich Industry in Queensland and Northern New South Wales

Results of a Survey Conducted by the Queensland Poultry Research and Development Centre, PO Box 327, Cleveland Q 4163

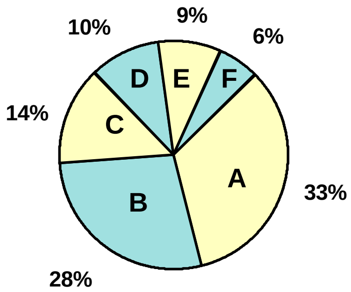
BACKGROUND

- A project funded jointly by the Rural Industries Research and Development Corporation and the Australian Ostrich Association is now in progress at the Queensland Poultry Research and Development Centre. The purpose of the project is to examine the nutrition of ostriches and their management. The aim is to produce more cost-effective diets for the industry. It was first necessary to obtain information on the present status of the ostrich industry in Australia in order to establish research priorities.
- A detailed survey form was distributed in January 1997 to 618 producers in Northern New South Wales and Queensland. There were about 160 responses and **we are grateful to those ostrich producers who spent time completing the survey questionnaire.**
- A preliminary report of this survey is given here.

4.1 SOURCES OF ASSISTANCE AND INFORMATION

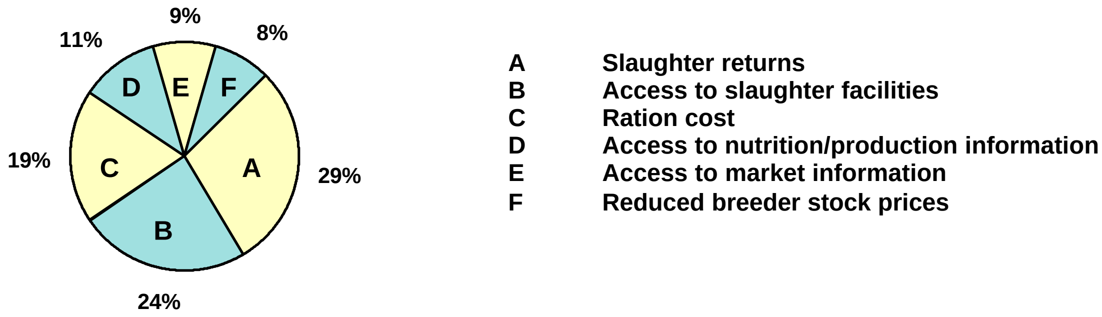
- In order to obtain information on sources of nutritional and veterinary assistance we asked several questions.

(a) *Where did you get your information on flock management and nutrition? The responses were:*

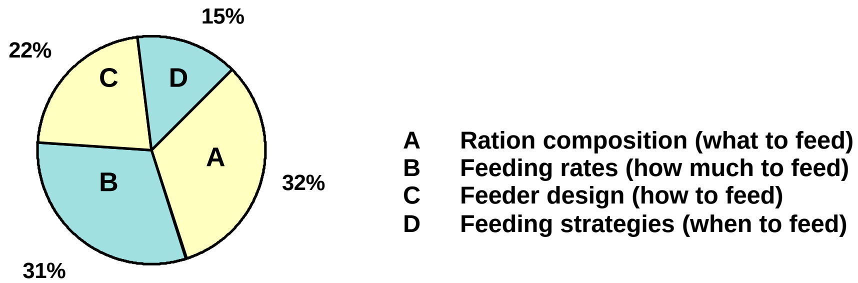


A	**From other growers**
B	**From industry newsletter**
C	**From feed supplier**
D	**From veterinarians**
E	**From field days**
F	**From consultancy**

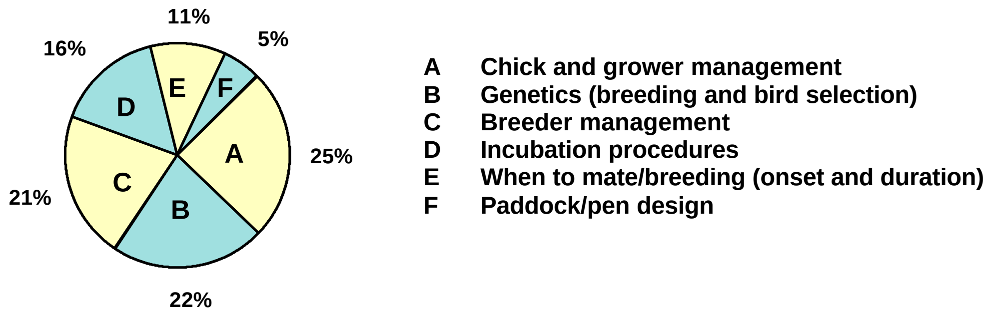
(b) *What are the **most important** factors affecting farmers outlook for the industry.*



(c) *What nutritional information do you need to make your business more profitable?*



(d) *Information on different management areas was requested.*



Comment

⇒ Slaughter returns and slaughter facilities were seen to be very important while there was clearly need to provide ostrich growers with information in the general area of feeding and nutrition. Management of the young chick, breeder management and bird selection were also identified as high priority. Information on ostrich practices was generally sourced from other growers and industry newsletters.

⇒ Other factors considered to be important to the producer were: high feed prices, chick mortality, markets for products and ‘cheats’ in the ostrich industry.

4.2 THE PEOPLE

- In order to learn something about the people in the industry and their future plans, we sought the following information.

(a) *(i) Your length of time in the Ostrich Industry, (ii) whether it was a full-time or part-time occupation, and (iii) whether it was owner-operated or run as a partnership.*

(i) PERIOD OF INVOLVEMENT

< 1 year	6%
1-5 years	83%
> 5 years	11%

(ii) OCCUPATION

Full-time occupation	Part-time occupation
40%	60%

(iii) OPERATION

Owner-operated	Partnerships	Others
81%	14%	5%

(b) *Before joining the ostrich industry did producers have an involvement with other livestock species.*

Yes	No
73%	27%

(c) *A question was asked about incubation of eggs*

Egg Incubation	Yes	No
Do you operate your own incubator?	48%	52%
Do you plan to do so in the future?	69%	31%

Comment

⇒ The majority of farmers are part-time ostrich producers and most had previous experience with other forms of livestock and most had several years of experience with ostriches. Only a few producers are in partnerships. About half of the producers surveyed ran their own incubator, and it appears this trend will increase in the future.

4.3 THE FARMING OPERATION

- The nature of the farming operation focussed on stock details, management, mating regimes and hatching.

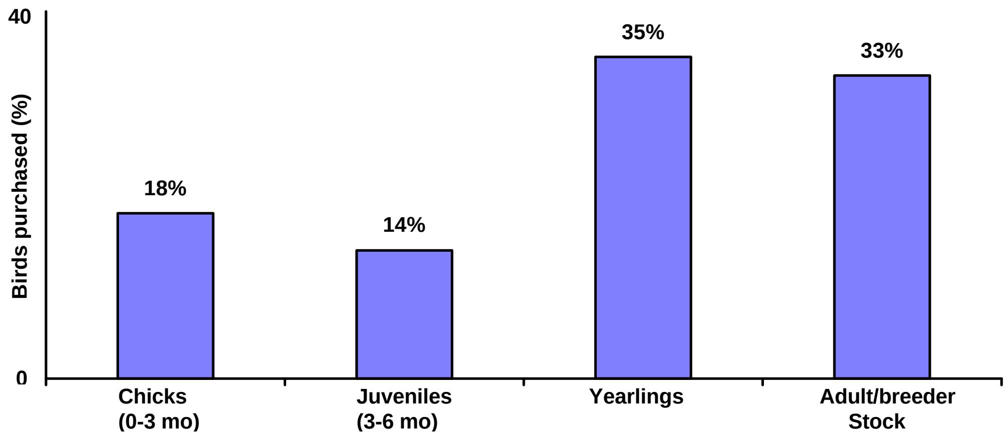
(a) We wanted to know more about:

(i) THE ORIGIN OF THE OSTRICH FLOCK IS GIVEN HERE

Origin of ostrich flock	**Australian**		**Zimbabwe blue**		**F1 Crosses**		**Other**	
	1996	1997	1996	1997	1996	1997	1996	1997
Number of birds	2779	9918	96	188	596	1057	1209	1542
% of total flock	59.4%	71.9%	2.1%	1.9%	12.7%	10.7%	25.8%	15.6%

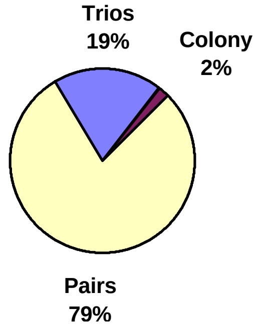
- About 58% of birds were purchased and 42% were hatched and raised by the owner.

(i) THEY WERE PURCHASED AT THE FOLLOWING AGES

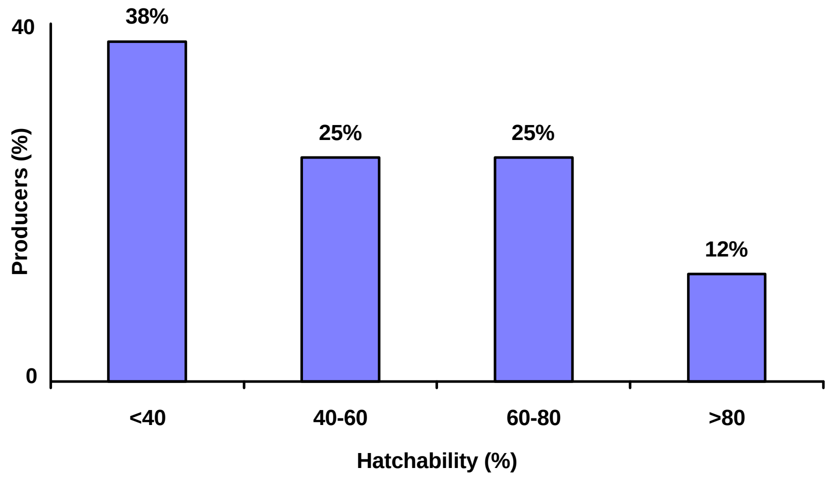


- Of the 18 056 birds on farms: 34% were chicks, 12% were juveniles, 29% were yearlings and 25% adult/breeder birds.
- The majority (57%) were not satisfied with breeder performance.
- Of the 2 548 breeder birds: 46% are males and 54% females

(i) THEY WERE MANAGED IN THE FOLLOWING WAYS



- There was a question on incubation and hatchability including infertile eggs (eggs hatched/eggs incubated). The response was as follows



Comment

⇒ Most birds originated within Australia and very few were imported. The most common ages at which ostriches were purchased were as yearlings and adults (68%). Breeding birds are kept largely in pairs (79%) and many producers were dissatisfied with breeder performance. This is partly because of a rather low (but not unexpected) hatchability. Only 11% of farmers weighed their growing ostriches but most (85%) were satisfied with their rate of growth.

4.4 FLOCK NUTRITION

- The feeding of ostriches is the most costly production component. Detailed information in this area is most important.

- Source of feed, in what form it was offered, and to what birds it was fed, were important questions.

(a) The first question was the proportion of producers that purchased feed.

Purchased feed	On-farm mixing
77%	23%

- However most farmers (94%) relied to some extent on commercial products such as feed additives, minerals and vitamin premixes or a grain balancer. Most (80%) of the diets contained some lucerne chaff as a source of roughage and >95% of all diets used contained some roughage (including lucerne) in one form or another.

(a) The form in which the diet was offered was also reported.

	Pellets	**Combination†**	**Mash**	**Whole grain**
Chicks	25%	19%	5%	5%
Juveniles	32%	43%	7%	18%
Yearlings	35%	34%	4%	27%
Adults	39%	42%	2%	17%

† Mixture of pellets and mash and/or grain.

