RURAL INDUSTRIES
RESEARCH & DEVELOPMENT CORPORATION

Emu Processing and Product Development

Report for the

Rural Industries Research and Development Corporation

by

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"Emu Processing and Product Development"

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Foreword

Emu meat and other related products such as leather, make up a new and growing market. In order to keep up the momentum, the industry saw the need for a successful processing, product development and marketing program.

This report is the culmination of a study to produce such a plan. The project evaluated the markets for emu products, particularly meat and leather.

It examined how costs could be cut, particularly in defeathering and skinning and it studied how to eliminate skin and meat stress during transport.

The marketing aspects of the project sought to establish the quality of emu products, setting up a description system for meat, preparing generic promotional material, and activities to create more awareness.

The report is a valuable addition to the Rural Industries Research and Development Corporation's new animal products program.

Peter Core
Managing Director
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PROJECT SUMMARY:

At the commencement of the project, the Australian emu industry was based on the production and sale of chicks and less than 1,500 birds had been processed in licensed abattoirs. The products from an emu at marketable weight (50-60 weeks) were worth approximately $400 at that time but that figure could only be maintained, in a situation of increasing supply, with a successful processing, product development and marketing program.

The project focused on these processing and market related issues, with the following objectives:-

(1) To evaluate markets for emu products, particularly meat and leather.

(2) To reduce slaughter costs particularly in the areas of defeathering and skinning.

(3) To eliminate skin and meat stress damage during transport.

(4) To determine the cost of supplying emus for different end uses.

(1) The marketing activities in the project centred on:-

(i) Establishing the quality of emu products, particularly meat

• Research was conducted to determine the shelf life of chilled, vacuum packaged emu meat. Meat quality assessments and microbial contamination counts were recorded. The meat was found to be acceptable when held for up to 9 weeks at 2.5^{o}C. It was considered that emu meat maintained at -1 to 0^{o}C would be acceptable after 12 weeks of storage.

• The effect of "ageing" on meat quality was determined. There was no appreciable improvement in the tenderness of the emu meat after ageing for up to 12 weeks.

• A nutritional analysis of emu meat was prepared which showed the meat to be low in fat and cholesterol and extremely high in iron.

(ii) Establishment of a description system for meat

• An emu cut description system was developed and incorporated into an export trade description as required by the Australian Quarantine and Inspection Service (AQIS). A Register of Approved Emu Cuts and Items was produced and this has been adopted internationally as the standard emu meat trading language.

• The weight of cuts from birds of different sizes was also determined, as an aid in meat marketing.

(iii) Preparation of generic promotional material

• In addition to the *Register of Approved Emu Cuts and Items*, the Agency prepared promotional leaflets promoting emu meat, recipes and emu leather, an emu meat poster, and videos showing the stages in the commercial processing of emus and carcase boning.

(iv) generic promotional activities to create awareness of emu products.

• Emu meat was featured twice at Agriculture Western Australia's display at the Perth Royal Show annually at the "Nationwide Food Service Expo" and twice at "Foodfest". In addition, emu meat was supplied for numerous rural expo's and consignments overseas.

• Emu skins were made available to every exotic leather tanner in Australia and most of the major exotic leather tanners overseas. Agency staff also promoted emu leather at the Hong Kong Leather Fair in 1992.

(2) Efforts to reduce slaughter costs concentrated on defeathering by scalding and dry plucking.

(i) Evaluation of scalding procedures

• For birds of 60 weeks of age or older, scalding at 60^0 C for 1 or 2 minutes makes plucking easier, without any detrimental effect on the resulting leather. However effective scalding makes the skins harder to remove.

(ii) Development of dry plucking procedures.

• The use of a spinning disk dry plucker for defeathering emus was evaluated. While the disks successfully plucked the feathers from the emu without apparent skin damage more design and development work is required before it could be adopted by commercial emu processing facilities.

(iii) Application of existing wet plucking technology

• Emus were scaled and plucked in a commercial poultry processing establishment and passed through a commercial pig de-hairing machine in a slaughter house. While these existing technologies have obvious application to the plucking of emus it was apparent that the machines will require substantial modification to achieve a commercially accepatable result.