- Farmers who purchased feed regularly did so on the following basis:

Three months	**Two months**	**Monthly**	**Two weeks**	**Weekly**
2%	6%	41%	39%	10%

- Many farmers (61%) changed their feed supply in the past six months due to cost (42%) and (23%) because of poor performance.

- The amount of mixed feed or grain (kg/week) given to ostriches in the different age categories and the number of producers surveyed that fed them were:

Feed (kg/week)	**0-20**	**20-50**	**50-100**	**100-200**	**200-250**	**250-500**	**500-1500**	**1500-2000**	**2000-3000**	**3000-4000**	**4000-5000**
Chicks	50		37.5			9.8	1.5				
Growers		53	9.0	34					3.0		
Yearlings	33			49		14				4.0	
Juveniles		43	36	13.5				6.5			
Adult/breeder		53			42		2.7				1.8

- The majority of farmers (55%) believed that pasture made a ‘significant contribution’ to the diet of ostriches, 38% suggested ‘some contribution’ and 6% ‘none’. Only 19% of farmers irrigated their pasture regularly.

- When asked where they obtained drinking water from for ostriches, 26% came from dams, 23% from bores, 10.4% from creeks and only 8% from town supply.

Comment

⇒ Almost all farmers rely on feed manufacturers but many were dissatisfied with price and to a lesser extent with bird performance. Although many felt pasture was an important feed, only very few gave their birds a consistently high-quality irrigated pasture. The form in which the feed was given varied according to the age of the ostrich. Largely mash was given to chickens but thereafter pellets or a combination of pellets and mash/whole grain was offered. Feed was usually purchased on a monthly basis.

4.5 FUTURE OF THE OSTRICH INDUSTRY

- Prospects for the industry and some producers' plans for the future were requested and these are summarised in the following table.

Statements	1†	2	3	4
The outlook for the industry is better now than ever	18	48	24	10
The future for my business is in the supply of breeding stock	8.6	30	47	14
The future for my business is in commercial leather production	8.7	59	25	7.4
I intend concentrating my efforts on one phase of production e.g. chick rearing or growing out birds for slaughter	21	34	35	11
I intend growing my birds intensively from hatch to slaughter	28	40	22	11
I intend using pasture as a major component of the ration for grower/finisher birds	19	45	29	7.2
I am waiting for clearer market signals before deciding the future direction of my ostrich business	29	27	29	17

† 1 strongly agree, 2 agree, 3 disagree, 4 strongly disagree.

Comment

⇒ Most producers (48%) feel that the future of the ostrich industry is good. Some farmers (38.6%) felt that income would come from the supply of breeding stock. The majority intend using pasture as a component of the diet and many (56%) are awaiting clearer market signals before making future decisions regarding their enterprise.

4.6 CONCLUSIONS

This survey was restricted to Queensland and northern New South Wales. Responses by ostrich producers from other regions may have been different and priorities not in the same order as those given here. Nevertheless some very important information was obtained which will be of great interest and value to those involved in different capacities that relate to the ostrich industry. As would be anticipated, slaughter returns and access to slaughter facilities were seen to be of great importance. However diet costs, diet composition and the contribution of pasture were all seen as significant performance indicators for industry development. How much feed should be given to ostriches was also rated as very important information and improved breeding also rated highly.

Producers were optimistic, if a little cautious, about the future of the ostrich industry. This survey will hopefully guide the industry leaders in establishing its future needs and priorities.

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This report was presented in June 1997. Because of the rapid change that has occurred, information and survey of results are mainly of historical interest and may often bear little relevance to the industry in 2000.

5. Measurement of Apparent Metabolisable Energy of Roughage Sources

There has historically been considerable reliance in the ostrich industry, world-wide, on lucerne either as a source of dietary fibre or for grazing. In Australia, lucerne is expensive particularly high-quality lucerne meal because it usually requires good soil type, fertiliser application and irrigation.

There is some debate as to the importance and level of fibre in ostrich diets (Farrell, 1997). The question is, whether fibre is needed for gut function, or are the end-products of fibre fermentation (steam volatile fatty acids) critical to the well-being of the bird?

We investigated the use of four fibre sources when included at 200 g/kg of diet when fed to growing ostriches, emus and adult cockerels. The reason was to examine the possibility of using cockerels as an assay bird for the two other species of ratites.

5.1 Materials and Methods

Five ostriches, five emus and five adult cockerels (White Leghorn strain cross) were used in a Latin Square design. Ostriches and emus weighed initially 10 kg and were hatched between 2-11 January 1998 and 13-20 October 1997 respectively. The cockerels were not weighed but were about 4 kg. Measurements were made at two different ages on the emus only.

Ostriches and emus were housed individually in small pens (1.85 m long x 0.93m wide x 1.20 m high) in a fully-enclosed house on rubber mats to allow collection of excreta. They were given food and water *ad libitum* in suitable containers. Natural day-light was the only source of lighting.

Adult cockerels were housed in individual wire-mesh cages designed specifically to measure AME of feeds (Farrell 1978). Suitable feeders to minimise spillage were attached to the outside of cages and hen float type drinkers delivered water.

Data were analysed using an analysis of variance and the least-significant difference (LSD) and a computer package (SAS).

Dry matter of feed and excreta was determined at 75^{o}C to constant weight in a forced-draft oven. Energy was measured on samples of feed and excreta in a CP500 automatic bomb calorimeter. Acid insoluble ash (AIA) was used as an inert indicator to measure dry matter digestibility (Van Keulen and Young 1977) of ostriches and emus. Bentonite was added at 10 g/kg diet to increase AIA content. Neutral detergent fibre (NDF) of diets was measured according to the method of the AOAC (1990).

The rapid method of Farrell *et al.* (1991) was used to determine the AME of diets with cockerels when birds were on the diets for at least three days. Ostriches were given the experimental diets for five days prior to a two day collection of excreta. Emus were allowed to adapt for three days followed by a two day collection due to their faster feed passage than ostriches.

The basal diet (A) contained per kg, wheat (433 g), sorghum (433 g), soybean meal (24 g), fishmeal (68 g), molasses (30 g), bentonite (10 g), vitamin and mineral premix (2 g) and dicalcium phosphate (10 g). Four sources of roughage, wheat pollard (B) or milled lucerne meal (C) or milled Rhodes grass (D) or milled wheat straw (E), replaced 200 g/kg of basal diet.

5.2 Results and Discussion

The NDF (g/kg) content of the basal diet was 97, of the pollard diet 143, the lucerne diet 162, the Rhodes grass diet 217 and of the wheat straw diet 228. Generally speaking the increase in NDF of diets was associated with a concomitant decline in dry matter digestibility and in AME values. Results are given in Table 1.

Overall there were significant effects ($P<0.01$) of species, diets and a species x diet interaction. For the three species, the basal diet gave the highest DM digestibility coefficient and AME. There was no difference ($P>0.05$) in the mean AME (MJ/kg) or DM of emus at the two different liveweights; mean values were 13.28 and 13.23, and 0.67 and 0.66 respectively. However the values for the lucerne meal diet for the older emus seem to be questionable. Although very variable, there is no explanation for the very low dry matter digestibility value. A leg injury to one of the emus reduced the number of older birds to four. There was a large improvement in the AME of the pollard diet when measured with the older compared to the younger birds (14.51 vs 12.78) . Mean dry matter digestibility and AME values were not different ($P>0.05$) between cockerels and emus at either age. Changes in the DM digestibility and AME values of cockerels were similar to those of the two other species.

Both DM digestibility and AME of the diets when fed to ostriches were much higher than when fed to emus and cockerels. Ostriches were observed to practise coprophagy on all diets. This practice was prevented in other studies particularly those in South Africa where AME measurements were made on birds fitted with canvas collection bags in metabolism crates (Cilliers *et al.* 1998). This did not allow ostriches to recycle their excreta.

No attempt has been made to calculate the apparent dry matter digestibility of the forage *per se*. The small inclusion of 200 g/kg is too low to give satisfactory results, although the amount is around that used in practice in formulated diets for ostriches.

It is recognised that for feedstuffs high in fibre, ostriches have a much better capacity to digest these than do adult cockerels. Cilliers *et al.* (1994) found that the AME of lucerne was 8.6 MJ/kg for ostriches compared with 4.0 in adult cockerels. This large difference can be explained by the very large caeca and proximal colon in ostriches (Swart 1987). The emu on the other hand has a digestive system not unlike that of chickens and the similar AME values for the diets were expected.

The similarity in values for emus at two different ages is in agreement with data for ostriches. Cilliers *et al.* (1998) found no difference in the AME values of adult (110-112 kg) and growing (50-60 kg) ostriches for lucerne and barley.

It is concluded that AME values of diets for adult cockerels apply well to the same diets when fed to emus. They should not be applied to ostriches especially when the diets are high in fibre.

It is uncertain whether ostriches in the wild recycle their excreta or whether this is a behavioural response to confinement. Coprophagy was not observed to any extent by emus.

TABLE 1. Dry matter (DM) digestibility coefficients and apparent metabolisable energy. (AME, MJ/kg DM) of ostriches aged 4-5 months, emus aged 4-5 months and 9 months, and adult cockerels on diets with different sources of roughage.

	Emus				Ostriches		Cockerels	
	(11 kg, n = 5)		(21 kg, N = 4)		(10 kg, n = 5)		(n = 6)	
Diet	DM	AME	DM	AME	DM	AME	DM	AME
A Basal (b)	0.79[a][1]	15.65[a]	0.74[a]	14.88[a]	0.96[a]	18.31[a]	0.73[a]	14.96[a]
B (b) + Pollard	0.64[b]	12.78[b]	0.72[ab]	14.51[a]	0.93[a]	17.82[a]	0.69[b]	14.15[b]
C (b) + Lucerne	0.65[b]	12.79[b]	0.54[a]	11.08[c]	0.94[a]	18.22[a]	0.69[b]	14.04[b]
D (b) + Rhodes grass	0.62[b]	12.32[b]	0.64[c]	12.86[b]	0.85[b]	16.13[b]	0.65[c]	13.12[c]
E (b) + Wheat st	0.65[b]	12.85[b]	0.64[bc]	12.83[b]	0.84[b]	16.26[b]	0.61[d]	12.63[d]
SEM	0.057	1.004	0.040	0.659	0.039	0.718	0.020	0.155

[1] Values within a column with different superscripts are significantly different ($P<0.05$).

6. Free Choice Experiments

6.1 Experiment 1

Introduction

The concept of allowing animals to select diets according to their nutritional needs when given a choice is not new (Emmans 1977; Anonymous 1992). The purpose of such experiments is to identify how their nutrient requirements change with age by allowing birds to choose between diets that vary considerably in energy and protein (amino acids) but are otherwise complete. There is also opportunity to reduce diet costs.

To our knowledge such experiments have not been undertaken with ostriches. We therefore undertook four such studies on-farm. Since it was not possible to replicate treatments on a second farm at the same time, statistical analyses have had to be kept to a minimum.

There were four experiments. The first was a preliminary experiment (Experiment 1) run simultaneously on two farms. The remainder were run on a single farm near Gin Gin, Queensland.

Materials and Methods

Prior to commencement of the preliminary trial, self-feeders were designed to prevent any spillage and then tested. Two diets were formulated using conventional ingredients; one had 10.2 MJ AME/kg and a crude fibre content of 60 g/kg, the other an AME of 7.6 MJ AME/kg (Appendix II). A commercial vitamin and mineral premix prepared by a commercial feed company was purchased and used in this experiment. Six ostriches per pen each weighed initially about 23 kg and the trial ran for 10-12 weeks. There were three groups on each farm. They were weighed at regular intervals, held in small paddocks with little pasture cover and there was a shelter in which two feeders were placed side by side. Ostriches were allowed a few days to adjust to feeders and pelleted diets before the experiment commenced.

The manager of one of the farms, for comparative purposes, gave a similar group of birds his regular commercial diet.

Results and Discussion

Results are given in Table 2.

Except for pen 1 on Farm 1, there was excellent agreement between groups, between pens on both farms. Birds selected much more of the high energy than the low energy diet. This was generally in the ratio of about 60:40. Feed conversion ratio was similar for all pens. Agreement between pens in total AME intake was for each farm remarkably constant. For Farm 1, it was 6012, 6299 and 6292 MJ; for Farm 2, it was 5615, 5646 and 5464 MJ for the three pens. These results indicate that not only can ostriches when given a choice select reasonably consistently between diets, but their mean total AME intake is remarkably similar.

TABLE 2. Growth rate, feed consumption and FCR of three replicate groups each of six ostriches given choice of a high-energy (HE) and low-energy (LE) diets and grown for 77-84 days on farm (Experiment 1 free-choice).

Pen	Age (days)	Liveweight (kg)		Average daily gain (g/bird day $^{-1}$)	Feed intake (kg/pen) And ratio			Ratio (LE:HE)	FCR
Farm 1	S[1] F	S	F						
1	126-210	21	58	435	LE 423 HE 274	697	0.60 0.40	1.5:1	3.2
2	143-227	24	65	490	LE 276 HE 412	688	0.40 0.60	1:1.5	2.8
3	153-237	25	63	450	LE 304 HE 391	695	0.44 0.56	1:1.3	3.1
Farm 2									
1	196-273	22	55	423	LE 250 HE 364	614	0.41 0.59	1:1.5	3.1
2	186-263	27	61	449	LE 212 HE 396	608	0.35 0.65	1:1.9	2.9
3	171-248	23	57	447	LE 241 HE 357	598	0.40 0.60	1:1.2	2.9

S[1] = start
F = finish

TABLE 3. Producer's own commercial feed (single diet) (Farm 2)[1]

Period	Days	Average liveweight (kg/bird)	Average daily gain (g/bird day^{-1})	Feed consumed (kg/pen)	FCR
02/10/97 – 01/12/97	60	14-34	331	267	2.24
01/12/97 – 22/12/97	21	34-43	448	136	2.41
Total period					
02/10/97 – 22/12/97	81	14-43	362	403	2.29

[1] Age of birds unknown.

Interestingly the mean daily growth rate of birds on Farm 1 was 458 g/day but, on the commercial diet, it was only 362 g/day (Table 3). Mean growth rate on Farm 2 was 440 g/day suggesting that there was little difference in genotype between farms.

The overall outcome of this preliminary trial suggested that the protocol, feeders, management and other procedures were of a sufficient standard to obtain meaningful results in self-selection experiments with ostriches on-farm.

6.2 Experiment 2

Introduction

The main purpose of this study was to construct cost-effective diets. It was not feasible to undertake long-term experiments to determine requirements for all dietary nutrients for ostriches in a three-year study. We were therefore concentrating initially on the two most important and costly components, protein (amino acids) and energy. The critical question was, how do the requirements for these two important nutrients change as the bird ages?

Presently diets are not formulated strictly to least cost, and specifications for nutrients tend to be overgenerous. We have already demonstrated in free choice (Experiment 1) that it is possible for the ostrich to select from two choices of feeds that differ in energy levels to meet their daily requirements. Using this information we planned to further test this concept using additional diets (4) and observe the change in ostrich nutrient requirements over time. This was both a nutrition and management study.

In Experiment 2, three on-farm collaborators were identified and detailed discussions of experimental protocol were undertaken.

There were four least-cost diets formulated:

(A) high protein (HP) and high-energy (HE);
(B) high-protein (HP) and low energy (LE);
(C) low protein (LP) and high-energy (HE);
(D) low-protein (LP) and low-energy (LE).

The ingredient composition is given in Appendix III while the special vitamin and mineral premix formulated at QPRDC is presented in Appendix IV.

The diets contained either 12.5 or 8.5 MJ AME/kg, and 200 or 130 g crude protein/kg. There were six combinations of the four diets given in two choices. However there was only one pen of six birds per treatment. Birds were weighed at the start of the experiment and again three times during the experiment. Mean starting liveweight was 21-25 kg and final weight was about 95 kg/bird, although this varied considerably.

Results

The mean values for bird performance and estimates of energy and protein intakes for each pen are given in Table 4. Adjustment has been made for the death of one ostrich in pens 21 and 23 from unknown causes. It is not possible to apply statistical analysis to these data as they are only for one farm. Although the diets were delivered to two other farms, neither producer was in a position to collaborate.

Details of the amounts of each of the two diets consumed after 35, 70, 112, 147 and 168 days, as well as their percent contribution to the total, and the protein and energy intakes at these times, are given in Appendix V.

The results showed that birds not only grew at an acceptable rate, but overall differences in growth rate between most groups were small. However there were differences in the final liveweights when the experiment was terminated at 168 days. Energy and protein per kg of weight gain were different according to treatment. The combination of HP-LE and LP-HE (pen 24) gave the most economical outcome (Table 4).

In agreement with Experiment 1, total energy intake per pen was reasonably constant between pens. This was not so for protein intake. To some extent, this was imposed by the combination of diets offered. Ostriches given the two high-protein diets had little choice but to consume these to meet their energy needs and therefore took in more protein than they required for lean tissue accretion.

TABLE 4. Results of ostrich Experiment 2 (free choice).

Pen	Diets[1]	Gain (g/d)	Energy (MJ/kg)	Protein (kg/kg)	$/kg gain	FCR	Final weight[2] (kg)
21[1]	HP:HE HP:LE	448	59.6	0.86	1.18	4.3	95.1
22	HP:HE LP:HE	409	39.1	0.57	0.87	3.9	92.4
23[1]	HP:HE LP:LE	398	51.8	0.83	1.20	4.5	96.6
24	HP:LE LP:HE	426	36.2	0.56	0.77	3.4	92.1
25	HP:LE LP:LE	380	43.7	0.87	1.04	5.1	88.2
26	LP:HE LP:LE	372	43.3	0.54	0.84	4.1	99.8

[1] Diet costs: $228-297/ton (ingredients only)
CP: 13.0% or 20.4%
AME: 8.5 MJ/kg or 12.5 MJ AME/kg
[2] Average start weight 25.5 kg
70-168 days; rest 0-168 days

† HP = high protein
LP = low protein
HE = high energy
LE = low energy

A surprising outcome of this trial was the very constant relationship between the ratio of protein (g) and energy (MJ) over the duration of the study. This is contrary to conventional nutritional wisdom. It would be expected that, as ostriches age, the amount of protein required per MJ AME would decline as would lean tissue accretion (g/day). However other proteins deposited are in the form of skin and feathers. There is no information on the dietary protein requirements for these purposes which may be substantial at certain times during the growth cycle.

In conclusion, this free-choice feeding trial has provided us with useful information. It has demonstrated that growing ostriches can achieve a high level of performance when given low-protein diets. Birds on the two low-protein diets had an overall protein to energy ration of only 12.4 g/MJ AME. It should be noted that both the high- and low-protein diets contained protein of high quality.

6.3Experiment 3

In the previous experiment (2), ostriches in each pen maintained a reasonably constant ratio between protein and energy which was independent of age. Furthermore, birds with the lowest ratio (12.4 g/MJ AME) grew at a rapid rate reaching 100 kg at the end of 168 days on the experiment. However all diets contained protein of high quality. In the present study, there were four diets of either low or high energy and having a protein level that contained either 1.0 or 0.5 of the lysine requirement of the growing bird (Table 5). Several other essential amino acids in the diets were adjusted accordingly, and relative to lysine (Appendix VI).

TABLE 5. Calculated nutrient composition of the experimental diets

Diet		**Energy (MJ AME/kg)**	**Crude protein (g/kg)**	**Lysine (g/kg)**	**Lysine (g)/MJ AME**
A	HP-HE	12.5	256	12	0.96
B	HP-LE	9.0	261	12	1.33
C	LP-LE	9.0	143	6	0.67
D	LP-HE	12.5	146	6	0.48

These diets were fed to groups of six growing ostriches on the same farm as in Experiment 2.

Birds and feed were weighed at the start and afterwards at regular intervals on days 35, 63, 97, 125 and 158.

Results and Discussion

Results are summarised in Table 6 and are given in more detail in Appendix VII.

TABLE 6. Results of ostrich Experiment 3 (free choice)

Pen	Diets[1,2]	Gain (g/d)	Energy (MJ/kg)	Protein (kg/kg)	$/kg gain	FCR	Final weight (kg/bird)[3]
22	HP:HE HP:LE	410	52.5	1.17	1.44	4.6	93.4
23	HP:LE LP:LE	391	48.7	0.98	1.02	5.6	88.3
24	HP:HE LP:LE	376	56.6	1.13	1.46	4.8	91.6
25	HP:HE LP:HE	390	55.7	1.01	1.19	4.4	90.4
26	HP:LE LP:HE	367	52.0	1.01	1.24	4.9	85.3
27	LP:HE LP:LE	355	53.7	0.73	1.04	5.1	84.4

[1] HP = high protein
LP = low protein
HE = high energy
LE = low energy

[2] Diet costs: $185-333/tonne (ingredients only)
CP: 14.0% or 25%
AME: 9 or 12.5 MJ AME/kg

[3] Average starting weight 28.5 kg

Growth rate was satisfactory but protein and energy intake and food costs per kg of gain were higher than in the previous trial with poorer FCR. No birds died during this trial but final liveweight differed considerably between groups.

As in the previous trial, the ratio of protein to energy remained relatively constant at different ages (Appendix VII) on the same diet. The amount of lysine (g) per kg of liveweight gain was very much lower (30.3) for pen 27. These ostriches were on two choices both of which were low in protein and the birds did not have the option to select for lysine. These birds grew at the slowest rate of any pen and they selected essentially equal amounts of the two choices offered. It would seem that about 50 g lysine per kg liveweight gain is needed for fast-growing birds. On the other hand focus has changed from a fast-growing to a slower-growing ostrich because of the greater emphasis on production of leather and less on meat. Birds that reach about 95 kg in over 12 months is one aim of the producer allowing the use of diets with lower nutrient specifications or restricted feeding of high-quality diets.

6.4 Experiment 4

This experiment was again undertaken at Lagoon Park. It replicated Experiment 3 and diets were the same. It was terminated after 150 days when individual birds had reached about 85 kg liveweight.

Growth rate was not quite as high as in the previous experiment although FCR was generally better on several diets (Table 7). Energy and protein, expressed per kg of gain, were also similar to those found previously. One bird died in pen D22. This occurred on the day following weighing and recording bodyweight and feed; accurate adjustment was made for this loss. Except for pen C24, all groups grew at about the same rate. This was not the case in Experiment 3 (Table 6).

Protein per kg of gain was lowest on D24 because the choice was from two low-protein diets. Protein when expressed as g/MJ AME was 15 for pen C23 and went as high as 23 for pen D23 (Appendix VIII).

These results again support the contention that ostriches, when given a choice of two diets, and provided both are not low energy, can grow at a satisfactory rate.

All diets were costed as previously for ingredients only. Amount per kg of gain was usually less than in Experiment 3, but generally in the same order. Clearly there was opportunity to reduce feed costs significantly.