(3) Elimination of skin and meat stress damage during transport.

(i)   Evaluation of de-clawing to reduce skin damage

• De-clawing, which involves removing the toe nail and its growth point is a recognised procedure in the poultry industry. Research has demonstrated that de-clawing emu chicks at hatch by removing the tip of the toe approximately at the last phalangeal joint with a hot blade de-beaking machine dramatically reduced damage to the birds and their skin from fighting and transport. The risk of injury to people handling the birds was also greatly reduced. The operation did however, depress feed consumption during the first few weeks of life and live weight at 2 weeks of age was about 10 percent lower. There was no significant effect on growth beyond this age. No difference in mobility was observed, fighting was reduced, the birds were easier to handle and there was no effect on mortality.

• No evidence of traumatic neuromas, abnormal tangles of regenerative nerve fibres that can spontaneously discharge and cause chronic pain in amputated limbs, was found in 3 toes analysed by a neuro scientist.

• The quality of skins collected from the de-clawed birds was dramatically improved with 72 percent of the skins being graded A or B grade compared to 35 percent for untreated controls. There was no effect on the amount of muscle and fat recovered at slaughter.

(ii) Transport of emus

• Evaluation of stock crate design

A prototype stock crate was constructed to evaluate the impact of stock density and ceiling height, on the incidence and severity of skin damage. The results indicate that there would be no benefit in transporting de-clawed emus in single sex groups and showed that reducing the ceiling height in the stock crate to 1.4 metres had no impact on skin quality,. There was an indication that group sizes of greater than 7 birds and a pen area below 0.45 square metres per bird resulted in increased skin damage. This is likely to arise because birds which sit or fall are less likely to get to their feet and are damaged by the feet of the other birds.

• Measurement of the ultimate pH and glycogen content of the meat from emus in the trial confirmed that birds transported in single pens travel poorly. Placing birds in individual pens resulted in additional stress for the birds which was confirmed by high muscle pH and low muscle glycogen at slaughter.

(4) Determine the cost of supplying emus for different end uses.

• Suggested nutritional restraints for the formulation of rations for emus were developed and made available to industry.

• Emus can be fattened to maximise fat yield rapidly by feeding high energy fat supplemented diets. This will result in substantial savings in feed.

• Emus eat to a consistent demand for energy and diets formulated to contain 10.5 MJ of energy for each kilogram do not limit growth. Diets should therefore be formulated on the basis of least cost per unit of dietary energy.

• Average weight for age, energy consumed and expected yield of meat and fat have been tabled.

BACKGROUND TO THE PROJECT:

Commercial scale emu farming began in Western Australia in 1987. At the commencement of the project there were 29 licensed farms in Western Australia with a total flock exceeding 20,000 birds and it was estimated that a further 25,000 chicks would be reared in WA in 1992/93. In addition, there were commercial emu farms operating in Queensland and Tasmania and interest in emu farming in all other States.

At that stage, the industry had been based on the production and sale of chicks and less than 1,500 birds had been processed in licensed abattoirs. At that time the products from an emu at marketable weight (50-60 weeks) were worth approximately $400. This figure could only be maintained, in a situation of increasing supply, with a successful processing, product development and marketing program.

The necessity for emphasis on this area rather than production research had been recognised in a report funded by the Government of Western Australia titled 'A Development Strategy for the Emu Industry'.

The key recommendations for research by the WA Department of Agriculture were as follows:-

Recommendation 5	Determine the cost of supplying emus for different end uses.
Recommendation 7	Reduction of slaughter costs.
Recommendation 8	Eliminate skin and meat stress damage during transport.
Recommendation 18	Establish clear product development research priorities, including • identify and refine meat cuts for target markets; and • prepare cooking instruction and recipes.

Specific areas addressed by the Department in this submission were as follows:

(a) Meat marketing

Previous research had confirmed that emu meat was acceptable to consumers in Western Australia. Apart from the general eating quality characteristics, emu meat has two other strong marketing points in that it is novel and low in fat. Because of restrictions in importing countries and the difficulty of servicing the export market, it was decided to concentrate on the domestic market initially. At that stage very little emu meat has been produced so there was virtually no commercial exposure of emu meat on the Australian market. A promotional campaign was seen as essential to successfully sell the meat produced after 1991.