TABLE 7. Results of ostrich Experiment 4 (free choice)[1]

Pen	Diets[1,2]	Gain (g/d)	Energy (MJ/kg)	Protein (kg/kg)	$/kg gain	FCR	Final weight (kg/bird)[3]
C22	HP:HE						
	HP:LE	314	53.3	1.17	1.19	3.6	84
C23	HP:HE						
	LP:HE	338	46.6	0.70	1.08	3.7	87
C24	HP:HE						
	LP:LE	290	53.5	0.96	1.23	4.3	79
D22	HP:LE						
	LP:HE	342	46.6	0.82	0.96	3.7	87
D23	HP:LE						
	LP:LE	329	47.4	1.11	1.27	5.3	84
D24	LP:HE						
	LP:LE	323	58.7	0.75	1.08	5.1	84

[1] See footnotes Table 6, Experiment 3 for abbreviations
[2] Feed costs as in Table 6
[3] Initial liveweight approximately 36 kg

Integrated Discussion of Choice Feeding Experiments

The four choice-feeding experiments showed that ostriches need a constant amount of energy to meet a particular target liveweight and can regulate their energy intake precisely. This is common to almost all other livestock species. It was evident that ostriches require a high protein diet at least during early growth. Those offered a high-protein diet during the period 25-95 kg showed the most rapid gain, particularly when the high protein was combined with high energy.

A consistent but surprising response was that when offered the high protein-high energy diet, they consistently chose this as they aged. When offered a combination of diets with low protein and low energy – low-protein and high energy they changed their choice as they grew older, generally favouring the low-energy diets.

Similarity between experiments in choice of diets (kg) on the different treatments is shown here.

Feed Intake (kg)

Diets	Experiment		
	2	**3**	**4**
A	1005	1274	1009
B	342	503	278
Lysine[1]	34.2	54.7	54.4
A	962	1410	775
D	333	290	343
Lysine	37.3	53.6	42.6
B	1046	1113	895
D	903	786	667
Lysine	40.0	52.6	49.7
A	961	1194	715
C	333	372	419
Lysine	30.6	46.1	36.9
B	694	899	932
C	771	798	527
Lysine	27.5	47.9	47.8
C	762	787	1032
D	792	920	462
Lysine	23.6	30.3	30.9

[1] g/kg gain

Lysine (g) required per kg of gain was much less in experiment 2. Diets contained much lower amounts of protein and lysine but with no loss in performance (Table 4). For diets A and B this was 0.85 and 0.96 % respectively, and for C and D it was 0.57 % for both. This suggests that growing ostriches can achieve good growth rates with low FCR on diets of lower protein than than those used in experiments 3 and 4.

The lysine per kg gain in experiments 3 and 4 was very similar on each choice except for treatments A and C.

In the last three free choice experiments, there was opportunity for significant cost savings to be made. Although birds did not grow the fastest on the high energy-high protein – high energy-low protein diets, feed efficiency was generally high and costs low in the three experiments.

Growth rate is plotted against age of bird (Figures 1, 2 and 3) for each of the six treatments for Experiments 2, 3 and 4. These graphs show that generally ostriches grew satisfactorily, particularly in relation to performance found in the field, where an average daily gain of 300 g/day is considered to be above average from hatch to 90 kg liveweight.

A criticism of these choice feeding experiments is the few birds used per treatment. The cost of undertaking such research is high, and diets were often provided at little or no cost as an inducement to farmers to cooperate and to provide accurate measurements. Nevertheless this approach to feeding birds can realize a significant saving in feed costs of 25-30%, at a time when the industry is struggling; this is not inconsiderable.

7. Grazing Trials

The digestive system of the ostrich is such that it can consume and digest large amounts of forage. In the wild, it depends entirely on foraging although growth is slow. There is very little information on grazing ostriches, although Balmanis *et al.* (1997) have undertaken experiments on ostriches given lucerne hay with access to pasture.

With greater emphasis on reducing feed costs and growing ostriches at a slower rate to produce leather of high quality, grazing of ostriches is a viable option.

We report here the results of two grazing trials. One was preliminary and an attempt was made to determine pasture intake; this was also done in the second trial but in a more sophisticated way.

7.1Materials and Methods

In both trials, birds had access to a mash diet provided daily in different amounts in a self-feeder. This contained 200 g protein/kg, and 12.1 MJ AME/kg (Appendix X). Rectangular fenced paddocks of 555 m^2 to 729 m^2 of mixed pasture species were established. These held four birds randomly allocated to each pen at a stocking rate of approximately 160 m^2/bird.

Pasture dry matter on offer was determined using a pasture probe (Filips Folding Plate Pasture Meter). This meter is used for measuring the amount of pasture in paddocks. The rising plate principle allows the meter to measure the average height of the pasture, adjusting for any variations in pasture density. Readings can then be converted to an amount of dry matter (DM), ready for use in feed budgeting. The meter's plate is calibrated for weight and area. During use the plate is supported by the pasture. The taller and denser the pasture, the further off the ground the plate sits. The shaft of the meter drops through the pasture to rest on the ground. The bottom counter records the position of the plate relative to the shaft, totalling the readings as each sample is taken. A sample counter at the top of the meter is used to record the number of samples taken in each paddock. The sample counter can be zeroed. Usually, 30 to 50 samples are taken in each paddock, and a simple formula is used to convert the average reading into an assessment of dry matter per hectare.

In the preliminary experiment, the meter was calibrated against 10 samples x 0.1 m^2 quadrants in which the cut grass was dried at 70°C to determine dry matter yield according to the instruction manual. At the end of the experiment 70 readings were made twice on each of the trial pens in a chequer board pattern. This allowed calculation of regression equations (r^2 = 0.877) and using these, the disappearance of pasture during the 84 day trial was calculated. Trial pens were assessed against an untouched pen as a control. No account was taken of pasture growth during this time. In the second trial, this was accounted for by clipping an ungrazed, protected area at regular intervals and the amount of dry matter determined. These samples were also used to calibrate the probe and chemical analyses of some samples were undertaken for nitrogen and neutral detergent fibre (NDF) following the procedure of the AOAC (1990). In the second trial only, due to inclement weather the area trampled and unfit for grazing was calculated in order to estimate the area containing edible herbage. Measurements of dry matter were adjusted accordingly.

In the preliminary trial there were four pens each of four ostriches weighing on average about 50 kg. One pen was given feed ‘to appetite’, other groups were given 80%, 70% and 60% of this amount.

In the second experiment, amounts offered were 50% and 70% of those fed to appetite (100%) and groups were replicated twice. Ostriches weighed on average 37 kg at the start of the experiment which ran for almost six months.

A portable, low-cost shelter was placed in each paddock. This allowed protection of feed and ostriches from inclement weather (Appendix IX). The shelter was designed by the staff at QPRDC and constructed on the site.

7.2Results and Discussion

The preliminary trial which ran for 84 days was undertaken in generally fine weather and the birds remained in good health. Results are given in Table 8.

TABLE 8. Results of the preliminary grazing trial of four ostriches per group each weighing on average 50 kg and supplemented with a concentrate feed at four different levels (Experiment 1)

Pen No	Feeding level (%)	Growth rate (g/d)	Feed intake (g/d)	Feed conversion ratio	Pasture[2] intake (g/day)
1	100	299	1.393	4.66 (6.98)[1]	703
2	80	254	1.125	4.42 (7.28)	720
3	70	279	0.998	3.57 (6.67)	858
4	60	248	0.868	3.50 (6.12)	648

[1] With ( ) and without pasture intake.
[2] Dry matter/ostrich.

Results show that ostriches given smaller amounts of concentrate feed consumed more dry matter per day except for those birds fed at 60% of appetite. However, one must be cautious when considering pasture intake here since measurements did not account for all sources and there is no estimate of pasture growth or quality during the period. Relative intakes between pens are likely to be reasonably accurate.

The second trial, undertaken in unseasonal weather and record rainfall, commenced when ostriches were on average 37 kg liveweight. Results in Table 9 show that those given essentially *ad libitum* feed grew at 345 and 408 g/day. Those in pen 1 achieved target liveweight of 95 kg liveweight in 140 days; other pens were terminated at 168 days when only one pen (6) on *ad libitum* intake reached 95 kg.

TABLE 9. Results of the ostrich grazing trial (Experiment2)

Pen No.	Feed allocation	Pasture[1] intake (g/d)	Feed (kg/d)	Growth rate (g/d)	Feed conversion ratio	Final weight (kg) [3]
1	100%	307	1.77	408	5.1 (4.3)[4]	94.5[2]
2	75%	259	1.31	297	5.3 (4.4)	87.0
3	50%	193	0.92	180	6.2 (5.1)	67.2
4	50%	315	0.92	212	5.9 (4.4)	72.5
5	75%	311	1.31	300	5.4 (4.3)	87.5
6	100%	185	1.73	345	5.4 (5.0)	94.9

[1] Dry matter/ostrich
[2] In 140 days others at 168 days
[3] Average starting weight (all groups) 37 kg
[4] With ( ) and without pasture intake

Estimates of pasture intake gave much lower amounts of dry matter (185-315 g/day) than in the preliminary trial. One reason for this is probably the poor quality of the pasture. Analyses of N and NDF support this conclusion. The crude protein (N x 6.25) of pasture samples did not exceed 8% and were as low as 4%. The results of the analyses are shown in Table 10.

Pasture available throughout both experiments consisted mainly of Rhodes, Kikuyu and white clover. Pens were slashed on two occasions during Experiment 2 to try and maintain pasture quality.

A factor which must be considered in interpreting these results was the very high rainfall that occurred during this second trial. The effect on grazing behaviour is uncertain but is unlikely to be positive.

The results of the two trials suggest that pasture can contribute significantly to the nutrition of the ostrich but the pasture must be of good quality.

In both experiments feed conversion ratio (FCR) was about 5:1 or less, and lower in the first trial than the second one. This enforces the point that pasture intake made a significant contribution to liveweight gain in the preliminary experiment and much less in the second one.

Studies in the US (Balmanis *et al.* 1997) on ostriches given a high forage diet and on pasture with over 50% of the diet supplemented with a high-quality feed showed that they grew at only 180 g/day with a FCR of 8.7 compared with a group given a complete pelleted diet. These latter ostriches grew at 326 g/day with a FCR of 6.6 and were 113 kg at slaughter; the other group reached only 98 kg.

It was obvious in both experiments that levels below 70% supplementation had a detrimental effect on growth although pasture was not of a good quality.

Both experiments indicate that ostriches can consume substantial amounts of pasture even if the quality is not high as was indicated in the second experiment. Dry matter intake was only about half of that observed in Experiment 1, when subjectively assessed pasture was of higher nutritive value. This was supported by a much lower concentrate feed intake in Experiment 1, and a weight gain that was almost as good as in Experiment 2.

TABLE 10. Neutral detergent fibre (NDF) and crude protein (CP) in g/kg DM of pasture samples collected at two monthly intervals during the second grazing trial

Pen	Time (MO)	NDF	CP
1	0	663	53
2	0	650	51
3	0	705	43
4	0	683	61
5	0	675	68
6	0	661	70
1	2	666	70
2	2	673	53
3	2	623	61
4	2	669	45
5	2	632	78
6	2	667	66
1	4	648	66
2	4	636	63
3	4	625	59
4	4	671	44
5	4	618	78
6	4	668	57
1	6	701	71
2	6	684	56
3	6	720	61
4	6	679	39
5	6	657	61
6	6	669	66

8. No Frills Feeding

The cost of maintaining adult ostriches can be high. Many feed manufacturers have frequently included expensive ingredients and additives of uncertain value to the bird.

Reproduction in ostriches has been a major problem in the industry. There appears to be not one cause, but good nutrition is essential to the reproducing hen.

Most ostrich farmers are not in a position to formulate diets for their birds nor to mix complete diets. However the possibility of using whole-grain diets based on simple formulations would save the producer substantial sums on feed. It is understood that these raw ingredients would be available to the ostrich producers at reasonable cost and could be sourced locally.

8.1 Methods

Maintenance. A single wholegrain is fed in a specified amount. This is supplemented with a grain balancer and a specially prepared supplement (concentrate mix). This includes a low-cost specially formulated low-cost mineral and vitamin premix (Appendix XI). The concentrated mix (Table 11) is designed to balance the grain. There are therefore only two components. A daily amount would be 1.2-1.5 kg of a grain plus 100 g of the supplement.

TABLE 11. Premix for 'no frills' feeding of adult birds for maintenance and egg production (g/kg)

	Maintenance	Egg production
Mineral and vitamin premix	15[1]	40[2]
Threonine		15
Methionine		10
Tryptosine		60
Lysine	30	25
Meat and bone meal	400	
Salt	30	70
Dicalcium phosphate	100	450
Molasses	40	40
Wheat	385	290

[1]See Appendix XI for details.
[2]See Appendix XII for details.

Reproduction. The same approach is used as for maintenance except that there is the need for additional protein and a different low-cost mineral and vitamin premix (Appendix XII) in the supplement (Table 11).

The daily ration could consist of 1.3-1.6 kg of whole grain, 200 g of whole lupins or 200 g of whole peas and 100 g of supplement. Calcium in the form of coarse limestone or shell grit should be given *ad libitum* in a separate container.

These diets were designed based on first principles. Energy and amino acid requirements for maintenance and the chemical composition of the egg and assumed a production rate of 60-70 eggs per year. Data were taken from the paper by du Preez (1991) and those of Van Niekerk (1997 a,b,c).

8.2 Results and Discussion

Outcomes are based mainly on field observations by four producers who trialed the ‘No Frills’ approach. Records were kept of birds held at QPRDC. In general there was variation among individual birds in body weight change. Where liveweight was recorded, on average a small decline was observed for non-reproducing adult ostriches with small gains during the breeding season. Some eggs were laid but the study did not continue long enough to determine hatchability. The ‘No Frills’ approach is most suitable for pairs or trios. Large groups tend to discriminate against shy feeders.

The approach to ‘No Frills’ feeding has great merit in reducing dramatically feed costs. Availability of high quality pasture would reduce the quantity of grain offered, particularly in non-breeding birds. For breeding hens, there may be opportunity to reduce the amount of whole grain and legume seeds offered but not the supplement. There is clearly a need for long-term experiments with records of egg production and hatchability in the case of laying hens, as well as bodyweight recorded for both hens and cocks.

The ‘No Frills’ concept can be used by individual producers. Adjustments will be necessary depending on the raw ingredients available, pasture quality and weight of ostriches.

8.3 Implications

The most important outcome is that historically ostriches were given diets that were over prescribed and therefore unnecessarily expensive. The research undertaken here showed that grazing can contribute substantially to their nutritional needs resulting in a reduced reliance on concentrate feed. A reduction of 20-25% appears to be possible for growing birds provided the pasture is of high quality, otherwise they can only poorly utilize stemmy material. However studies showed that fibre sources when included at 20% of a formulated pelleted diet could be utilised and will yield energy. The implications are that reliance on lucerne meal can be avoided and a milled grass/clover hay, millrun or even milled cereal straw are practical substitutes.

The ability of ostriches to select from two diets that differed significantly in either protein or energy allows substantial feed cost savings without compromising growth although feed efficiency will differ according to choices made. The implications are that a low energy-low protein diet offered with a diet of higher quality allows birds to select according to their nutritional needs. Slower growth of young ostriches will be more acceptable than previously because of a greater emphasis on high quality hides. The implications of the ‘No Frills’ feeding of adult birds, although preliminary in nature, offers wide scope for utilizing local feedstuffs provided they are cheap. However each producer must trial these feed combinations and amounts to suit his own stock taking into account pasture availability.

Significant outcomes of this project were the formulation of inexpensive mineral and vitamin premixes reported here; these should reduce substantially the cost of formulated feed. Other activities such as the construction of low-cost portable shelters to protect birds and feed, and the manufacture, on-farm, of a suitable portable crate for transporting ostriches long distances. The transporter is ideal for ‘on farm’ use due to its compact size 3.7 m (L) x 2.3 m (W) x 2.1 m (H) . It can be covered or open on top as well as 700 mm down the sides. A gap of 150 mm around the bottom also provides additional ventilation. The transporter has four compartments allowing it to carry twelve adult birds comfortably.

9. Recommendations

There is great opportunity for ostrich producers and feed manufacturers to reduce feed costs. It is estimated from this study that a realistic cost of feeding a bird grown to 95 kg will be not less than $130. This amount can be reduced to under $100 if good quality pasture is offered particularly from about 30 kg liveweight onwards.

Holding ostriches for slaughter or feeding adult birds can be kept to a minimum using the 'No Frills' approach as described in this report. Choice feeding in which birds are given opportunity to select from two diets that differ significantly in either protein or energy content (or both) should be further tested.

Lucerne meal can be substituted by low cost, low quality sources of fibre at about 20% of the diet. A reduction in performance will be either nil or marginal.

The change from growing ostriches largely for meat production to leather production means that they should be grown slower, giving great opportunity to further test the findings presented in this study.

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11. Appendices

APPENDIX I: Producer survey and collaboration

1. Most potential collaborators, (60%) appear reluctant to change their existing feed patterns and diets overnight.

2. Most would not be happy with changes that might affect their breeder flocks or breeding potential (60-70%).

3. Most do not have access to bird scales (60-70%).

4. Most think it's better to leave the birds alone (50%+) particularly chickens under three months of age.

5. Most cannot supply a lot of assistance (50%+).

6. Most do not have a crush or handling facilities (70% -20%).

7. Can only visit one farm/day as a general rule (potential disease transfer). Farmers are very conscious of hygiene albeit for the wrong reasons.

8. Need to gain confidence of collaborators quickly by tailored research.

A.O.A. is not keeping its members up to date eg slaughter information, Codes of Practice etc.

Benefits for collaborators

1. Birds fed by QPRDC (The Queensland Poultry Research and Development Centre) throughout the duration of the trial.
2. Benefits of research results first.
3. Lab facilities, DPI diagnostics.
4. Copies of Code of Practice.

Issues for QPRDC

Determine what are real problem areas and what have been farmer/farm/group responsibility e.g. egg incubation: is there a genuine problem requiring scientific research or is it a farmer/group issue associated with the practices and techniques used.

OSTRICH FARM COLLABORATOR LIST

No	Name	Farm Name	Postal Address	Farm Address	Phone No	Fax No	Visited	Survey
1	Alistaire/Sue McCreath	Jaabulani O/F	PO Box 257 Landsborough 4550		075 4941414	075 4941625	Y	Y
2	Peter/... Tompkins	Bimble O/F	PO Box 312 Tenterfield 2372	Bellevue Road Tenterfield	067 362142		Y	
3	Ross/ Wicks	Dakota Ostriches	M/S 780 Kingaroy		071 641142	071 641142	Y	
4	Rod/Colleen Mundt		M/S 205 Yandilla	Yandilla/Leyburn Road	076 655176		Y	
5	Rob/.... Hayes	Toorinbirra	M/S 1448 Chinchilla 4415		076 655282		Y	
6	Bill/Wendy Siedofsky	Woodlands O/F	PO Box 459 Gatton 4343	Woodlands Road Gatton	0754 627144		Y	
7	Barry/….. Blackmore	Blackmores O/F	PO Box 56 Gatton Road Esk	Gatton/Esk Road Esk	074 241641		Y	
8	Brian/….. McDeamott		Brooklands Road Gleneagle Beaudesert Q 4285	Brooklands Road Gleneagle Beaudesert Q 4285	075 5431159	075 5432052	Y	
9	Mark Shermer	Australian Emu and Ostrich Co	C/- Post Office Wallaville	Childers/Gin Gin Rd	071 576330	071 576326	Y	Y
10	Charles/.... McDonald	Australian Management Services O/F	220 Millstream Road Jimboomba Q 4280	220 Millstream Road Jimboomba Q 4280	075 5431183	075 5432122	Y	
11	Denis/Glynis Peacock	Warwick O/F…	M/S 848 Leslie Dam Road Warwick Q	Leslie Dam Road Warwick	076 619450		Y	Y
12	John Hoare/Phil Carver	Charra O/F	17 Yowani Street Robina 4226		075 5931918	075 5789181	N	Y
13	Andrew/.... Youngberry	Eden Farms	M/S 617 Highfields 4352		076 968311	076 968322	N	Y
14	Cathy & Stewart		Kingaroy					

COLLABORATOR IDENTIFICATION SHEET

Research Priority Areas		Survey Question	Influence		
			Farmer	Project Group QPRDC	Weighting
1.	Bird no’s - chicks, yearlings, breeders	1	Yes		10
2.	Pens - space, availability	2.2	Yes		9
3.	Feed - Identification of spec.	2.5 2.10	Yes ?	Yes ?	8
4.	Handling facilities - yearling, breeders		Yes	Yes	7
5.	Sales - Feed weighing - Bird weighing	 2.6	Yes Yes	 Yes	6(a) 6(b)
6.	Troughs - Type Feeding regime	2.3 (b) 2.4	Yes Yes	Yes Yes	5(a) 5(b)
7.	Pasture - type, consumption %	2.3(a)	Yes ?	Yes	4
8.	Accurate recording (record sheets)	3.2		Yes	3
9.	Location - within 3-4 hours			Yes	2
10.	Identification - pens/individual			Yes	1

PROCESS FOR IDENTIFICATION OF COLLABORATORS

Prioritise research areas
Check against “criteria for collaborators” form
Apply weighting

Short list priorities (Sarah Meibusch)

Farm Identification											
Category	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
10x1	9	5	10	3	8	4	7	6			Bird nos.
9x2	$8^?$	7^+	10^+	6^-	9^+	5^+	4^+	3^-			(+ - = chickens) Pens min
8x3	3	2	3	2	1.5	2	2.5	3			B/B F/S 0 3, 2, 1
7x4											
6x5	2	3	1	1	1	1	1	2			Scales: Feed = 1 Bird (S) = 1 Bird (L)= 1
5x6	2	2	2	1	2	2	2	2			Chick - self feeders = 1 Adult - self feeders = 1 Troughs = 1
4x7	3	5	4	3	1	6	3	3			Irrigated 3 Improved 2 Native 1
2x9	3	1	3^+	3^+	3^+	3	2	3^+			2-3 hrs = 3 3-4 hrs = 2 4+ = 1
TOTAL	**226**	**179**	**252+**	**129**	**199+**	**147**	**158**	**151+**			**+ Distance**
Farm Priority	2	4	1	8	3	7	5	6			

Ostrich Farms Visited – Good Research Collaborators						
Farm No.	**Name of Ostrich farm**	**Name of owner/manager**	**Address**	**What area for research**	**Comments**	**Priority rating**
1	Tenterfield Ostrich Breeders	Peter Tompkins	PO Box 312 Tenterfield Ph. 067 362 142	Chicks, growers		2
2		Rod and Colleen Muot	M/S 205, Yandilla Ph. 076 955176	Juveniles		4
3	Jabulani	Alastair McCree	?	All areas	Large well run operation-Landsborough	1
4		Laurie McDonald	C/- Blackwell's Road Westbrook Tmba Ph. 076 306306	Growers, juveniles		8
5		Ross Wicks	Dangore MH M/S 780 Kingaroy Ph. 071 641142	All areas	Federal Education Committee –could be helpful	3
6	Warwick Ost. Ranch	Denis & Glenis Peacock	M/S 848 Leslie Dam Road Warwick Ph. 076 619450	Chicks, juveniles		7
7		Rob Hayes	Toorinbirra M/S 1448 Chinchilla 4413 Ph. 076 65528	All areas	Extensive operation	5
	Ifraborough	Sue Hoffman	Spring Creek Killarney Ph. 076 641520	Chicks, juveniles	No criteria sheet – didn't …. enough	
	Dalby Ostrich Group	C/- Max Kretzman	? – Betterblend client	Growers, breeders	Meetings 1st Tues. every month	
8	Siege …..		Lot 3 South Branch Road Maryvale Ph. 076 661232			6