(b) Marketing other emu products

A similar situation applied to the marketing of other emu products as applied to meat marketing. Few birds have been processed in Australia, and none were processed elsewhere so the potential markets had to be made aware of the existence and quality of emu products.

(c) Defeathering and skinning

Feather removal was the major problem facing the emu processing industry and cost producers around $20 per bird. The major problem was to remove the feathers in a cost effective manner without damaging the skin.

(d) Reduction of skin damage

The major cause of skin damage is scratches inflicted by the toe nails of other birds through fighting or during transport. De-clawing, which involves removing the toe nail at the first knuckle is a recognised procedure in the poultry industry and is approved under the SCA Code of Practice for the Husbandry of Poultry.

The potential advantage of de-clawing emu chicks was that damage to the birds, including skin damage, would be markedly reduced and the birds would be easier and safer to handle. This would largely overcome the transport problem.

(e) Stock crate design

Emus did not travel well over long distances and significant losses had occurred from skin damage, dark cutting meat and occasionally deaths. Given the large numbers of birds to be processed, humane and efficient transport procedures had to be developed.

(f) Specialised production

The standard production system was based on producing a bird suitable for meat, oil and leather production. However accepting that the demand and price of these products would vary, it was likely to be more profitable to specialise in production for different end uses. From previous research, the two products likely to vary most with changes in production methods were meat and particularly fat.

OBJECTIVES OF THE PROJECT:

(1) Evaluate markets for emu products, particularly meat and leather.

(2) Reduce slaughter costs particularly in the areas of defeathering and skinning

(3) Eliminate skin and meat stress damage during transport.

(4) Determine the cost of supplying emus for different end uses.

DESCRIPTION OF RESEARCH ACTIVITIES:

(1) Emu product marketing

Introduction:

Emu production is relatively easy, but developments in emu processing and marketing have not kept pace with emu production. The industry is faced with attempting to position three emu products - oil, meat and skin - at the top end of world markets which know virtually nothing about them. Other fledgling animal industries in Australia, such as the deer and ostrich industries, have the benefit of substantial research and market development carried out in other countries. In a global sense, these industries are mature, whereas the emu industry is in its infancy.

Previous research had confirmed that emu meat was acceptable to consumers in Western Australia. Of 140 consumers involved in in-store tasting in Perth, over 90% thought that emu meat was as good (72%) or better (19%) than the grilling steak they were buying at the time. Eighty percent said they would buy emu meat at least once per month at grilling steak prices.

At the time of commencement of the project , very little emu meat had been produced so there had been virtually no exposure of emu meat to the marketplace. A similar situation applied to the marketing of other emu products. Few birds had been processed in Australia and none had been processed elsewhere, so the potential markets had to be made aware of the existence and quality of emu products.

Methodology:

Marketing activities in the Project centred on:-

(a) establishing the quality of emu products, particularly meat,

(b) establishment of a description system for meat

(c) preparation of generic promotional material

(d) generic promotional activities to create awareness of emu products.

(a) Establishing the quality of emu products

(i) Determination of the shelf life of chilled emu meat

• Background:

The emu meat industry faces two particular problems in meat marketing. Firstly, emus are seasonal breeders and the industry has identified 60-70 weeks of age as the optimum age at slaughter. This means that fresh meat will only be available for six months of the year.

Secondly gourmet and export markets greatly prefer fresh to frozen meat. Because of the cost of air freight to Europe (approximately $7/kilo) it is essential that fresh meat will remain wholesome and palatable for the duration of a sea journey which can be as long as

56 days.

Chilling vacuum packed meat is the conventional method of extending the shelf life of fresh meat. The meat is placed in special plastic bags which have low oxygen and moisture permeability's. The low level of oxygen, the raised level of carbon dioxide and the low storage temperatures (-1 to 0°C) reduce the growth of spoilage bacteria on the meat.

• Methodology:

Fifty emus were processed at Dardanup Butchering Company and the following day, the Biceps femoris muscle (fan fillet) was taken from each side of the birds and vacuum packaged in a shrink bag.

Five chilling treatments were applied, with 10 birds per treatment, as follows:-

The fan fillet from one side of each bird was frozen after boning as a standard. The fan fillet from the other side was chilled for a period of 3, 6, 9 or 12 weeks. It was assumed the meat held in the commercial cold store was chilled at -1°C, however, the temperature was maintained around 2.5 ^{0}C and at times rose above this temperature for short periods.

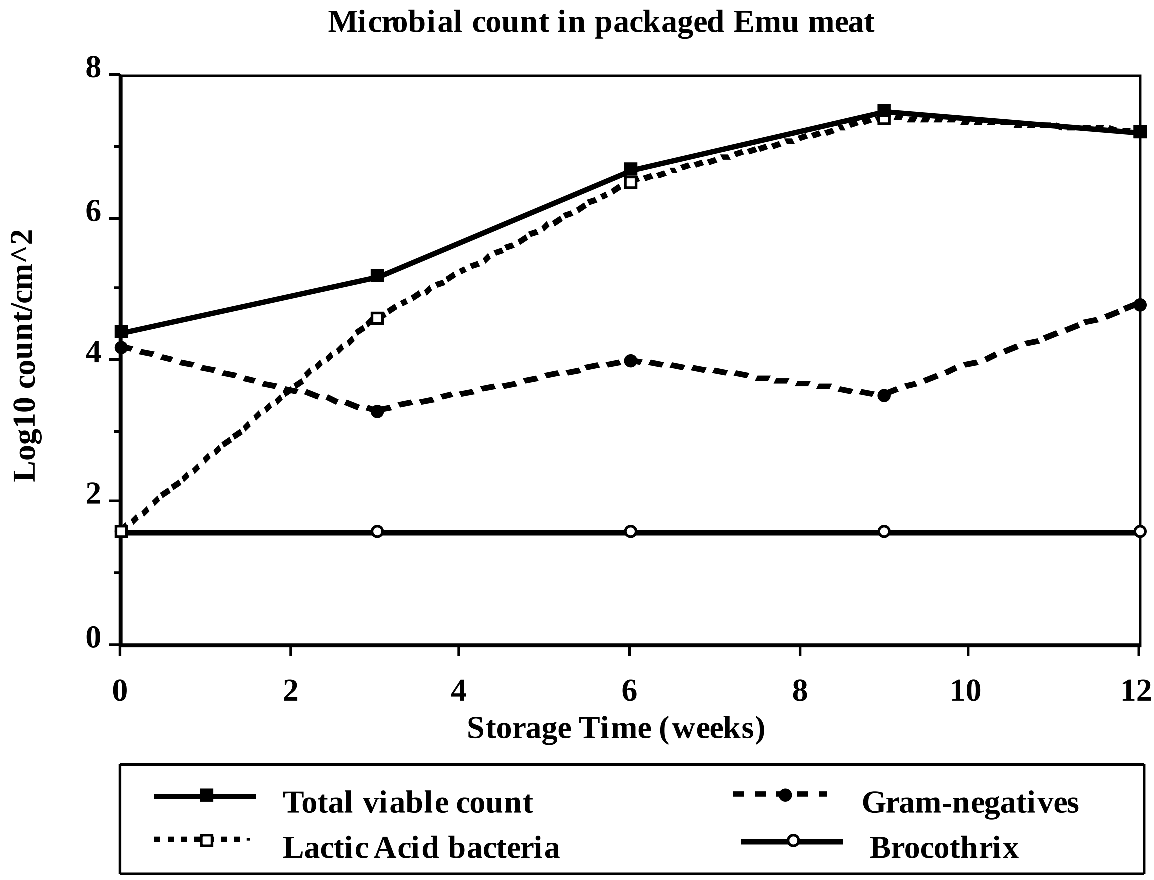
At the end of each period (3, 6, 9 or 12 weeks), the frozen and chilled muscles from sides of the same 10 birds were compared for meat quality characteristics and microbial assessment. The microbial assessment was co ordinated by Dr Barry Shay from CSIRO, Cannon Hill Qld.