APPENDIX II: Free choice ostrich diets (Experiment 1)

Ingredients	Diet A 10.2 %	Diet B 7.6 %
Molasses	4.0	4.0
Sorghum 10%	20.7	-
Oats 11%	-	7.3
Wheat 13%	21.0	21.0
Soyabean 48% (solvent)	2.6	9.3
Lupins 30%	4.5	11.9
Millrun 16%	27.5	20. 7
Rice hulls/wheat straw chaff	-	13.4
Sunflower meal 36%	-	2.2
Cotton seed meal 37% (solvent)	3.0	-
Fish Meal Peruvian 65%	2.0	-
Meat Meal 50%	8.4	-
Lucerne Meal	5.0	5.0
Sodium Bentonite	1.0	1.0
Limestone	-	2.2
Dicalcium phosphate	-	1.2
Salt	0.097	0.210
L-Lysine Hcl	0.112	0.261
DL-Methionine NP99	0.052	0.119
L-Threonine 98%	0.001	0.087
R/Pan 0007 Gw Premix	0.100	0.100
	100.0	100.0

APPENDIX III: Ingredient composition (kg/t) of free-choice on-farm ostrich diets (Experiment 2)

Ingredients	Diet A (HP:HE)	Diet B (HP:LE)	Diet C (LP:HE)	Diet D (LP:LE)
Oats ostrich values	314.7		100.0	139.5
Wheat (general)	200.0	200.0	200.0	200.0
Lupins (all cultivars) ostvals	77.9			82.6
Sorghum (general)			476.9	
Cottonseed (solvent)		50.0		
Canola Meal		100.0		71.3
Sunflower 32% ostrich values	156.6	160.9		50.0
Soybean 45% (expeller) ost val	160.0	150.0	104.1	30.1
Filler (rice hulls)		175.7	34.8	205.5
Lucerne 17% ostrich values				50.0
Rhodes Grass (early flower)		94.1		100.0
Sunflower oil	18.6		8.8	
Molasses (cane)	40.0	40.0	40.0	40.0
Vitamins and minerals	2.0	2.0	2.0	2.0
DL Methionine (98%)	0.19		0.02	
Lysine Mono HCL (78% Lysine)	1.03	0.34	1.03	0.06
Dicalcium phosphate	10.2	9.3	12.7	12.6
Limestone	15.6	14.4	16.7	13.1
Salt	3.0	3.3	2.9	3.2
TOTAL	**1000.0**	**1000.0**	**1000.0**	**1000.0**

APPENDIX IV: Ostrich grower vitamin and mineral premix[1]

ACTIVE CONSTITUENTS @ 2Kg/Tonne				
Name	**Raw Material**	**Level/Kg of Premix**	**Level/Tonne Finished Feed**	**Unit**
Vitamin A (Retinol)	MICROVIT A 500 SUPRA (25 KG)	3,750,000.00	7,500,000	iu
Vitamin D3 (Cholecalciferol) Water Dispersible	MICROVIT D3 PROSOL 500 (25 KG)	1,000,000.00	2,000,000	iu
Vitamin E (DL-alpha-tocopheryl acetate)	MICROVIT E PROMIX 50 (25 KG)	12.50	25	g
Vitamin K3	VITAMIN K STAB 22.7% KG	0.50	1	g
Vitamin B1 (Thiamine)	VITAMIN B1 THIAMINE MONO (25KG)	0.50	1	g
Vitamin B2 (Riboflavin)	MICROVITG B2 SUPRA 80% (25 KG)	3.00	6	g
Vitamin B6 (Pyridoxine HC1)	VITAMIN B6 (25 KG)	0.50	1	g
Vitamin B12 (Cyanocobalamin)	MICROVIT B12 PROMIX 10000 25 kg	4.00	8	mg
Niacin (Vitamin B3)	NIACIN (25 KG)	12.50	25	g
D-CalciumPantothenate (Vitamin B5)	CALCIUM PANTOTHENATE (25 KG)	5.00	10	g
Folic Acid (Vitamin B9)	FOLIC ACID 95% (25 kg)	0.50	1	g
Biotin (Vitamin H)	MICROVIT H PROMIX 2000 (25 KG)	15.00	30	mg
Choline Chloride (vegetable carrier)	CHOLINE CHLORIDE 60% (25 KG)*	144.00	288	g
Cobalt (Co)	COBALT SULPHATE 21% (25 KG)	0.25	0.5	g
Copper (Cu)	COPPER SULPHATE PENTA (25 KG)*	20.00	40	g
Ferrous Iron (Fe++)	FERROUS SULPHATE MONO (25 KG)*	25.00	25	g
Iodine (I)	POTASSIUM IODIDE 90/10 (50 KG)	0.40	0.8	g
Magnesium (Mg)	MAGNESIUM OXIDE 58.5% (20 KG)*	5.00	10	g
Manganese (Mn)	MANGANOUS OXIDE 60% (25 KG)*	50.00	100	g
Selenium (Se) BiModally Protected form	SELENIUM BMP 4.5% (25 KG)	0.10	0.2	g
Zinc (Zn)	ZINC OXIDE 80% (25 KG)	37.50	75	g

[1] Formulated at QPRDC.

APPENDIX V: Free choice - 2

Intake of the two diets by each group measured six times, the proportion of each to the total, and the amounts of protein and energy consumed at these same times (Experiment 2).

Pen 21

Diets	*A & B*	Day 0	Day 35	Day 70	Day 112	Day 147	Day 168	Total
Feed intake (kg)								
	A HP-HE	0	185.5	141.3	219.7	295.9	162.1	1004.5
	B HP-LE	0	7.3	72.1	105.7	112.7	43.8	341.6
	Total	0	192.8	213.4	325.4	408.6	205.9	1346.1
B as percentage of total (%)		0	3.8	33.8	32.5	27.6	21.3	25.4
Total protein (kg)		0	38.6	43.0	65.5	82.2	41.4	270.6
Total energy (MJ AME)		0	2380.8	2379.1	3644.7	4656.7	2398.6	15459.9
Protein (g)/MJ AME			16.2	18.0	18.0	17.7	17.3	17.5
Lysine (g/kg gain)								34.2
Pen weight (kg)		130.6	214.2	256	363.5	438.4	475.6	
Mean weight (kg)		21.8	35.7	51.2	72.7	87.7	95.1	
Weight gain (grams/bird/day)		0	397	443	512	428	354	

Pen 22

Diets	*A & C*	Day 0	Day 35	Day 70	Day 112	Day 147	Day 168	Total
Feed intake (kg)								
	A HP-HE	0	118.5	145	241.9	285.3	170.3	961.0
	C LP-HE	0	65.9	36.9	85.8	73.7	70.4	332.7
	Total	0	184.4	181.9	327.7	359	240.7	1293.7
C as percentage of total (%)		0	35.7	20.3	26.2	20.5	29.2	25.7
Total protein (kg)		0	32.3	33.8	59.5	66.6	43.2	235.4
Total energy (MJ AME)		0	2305	2273.8	4096.3	4487.5	3008.8	16171.4
Protein (g)/MJ AME			14.0	14.9	14.5	14.8	14.4	14.6
Lysine (g/kg gain)								30.6
Pen weight (kg)		141.4	225.6	304.2	423.6	505.2	554.6	
Mean weight (kg)		23.6	37.6	50.7	70.6	84.2	92.4	
Weight gain (grams/bird/day)		0	400	374	474	389	390	

Pen 23

Diets *A & D*

		Day 0	Day 35	Day 70	Day 112	Day 147	Day 168	Total
Feed intake (kg)								
	A HP-HE	0	193.4	123.7	253.1	240.7	150.9	961.8
	D LP-LE	0	22.9	66.3	98.1	96.1	49.1	332.5
	Total	0	216.3	190	351.2	336.8	200	1294.3
D as percentage of total (%)		0	10.6	34.9	27.9	28.5	24.6	25.7
Total protein (kg)		0	41.7	33.4	63.4	60.6	36.6	235.6
Total energy (MJ AME)		0	2612.2	2109.8	3997.6	3825.6	2303.6	14848.75
Protein (g)/MJ AME			15.91	15.9	15.9	15.8	15.9	15.9
Lysine (g/kg gain)								37.3
Pen weight (kg)		151.3	213	287.5	385.5	461.5	482.8	
Mean weight (kg)		25.2	42.6	57.5	77.1	92.3	96.6	
Weight gain (grams/bird/day)		0	497	426	467	434	205	

Pen 24

Diets	*B & C*	Day 0	Day 35	Day 70	Day 112	Day 147	Day 168	Total
Feed intake (kg)								
	B HP-LE	0	29.6	77.6	205.6	231.0	149.7	693.5
	C LP-HE	0	143.1	108.1	176.8	219.4	123.7	771.1
	Total	0	172.7	185.7	382.4	450.4	273.4	1464.6
C as percentage of total (%)		0	82.9	58.2	46.2	48.7	45.2	52.6
Total protein (kg)		0	24.6	29.9	64.9	75.6	46.6	241.7
Total energy (MJ AME)		0	2040.4	2010.9	3957.6	4706	2818.7	15533.5
Protein (g)/AME			12.1	14.9	16.4	16.1	16.5	15.6
Lysine (g/kg gain)								27.5
Pen weight (kg)		123.4	200.4	281.4	411	499.2	552.7	
Mean weight (kg)		20.6	33.4	46.9	68.5	83.2	92.1	
Weight gain (grams/bird/day)		0	366	386	514	420	425	

Pen 25

Diets	*B & D*	Day 0	Day 35	Day 70	Day 112	Day 147	Day 168	Total
Feed intake (kg)								
	B HP-LE	0	169.2	149.7	276.2	276.7	174.0	1045.8
	D LP-LE	0	83.8	149.3	243.7	247.8	178.2	902.8
	Total	0	253	299	519.9	524.5	352.2	1948.6
D as percentage of total (%)		0	33.1	49.9	46.9	47.2	50.6	46.3
Total protein (kg)		0	45.4	49.9	88.0	88.7	58.7	330.7
Total energy (MJ AME)		0	2150.5	2541.5	4419.2	4458.3	2993.7	16563.2
Protein (g)/MJ AME			21.1	19.6	19.9	19.9	19.6	20.0
Lysine (g/kg gain)								40.0
Pen weight (kg)		149.8	229.2	301.8	410.4	481.8	529.4	
Mean weight (kg)		24.9	38.2	50.3	68.4	80.3	88.2	
Weight gain (grams/bird/day)		0	378	346	431	340	376	

Pen 26

Diets	*C & D*	Day 0	Day 35	Day 70	Day 112	Day 147	Day 168	Total
Feed intake (kg)								
	C LP-HE	0	179.7	138.2	204.4	139.1	100.8	762.2
	D LP-LE	0	108.1	135.2	160.2	243.7	145.4	792.6
	Total	0	287.8	273.4	364.6	382.8	246.2	1554.8
D as percentage of total (%)		0	37.6	49.5	43.9	63.7	59.1	51.0
Total protein (kg)		0	37.4	35.5	47.4	49.8	32.0	202.1
Total energy (MJ AME)		0	3165.1	2876.7	3916.7	3810.2	2495.9	16264.6
Protein (g)/MJ AME			11.8	12.3	12.1	13.1	12.8	12.4
Lysine (g/kg gain)								23.6
Pen weight (kg)		222.9	317.4	399	502.8	561	598.6	
Mean weight (kg)		37.2	52.9	66.5	83.8	93.5	99.8	
Weight gain (grams/bird/day)		0	449	389	412	277	300	