• Results:

Table 1 Meat quality assessment

Weeks post slaughter	Treatment	Raw Off odours (1-5 v.strong)	Raw Appearance (1-6 poorest)	Off flavour (1-5 v.strong)	Acceptability (1-6 very un-acceptable)	Taste panel Score (1-6 v. tender)
fresh	fresh	1.3	2.4	1.1	2.1	3.8
3 weeks	Chilled	1.3	2.1	1.2	2.1	3.7
	Frozen	1.4	2.7	1.1	1.9	3.9
6 weeks	Chilled	1.8	2.8	1.1	2.3	4.0
	Frozen	1.4	2.8	1.0	2.3	3.2
9 weeks	Chilled	3.2	3.6	1.3	2.7	4.1
	Frozen	2.3	2.8	1.0	2.2	3.8
12 weeks	Chilled	3.2	4.1	2.2	3.5	4.0
	Frozen	1.7	3.3	1.4	2.6	3.9

Figure 1. Microbial count



• Discussion:

The microbial profile is consistent with that found in other meat stored under the same conditions.

In general, the meat was found to be acceptable when held for up to 9 weeks under the particular temperature regime of the trial. It is considered that it would have also been acceptable after 12 weeks had the temperature been maintained at -1 to 0°C as intended.

For maximum shelf life, it is important to ensure that the meat is correctly vacuum packaged, that no meat with pH over 6 is packed and that the meat is held at a temperature of around -1 to 0 degrees C.

It must also be remembered that the storage period includes time for distribution, display and consumption by the buyer . This time and the prevailing storage conditions, must be considered in determining the 'safe' storage period prior to shipment.

(ii) The effect of 'ageing' on emu meat quality

• Background:

Chilled storage of vacuum packaged meat is also a conventional method of ageing meat to improve tenderness. During the storage period, meat gradually becomes more tender as enzymes present in the meat, weaken and break down the fibre structure.

• Method:

To test the effect of ageing on the tenderness of emu meat, the flat fillet was removed from each of the 50 birds mentioned above and vacuum packed. Five treatments were applied as follows;

The flat fillet from 10 birds was frozen immediately as a control group and the muscle from the other 40 birds was chilled as above. Ten of the muscles were removed from the chiller after 3, 6, 9 or 12 weeks ageing and frozen at minus 20^{o}C. All 50 muscles were later thawed and assessed on the same day.

• Results:

Table 2 shows that in this trial there was no appreciable improvement in the tenderness of emu meat after ageing for up to 12 weeks.

Table 2.

Effect of ageing on the tenderness of emu meat

Weeks of chilled storage	Taste panel score (1-6) (6 = very tender)	Shear force (kg) (lower value more tender)
0	3.53	4.45
3	3.27	4.34
6	3.21	4.58
9	2.98	4.60
12	3.16	3.99

(iii) Nutritional analysis of emu meat

• Method:

The flat fillets were removed from 6 yearling emus and lightly trimmed of fat to a level ready for sale to a meat wholesaler. The flat fillets were then cut into strips and the strips were combined and thoroughly minced. A 1 kilo sample of the mince was provided to the Chemistry Centre (WA) where is was again minced and sub sampled prior to nutritional analysis.

The meat analysis was conducted according to the Chemistry Centre's method 44 and the minerals were analysed by ICP spectrometry according to the Chemistry Centre's method 53.

• Results:

The nutritional analysis of the emu meat is shown in the Table 3, below.

Table 3. Nutritional analysis of emu meat

Component	**Percentage**
Moisture	73.4
Protein	21.6
Fat	4.7
Ash	1.14
Cholesterol	.072
Component	**mg/kg**
Calcium	27
Magnesium	250
Sodium	530
Potassium	3700
Iron	48
Copper	2.8
Zinc	25
Phosophorous	2200
Sulphur	2300
Manganese	0.3
Calories (Kcal/100)	132
Energy (KJ/100g)	553

• Discussion:

Emu meat is low in fat and has an extremely high iron content. Both characteristics have positive health connotations and will be important components of any campaign promoting emu meat.