APPENDIX VI: Ostrich diets (kg/t) free choice Experiments 3 and 4

	Diet A HP:HE	**Diet B HP:LE**	**Diet C LP:HE**	**Diet D LP:LE**
Sorghum (General)	141.9		596.8	
Wheat (General)	200.0	200.0	200.0	322.9
Sunflower oil	6.3			
Oats ost. values				200.0
Lucerne 17% (ost. value)	50.0	64.8	50.0	91.1
Rhodes Grass (early flower)		50.0		100.0
Lupins	158.8			
Canola Meal		100.0		100.0
Cottonseed (solvent)		80.0	57.4	50.0
Soybean 48% (Expeller)	200.0	111.3	60.1	
Sunflower 32% (ost. value)	210.8	315.7		16.9
Lysine HCL (78%)		0.5	1.24	
Lysine 55.3 Tryptophan 15%	1.68	1.15		
DL Methionine (98%)	0.16			
Dicalcium Phosphate	11.3	7.8	13.7	10.5
Limestone	14.0	13.5	15.9	13.3
Salt	2.97	3.24	2.79	3.19
Filler (Ground rice hulls)		50.0		50.0
Vitamin and Mineral	2.0	2.0	2.0	2.0
Molasses (cane)				40.000
	1000.0	**1000.0**	**1000.0**	**1000.0**

APPENDIX VII: Free choice - 3

Details of feed intake and a breakdown of some dietary components for each period during free-choice Experiment 3.

Pen 22								
Diets	*A & B*							
		Day 0	Day 35	Day 63	Day 97	Day 125	Day158	Total
Feed intake (kg)								
	A HP-HE	0	133.1	153.1	298.5	329.8	359	1273.5
	B HP-LE	0	132.9	99.7	87	86.2	96.7	502.5
	Total	0	266	252.8	385.5	416	455.7	1776
B as percentage of total (%)		0	50.0	39.4	22.6	20.7	21.2	28.3
Total protein (kg)		0	68.8	65.2	99.1	106.9	117.1	457.2
Total energy (MJ AME)		0	2859.9	2811.1	4514.3	4898.3	5357.8	20441.3
Protein (g/MJ AME)			24	23.2	21.9	21.9	21.8	22.4
Lysine (g/kg gain)								54.7
Pen weight (kg)		170.7	262.7	322.6	413.6	487.2	560.4	389.7
Mean weight (kg)		28.5	43.8	53.8	68.9	81.2	93.4	
Weight gain (grams/bird/day)		0	437	357	444	439	370	

Pen 23								
Diets	*B & D*							
		Day 0	Day 35	Day 63	Day 97	Day 125	Day 158	Total
Feed intake (kg)								
	B HP-LE		194.1	191.0	224.5	248.4	254.5	1112.5
	D LP-LE		100.9	79.8	176.4	208.5	220.5	786.1
	Total		295	270.8	400.9	456.9	475	1898.6
D as percentage of total (%)			34.2	29.5	44.0	45.6	46.4	41.4
Total protein (kg)			65.0	61.2	83.6	94.4	97.7	402.0
Total energy (MJ AME)			2655.0	2437.2	3608.1	4112.1	4275.0	17087.4
Protein (g/MJ AME)			27.5	20.824.4	22.2	20.5	22.3	23.5
Lysine (g/kg gain)								53.6
Pen weight (kg)		159.1	262.9	327.9	414.96	473.4	529.8	337.6
Mean weight (kg)		26.5	43.8	54.7	69.2	78.9	88.3	
Weight gain (grams/bird/day)		0	494	389	426	346	285	

Pen 24								
Diets	*A & D*							
		Day 0	Day 35	Day 63	Day 97	Day 125	Day 158	Total
Feed intake (kg)								
	A HP-HE	0	204.2	170.9	301.5	348.7	384.7	1410
	D LP-LE	0	44.8	60.4	62.7	63.9	58.2	290
	Total	0	249	231.3	364.2	412.6	442.9	1700
D as percentage of total (%)		0	18.0	26.1	17.2	15.5	13.1	17.1
Total protein (kg)		0	58.6	52.3	86.1	98.3	106.7	402.1
Total energy (MJ AME)		0	2955.7	2679.9	4333.1	4933.9	5332.6	20235.0
Protein (g/MJ AME)			19.8	19.5	19.9	19.9	20.0	19.9
Lysine (g/kg gain)								52.6
Pen weight (kg)		193.1	292.3	354.4	434.4	493.8	549.6	356.5
Mean weight (kg)		32.2	48.7	59.1	72.4	82.3	91.6	
Weight gain (grams/bird/day)		0	471	371	391	354	282	

Pen 25								
Diets	*A & C*							
		Day 0	Day 35	Day 63	Day 197	Day 125	Day158	Total
Feed intake (kg)								
	A HP-HE		213.0	177.4	244.3	277.6	281.5	1193.8
	C LP-HE		84.5	77.6	113.3	75.6	103.5	454.5
	Total		297.5	255	357.6	353.2	385	1648.3
C as percentage of total (%)			28.4	30.4	31.7	21.4	26.9	27.6
Total protein (kg)			66.9	56.7	79.1	82.1	87.2	372.0
Total energy (MJ AME)		0	3718.8	3187.5	4470.0	4415.0	4812.5	20603.8
Protein (g/MJ AME)			18.0	17.8	17.7	18.6	18.1	18.0
Lysine (g/kg gain)								46.1
Pen weight (kg)		172	268.5	326.4	426.2	486.6	542.4	370.4
Mean weight (kg)		28.7	44.8	54.4	71.03	81.1	90.4	
Weight gain (grams/bird/day)		0	460	343	489	360	282	

Pen 26								
Diets	*B & C*							
		Day 0	Day 35	Day 63	Day 97	Day 125	Day 158	Total
Feed intake (kg)								
	B HP-LE		191.0	85.4	243.1	188.2	192.1	899.8
	C LP-HE		72.1	156	146.7	210.6	214.4	799.8
	Total		263.1	241.4	389.8	398.8	406.5	1699.6
C as percentage of total (%)			27.4	64.6	37.6	52.8	52.7	47.1
Total protein (kg)			60.4	45.1	84.9	79.9	81.4	351.6
Total energy (MJ AME)			2620.3	2718.6	4021.7	4326.3	4408.9	18095.7
Protein (g/MJ AME)			23	16.6	21.1	18.5	18.5	19.4
Lysine (g/kg gain)								47.9
Pen weight (kg)		164.2	254.4	316.3	408.2	465	511.8	347.6
Mean weight (kg)		27.4	42.4	52.7	68	77.5	85.3	
Weight gain (grams/bird/day)		0	429	368	450	339	236	

Pen 27								
Diets	*C & D*							
		Day 0	Day 35	Day 63	Day 97	Day 125	Day 158	Total
Feed intake (kg)								
	C LP-HE	0	103.3	89.9	176.5	178.5	239.2	787.4
	D LP-LE	0	148.5	169.4	210.7	200.1	191.3	920
	Total	0	251.8	259.3	387.2	378.6	430.5	1707.4
D as percentage of total (%)		0	59.0	65.3	54.4	52.9	44.4	53.9
Total protein (kg)		0	36.2	37.2	55.7	54.5	62.1	245.6
Total energy (MJ AME)		0	2627.8	2648.4	4102.6	4032.2	4711.7	18122.5
Protein (g/MJ AME			13.8	14.0	13.6	13.5	13.2	13.6
Lysine (g/kg gain)								30.3
Pen weight (kg)		168.9	241.1	304.9	396	444.6	506.4	337.5
Mean weight (kg)		28.15	40.2	50.8	66	74.1	84.4	
Weight gain (grams/bird/day)		0	344	379	447	289	312	

APPENDIX VIII: Free choice - 4

Details of feed intake and a breakdown of some dietary components for each period during free-choice Experiment 4.

Pen C22

Diets A + B

		Day 0	Day 42	Day 77	Day 115	Day 150	Total
Feed intake (kg)							
	A HP:HE	0	317.8	273.5	201.8	215.7	1008.8
	B HP:LE	0	113.3	38.5	76.0	114.2	342.0
	Total	0	431.1	312.0	277.8	329.9	1350.8
B as percentage of total (%)		0	26.3	12.3	27.4	34.6	25.3
Total protein (kg)		0	111.1	80.2	71.6	85.1	347.9
Total energy (MJ AME)		0	4992.2	3765.3	3206.5	3724.1	15688.0
Protein (g/MJ AME)			22.3	21.3	22.3	22.9	22.2
Lysine (g/kg gain)							54.4?
Pen weight (kg)		219.7	351.6	427.6	459.4	503.0	283.3
Mean weight (kg)		36.6	58.6	71.3	76.6	83.8	
Weight gain (grams/bird/day)		0	524	362	140	208	

Pen C23

Diets A + C

		Day 0	Day 42	Day 77	Day 115	Day 150	Total
Feed intake (kg)							
	A HP:HE	0	224.2	200.4	138.7	151.7	715.0
	C LP:HE	0	74.6	125.2	90.6	128.4	418.8
	Total	0	298.8	325.6	229.3	280.1	1133.8
C as percentage of total (%)		0	25.0	38.5	39.5	45.8	36.9
Total protein (kg)		0	51.9	61.4	43.5	55.1	211.9
Total energy (MJ AME)		0	3735.0	4070.0	2866.3	3501.3	14172.6
Protein (g/MJ AME)			13.9	15.1	15.2	15.7	14.9
Lysine (g/kg gain)							36.9
Pen weight (kg)		216.1	337.2	421.8	467.2	520.4	304.2
Mean weight (kg)		36.0	56.2	70.3	77.9	86.7	
Weight gain (grams/bird/day)		0	481	403	199	253	

Pen C24

Diets A + D

		Day 0	Day 42	Day 77	Day 115	Day 150	Total
Feed intake (kg)							
	A HP:HE	0	197.3	185.8	187.0	205.1	775.2
	D LP:LE	0	78.3	104.0	45.6	115.1	343.0
	Total	0	275.6	289.8	232.6	320.2	1118.2
D as percentage of total (%)		0	28.4	35.9	19.6	35.9	30.7
Total protein (kg)		0	62.0	62.8	54.6	69.4	248.8
Total energy (MJ AME)		0	3445.0	3622.5	2907.5	4002.5	13977.5
Protein (g/MJ AME)			18.0	17.3	18.8	17.3	17.8
Lysine (g/kg gain)							42.6
Pen weight (kg)		213.8	305.0	379.2	424.0	475.0	261.2
Mean weight (kg)		35.6	50.8	63.2	70.7	79.2	
Weight gain (grams/bird/day)		0	362	354	197	243	

Pen D22

Diets B + C

		Day 0	Day 42	Day 77	Day 115	Day 150	Total
Feed intake (kg)							
	B HP:LE	0	263.5	245.9	178.6	243.7	931.7
	C LP:HE	0	171.8	108.7	126.9	120.2	527.3
	Total	0	435.3	354.5	305.5	363.7	1459.0
C as percentage of total (%)		0	39.5	30.7	41.5	33.1	36.2
Total protein (kg)		0	94.0	80.1	65.2	81.2	320.5
Total energy (MJ AME)		0	4515.3	3571.9	3193.7	3695.8	14976.6
Protein (g/MJ AME)			20.8	22.4	20.4	22.0	21.4
Lysine (g/kg gain)							47.8
Pen weight (kg)		212.1	353.0	413.6	453.4	*436.5	300.0
Mean weight (kg)		35.4	58.5	68.9	75.6	*87.3	
Weight gain (grams/bird/day)		0	560	289	175	335	

* One bird died at day 116.