There is also a down side to both components. The leanness of emu meat means it is susceptible to dryness if overcooked and it is recommended that emu meat be served medium rare. The high iron content of emu meat contributes to the dark colour as it does to the colour of other game meats such as kangaroo and venison. The dark colour is unattractive to retail customers because they associate it with meat from old animals or meat that isn't fresh. An emu meat promotional campaign needs to address this issue by highlighting the positive health aspect of the high iron content and the fact that the dark colour is a feature of game meat.

(b) Establishment of a description system for emu meat

(i) Emu cut description:

To aid emu meat marketing and reduce confusion amongst buyers, an emu cut description system was developed. The description has been incorporated into an export trade description as required by the Australian Quarantine and Inspection Service (AQIS) and into promotional material for meat sellers and buyers. A Register of Approved Emu Cuts and Items was produced and has been adopted internationally as the standard emu meat trading language. The Register also includes information on packaging and labelling requirements for emu meat.

The outline of the system is shown in Figure 2

Figure 2 - Standard Description of Emu Cuts

E1 EMU CARCASE
↓
E 10 EMU SIDE
↓
→ → **E 20 FORE QUARTER**
↓
↓ E 21 STRIPLOIN
E 30 HIND QUARTER
↓ → → **E 40 DRUM**
↓
↓ E 41 Inside drum
E 50 THIGH E 42 Outside drum
E 43 Mid drum
↓ (E 51 Full rump) E 44 Drum strap
E 45 Inner mid drum
↓ E 46 Inner outside drum
E 60 FORE SADDLE **E 70 HIND SADDLE**
↓ ↓
E 61 Fore rump E 71 Hind rump
E 62 Round E 72 Flat rump
E 63 Flat fillet E 73 Fan fillet
E 64 Oyster fillet E74 Outside fillet
E 52 Inside fillet

(ii) Weight of emu cuts

• Background:

The emu cuts manual defines and illustrates the portions an emu carcase can be broken into for sale. At the time of its publication, information on the size of each cut relative to age and live weight of the bird was not available. Since its publication it has been possible to collect a limited amount of data on the size of cuts taken from birds grown at the Medina Research Centre.

• Method:

The birds were reared on a standard chick ration and slaughtered as part of a trial to determine the chemical composition of emus. The left side of six birds were broken up using the procedure outlined below at 25, 40, 51 and 70 weeks of age. Each cut was weighed, as was the bone, trim and waste.

The individual muscles recovered from 25 week old birds were prepared further by removing the facia and connective tissues. This increased the amount of wastage for drum muscles by an average of 15 percent and by 10 percent for muscles derived from the thigh.

This data has been combined with the information obtained from our initial work to determine the quantity of products derived from emus slaughtered at different ages, to produce table 4.

• Detailed method:

The drum was separated from the hindquarter by using a knife to cut from behind the junction of the tibia - femur joint to expose the joint. The knife was then forced through the joint to separate the drum from the hind quarter.

Drum

Individual muscles were removed from the drum by seam boning. The inside drum was removed first, followed by the mid drum and then the outside drum. The inner outside drum and the inner mid drum were removed next. Finally, the drum strap was removed from the tibia. Muscles were trimmed where necessary.

Thigh

The inside fillet was removed by cutting down to the facia that separates the inside and outside fillet which lie over the ilioischiatic and iliopubic fenestra.

The whole rump was separated from the flat rump by first forcing a finger between the junction of these two muscles in the area towards the tail bone. The full rump was then removed by separating it from the flat rump and peeling it over the round, cutting it here, over the fan fillet and then separating it from the flat fillet. The flat rump was removed next followed by the fan fillet, the round and the flat fillet. The oyster fillet was cut from the pelvis and finally the inside fillet cut from the iliopubic fenestra. Remaining meat was separated into trim and waste.

Table 4 Average cut weights from emus of different age and weight

	65 Weeks	55 Weeks	45 Weeks
Kilograms			
Live weight	41.32	34.70	30.60
Fat	10.24	5.44	3.53
Neck	1.01	0.97	0.97
Liver	0.47	0.47	0.37
Emu carcase	18.80	17.03	16.50
Forequarter	1.10	0.98	0.93
Strip loin	0.47	0.35	0.35
Hindquarter	8.20	7.74	7.31
Grams			
Drum	3,200	3,150	2,850
Mid drum	519	546	418
Outside drum	515	468	454
Inside drum	671	625	593
In out drum	344	314	320
In mid drum	317	306	284
Drum strap	84	102	94
Bone	669	667	691
Thigh	5,000	4,590	4,460
Fore saddle	1,958	1,885	1,737
Hind saddle	2,072	1,995	1,813
Fore rump	323	303	286
Hind rump	486	451	430
Full rump	809	754	717
Flat rump	237	233	213
Round	457	393	365
Flat fillet	450	381	404
Fan fillet	616	560	551
Oyster	370	313	311
Outside fillet	386	323	323
Inside fillet	237	192	195
Trim	329	417	410
Bone	826	745	917

(c) Preparation of generic promotional material

Apart from the Register of Approved Emu Cuts and Items, the Agency prepared a coloured leaflet featuring emu meat recipes and an emu meat poster for point of sale promotion. Over 20,000 copies of the leaflet have been sold to emu meat marketeers. The Agency also produced a video showing the various stages involved in the commercial processing of emus and another video describing a method of boning an emu carcase to produce the standard emu cuts and items. The videos have been used extensively by operators planning to build emu processing facilities in Australia.

A coloured leaflet was also produced which described the features of emu leather. The leaflet was produced for point of sale promotion and use at international leather fairs to educate potential buyers on the characteristics of emu leather. Over 10,000 copies of the leaflet have been sold to leather marketeers.

(d) Generic promotional activities

(i) Emu meat

Emu meat tasting was featured at the Agriculture Western Australia's display at the Perth Royal Show in 1993. The emu meat tasting display was featured in the 'West Australian' newspaper and was the subject of two radio interviews. The tasting involved serving grilled emu meat to the public at tasting sessions throughout the day. Over all, 10,000 people attended the tastings.

Some of those who ate the meat, were asked to complete a questionnaire describing their opinion of it. The replies from the 500 respondents were as follows.

Question 1: What do you think of the taste of the meat?

11.5% said it was tasty

8.2% said it was tender

2.3% said it was juicy

4.7% said it was beefy

3.5% were uncommitted

67.1% made other positive comments

2.5% made negative comments

Question 2: How does it compare to what you usually buy?

7.3% said it was more tender

18.5% said it was similar

33.9% said it was better

1.2% said it was poorer

9.5% were uncommitted

28.4% made other positive comments

0.4% made other negative comments

Question 3: Would you buy it?

84.7% said yes - 4.3% said no - 11.0% said maybe

Question 4: If so, at what price?

6.0% said $4/Kg

11.8% said $5-6/Kg

14.2% said $7-8/Kg

24.0% said $9-10/Kg

7.3% said $11-12/Kg

6.2% said >$12/Kg

30.5% were unsure

The results indicate that grilled emu meat is very well received by the public, which confirms earlier work conducted in supermarkets. With over 6% of respondents prepared to pay more than $12 per kg, there is potential for limited sales at current prices on the local retail market especially since emu meat is novel and lean. Bulk sales on the retail market however, will more likely be at grilling steak prices especially in the longer term.

The interest in emu meat and the quality perceptions indicate that it will be highly acceptable on a restaurant menu.

Emu meat was also featured by Agriculture Western Australia at the "Hospitality Expo" at the Perth Entertainment Centre in 1992-1994. The Expo is the major forum for displaying products and services for the hospitality industry in WA. and was attended each year by over 5000 industry members. The displays involved emu meat tasting sessions, each attended by one of the major emu meat wholesalers in WA.