Pen D23

Diets B + D

		Day 0	Day 42	Day 77	Day 115	Day 150	Total
Feed intake (kg)							
	B HP:LE	0	280.7	228.0	191.2	195.5	895.4
	D LP:LE	0	99.2	203.8	145.3	218.5	666.8
	Total	0	379.9	431.8	336.5	414.0	1562.2
D as percentage of total (%)		0	26.1	47.2	43.2	52.8	42.9
Total protein (kg)		0	87.4	88.7	70.7	82.3	329.1
Total energy (MJ AME)		0	3449.1	3886.2	3028.5	3726.0	14059.8
Protein (g/MJ AME)			25.6	22.8	23.3	22.1	23.4
Lysine (g/kg gain)							49.7
Pen weight (kg)		207.0	331.6	419.2	455.2	503.5	296.5
Mean weight (kg)		34.5	55.3	69.9	75.9	83.9	
Weight gain (grams/bird/day)		0	495	417	158	230	

Pen D24

Diets C + D

		Day 0	Day 42	Day 77	Day 115	Day 150	Total
Feed intake (kg)							
	C LP:HE	0	343.1	260.6	147.1	281.1	1031.9
	D LP:LE	0	47.8	135.3	205.4	73.1	461.6
	Total	0	390.9	395.9	352.5	354.2	1493.5
D as percentage of total (%)		0	12.2	34.2	58.3	20.6	30.9
Total protein (kg)		0	57.00	57.4	50.8	51.5	216.8
Total energy (MJ AME)		0	4718.9	4475.2	3687.4	4171.7	17053.2
Protein (g/MJ AME)			12.1	12.8	13.8	12.3	12.7
Lysine (g/kg gain)							30.9
Pen weight (kg)		216.0	306.5	402.8	452.4	506.5	290.5
Mean weight (kg)		36.0	51.1	67.1	75.4	84.4	
Weight gain (grams/bird/day)		0	359	459	218	258	

APPENDIX IX: Multi-species stock shelter

DPI note

Department of Primary Industries QUEENSLAND

Multi-species Stock Shelter

Kerry Barram and Mark Schermer, Queensland Poultry Research and Development Centre, Alexandra Hills

In order to provide adequate shelter for livestock, in this case ostriches, and their feeders from the elements, we created a simple and cost efficient design. This type of lightweight shelter can be easily moved or even dismantled when required.

Ostriches favour this design over the version that has fully enclosed sides. It provides better visibility and it does not get as hot due to increased ventilation. There is ample space inside for the placement of feeders. Each shelter can be placed over a fence line providing cover in two pens.

It was decided to build the lightweight frame from 26mm O.D. (20mm N.B.) galvanised pipe and using galvanised pipefittings for the construction of the tunnel shaped shelter. The base of the frame is of a rectangular design (3.6m x 4.0m) and arched hoops are used for the canopy. To manufacture the rounded canopy a standard 6.5m length of galvanised pipe is bent to a 2m radius. Short sections (800mm) of pipe are welded onto each end of the two outside hoops and two 763mm sections are attached to the central hoop to provide adequate head room, in this case 2.9m.

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The central hoop and the top bracing section are then covered with frameguard tape on the outside where they will be in contact with the cover to reduce wear and tear over time. The tarp is then stretched over the frame and attached with cable ties through the eyelets at 300mm intervals. The whole of the structure is anchored down with oversize tent pegs hooked over the bottom framework.

Materials required and costings

The shelter is constructed using the following sections of 26mm O.D. galvanised pipe

2 x 3578mm (base 3.6 m)
2 x 3926mm (base 4.0 m)
3 x 6500mm (3 hoops)
4 x 800mm (outside hoop extensions)
2 x 763mm (middle hoop extensions)
2 x 2786mm (centre uprights)
6 x 1739mm (hoop bracing)

Total pipe used is 55.25m, or nine lengths of 6.5 metres.

Gal. Pipe 26mm O.D. (20 N.B.) 6.5m ($12.30 each)	9	$110.70
Pipe bending to a 2m radius ($15.00 each)	3	$ 45.00
Solarweave tarp 3.6m x 6.4m ($245.00) (re-enforced with eyelets at 300mm)	1	$245.00
Gal. Pipe fittings (26 mm) "T"(Tee junction) ($1.50 each)	8	$ 12.00
"C"(corner) ($4.60 each)	6	$ 27.60
"X"(cross over) ($3.00 each)	3	$ 9.00
Frameguard tape (15m) ($12.50 each)	1	$ 12.50
Cable ties (250mm, 25 per packet) ($5.00/packet)	3	$ 15.00
Total cost (ex labour)		**$476.80**

* prices for S.E. Queensland at time of writing (March 1999).

Using black pipe and welding the joints, rather than utilising ready made fittings to hold the framework together can substantially reduce material costs. In addition the cost of the tarp can be significantly reduced through buying the material in bulk and by preparing it your self, a 50m roll (1.8m wide) costs $3.80 per lineal metre. Shade cloth can be substituted if shade only, and not waterproofing, is required. It is also possible to lace the tarp on using rope instead of using cable ties. The central strut at either end of the tunnel may be left out if so required.

Acknowledgement

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APPENDIX X: Ostrich grower diet

Ingredient	Inclusion (%)
Oats ostrich values	11.0
Wheat (general)	41.6
Sunflower meal 32% ostrich values	10.3
Soybean meal 45% ostrich values	19.0
Chick peas	9.0
Molasses	4.0
Lysine mono HCL (78%)	0.04
Methionine 98%	0.025
Salt	0.29
Limestone	1.6
Di Calcium phosphate	1.1
Sunflower oil	1.6
Filler	0.25
*Mineral & vitamin premix	0.2

Diet Composition	
Crude protein	20%
AME	12.5 MJ/kg
Lysine total	0.96%
Crude Fibre	5.9%
Cost approximately	$325/tonne

* Appendix IV

APPENDIX XI: Ostrich maintenance
vitamins and mineral premix

ACTIVE CONSTITUENTS @ 1 Kg/Tonne				
Name	**Raw Material**	**Level/Kg of Premix**	**Level/Tonne Finished Fee**	**Unit**
Vitamin A (Retinol)	MICROVIT A 500 SUPRA (25 KG)	2,000,000.00	2,000,000.00	iu
Vitamin D3 (Cholecalciferol) Water Dispersible	MICROVIT D3 PROSOL 500 (25 KG)	1,000,000.00	2,000,000.00	iu
Vitamin E (DL-alpha-tocopheryl acetate)	MICROVIT E PROMIX 50 (25 KG)	20.00	20.00	g
Vitamin K3	VITAMIN K MSB 51% KG	0.40	0.40	g
Vitamin B1 (Thiamine)	VITAMIN B1 THIAMINE MONO (25KG)	0.50	0.50	g
Vitamin B2 (Riboflavin)	MICROVITG B2 SUPRA 80% (25 KG)	2.00	2.00	g
Vitamin B6 (Pyridoxine HC1)	VITAMIN B6 (25 KG)	1.00	1.00	g
Vitamin B12 (Cyanocobalamin)	MICROVIT B12 PROMIX 10000 25 kg	3.00	3.00	mg
Niacin (Vitamin B3)	NIACIN (25 KG)	10.00	10.00	g
D-CalciumPantothenate (Vitamin B5)	CALCIUM PANTOTHENATE (25 KG)	6.00	6.00	g
Folic Acid (Vitamin B9)	FOLIC ACID 95% (25 kg)	0.30	0.30	g
Biotin (Vitamin H)	MICROVIT H PROMIX 2000 (25 KG)	5.00	5.00	mg
Choline Chloride (vegetable carrier)	CHOLINE CHLORIDE 60% (25 KG)*	120.00	120.00	g
Cobalt (Co)	COBALT SULPHATE 21% (25 KG)	0.10	0.10	g
Copper (Cu)	COPPER SULPHATE PENTA (25 KG)*	20.00	20.00	g
Ferrous Iron (Fe++)	FERROUS SULPHATE MONO (25 KG)*	10.00	10.00	g
Iodine (I)	POTASSIUM IODIDE 90/10 (50 KG)	0.50	0.50	g
Magnesium (Mg)	MAGNESIUM OXIDE 58.5% (20 KG)*	50.00	50.00	g
Manganese (Mn)	MANGANOUS OXIDE 60% (25 KG)*	40.00	40.00	g
Selenium (Se) BiModally Protected form	SELENIUM BMP 4.5% (25 KG)	0.10	0.10	g
Zinc (Zn)	ZINC OXIDE 80% (25 KG)	50.00	50.00	g

APPENDIX XII: Ostrich layer
vitamins and mineral premix

ACTIVE CONSTITUENTS @ 2Kg/Tonne				
Name	**Raw Material**	**Level/Kg of Premix**	**Level/Tonne Finished Fee**	**Unit**
Vitamin A (Retinol)	MICROVIT A 500 SUPRA (25 KG)	2,500,000.00	5,000,000.00	iu
Vitamin D3 (Cholecalciferol) Water Dispersible	MICROVIT D3 PROSOL 500 (25 KG)	1,000,000.00	2,000,000.00	iu
Vitamin E (DL-alpha-tocopheryl acetate)	MICROVIT E PROMIX 50 (25 KG)	50.00	100.00	g
Vitamin K3	VITAMIN K MSB 51% KG	0.50	1.00	g
Vitamin B1 (Thiamine)	VITAMIN B1 THIAMINE MONO (25KG)	1.00	2.00	g
Vitamin B2 (Riboflavin)	MICROVITG B2 SUPRA 80% (25 KG)	3.00	6.00	g
Vitamin B6 (Pyridoxine HC1)	VITAMIN B6 (25 KG)	1.50	3.00	g
Vitamin B12 (Cyanocobalamin)	MICROVIT B12 PROMIX 10000 25 kg	4.00	8.00	mg
Niacin (Vitamin B3)	NIACIN (25 KG)	12.50	25.00	g
D-CalciumPantothenate (Vitamin B5)	CALCIUM PANTOTHENATE (25 KG)	7.50	15.00	g
Folic Acid (Vitamin B9)	FOLIC ACID 95% (25 kg)	0.50	1.00	g
Biotin (Vitamin H)	MICROVIT H PROMIX 2000 (25 KG)	7.50	15.00	mg
Choline Chloride (vegetable carrier)	CHOLINE CHLORIDE 60% (25 KG)*	200.00	400.00	g
Cobalt (Co)	COBALT SULPHATE 21% (25 KG)	0.15	0.30	g
Copper (Cu)	COPPER SULPHATE PENTA (25 KG)*	20.00	40.00	g
Ferrous Iron (Fe++)	FERROUS SULPHATE MONO (25 KG)*	12.50	25.00	g
Iodine (I)	POTASSIUM IODIDE 90/10 (50 KG)	0.40	0.80	g
Magnesium (Mg)	MAGNESIUM OXIDE 58.5% (20 KG)&	50.00	100.00	g
Manganese (Mn)	MANGANOUS OXIDE 60% (25 KG)*	60.00	120.00	g
Selenium (Se) BiModally Protected form	SELENIUM BMP 4.5% (25 KG)	0.15	0.30	g
Zinc (Zn)	ZINC OXIDE 80% (25 KG)	50.00	100.00	g