(ii) Emu leather

Emu skins were sent to every exotic leather tanner in Australia and most of the major exotic leather tanners overseas. Unfortunately none of these tanners has been able to tan emu skin so that the follicles are raised significantly. Also none of the tanners expressed interest in buying commercial quantities of emu skin at the prices of A$15/square foot and A$15/leg set by industry. Generally tanners were suggesting prices of A$10/square foot and A$10/leg. Potential end users of the leather showed far more interest but at that stage there was no tanner available to produce commercial quantities of the quality required.

Emu leather was also promoted extensively by the Agency at the Hong Kong Leather Fair in 1992. Agency staff manned a display booth and exhibited samples of tanned emu leather and emu leather articles. Response from the trade was modest at the prices set by emu producers.

(2) Reduce slaughter costs

a) Development of defeathering procedures

(i) Evaluation of scalding procedures

• Background:

Feathers have to be removed from emu carcasses prior to skin removal and subsequent processing. Manual plucking is time consuming and therefore a costly process. It was considered that scalding, as practiced in the poultry industry, may make plucking easier and thereby reduce the number of pluckers required for manual plucking and/or facilitate mechanical plucking.

However, there was the potential that the temperatures required to make plucking easier could result in damage to the skins that would render them unsuitable for leather production or decrease the value of the leather produced.

A preliminary investigation was undertaken into the relationships between scalding regimes (temperature/ time), ease of plucking and skin damage.

• Methodology:

Laboratory trials

Three hand plucked emu carcases were cut in half, ie 6 sides. Matching experimental scalds were inflicted on each side of the one carcase by placing a ball peen hammer in a water bath at the required temperature (50, 55, 60, 65, 70 or 80^{o}C) allowing it to equilibrate (5 min) and then applying it to skin for the required time (5 or 10 sec) at the required location (neck, breast, butt or leg). After the skins were removed, one side from each bird was sent to a commercial tannery (Neptune Leather, Jandakot, WA) for tanning and the other side was used for histological examination.

The resulting histological sections were stained with Haematoxylin/ Eosin or Masson trichrome. Masson trichrome is an unusual stain that stains native collagen blue/green and stains disrupted (denatured) collagen red.

Abattoir trials

For the first trial six birds from a commercial farm were used. The birds were slaughtered at the Day Fresh Meat Processor's abattoir (Casuarina, WA). After slaughter, the carcases were immersed in water at either 65^{o}C for 1 minute, 60^{o}C for 2 minutes, 55^{o}C for 2 minutes, 50^{o}C for 2 minutes, 50^{o}C for 4 minutes or 55^{o}C for 1 minute with detergent added.

After scalding and plucking, samples of skin were taken from the breast and upper leg for histological examination. The skins were then sent for tanning.

For the second trial, four birds from a commercial farm were used. The birds were quite small and presumably younger than those used in the previous trial. After slaughter, the carcases were immersed in water at either 70^{o}C for 1 minute, 67^{o}C for 1 minute, 61^{o}C for minute or 56^{o}C for 1 minute.

For the third trial, 60 week old birds from the Agency's Medina Research Centre were used. Four carcases were scalded at 60°C for 2 minutes and four unscalded carcases were used as controls, to assess damage during tanning. The skins were photographed prior to tanning.

- **Results:**

Laboratory trials

The histological appearance of the undamaged emu skins is very different from the histology of the mammalian (sheep, pigs and cattle) skins. The emu skin has a reasonably dense and thick epidermis. Immediately under the epidermis, there is a thin dense collagenous layer that presumably forms the grain layer of the leather. Under this, and poorly connected to it, is the dermis. In the dermis nearly all the collagen fibres are oriented parallel to the skin surface. There is little collagen orientated perpendicular to the skin surface and little connecting the main dermis and grain layer. Also there is an extensive blood supply system just below the grain layer. The vessels are narrow but wide with the long axis parallel to the surface.

The application of an 80°C scald for 5 seconds to the breast resulted in leather with a dull grain. The grain was largely intact but there was some scuffing. The histological sections showed that the epidermis was missing in most areas. Most of the collagen in the dermis stained red, indicating denaturation but there was only minimal disruption of the collagen fibre organisation. The application of an 80°C scald for 10 seconds to the breast resulted in leather which was severely scuffed. The histological sections showed that the epidermis had largely been removed and there appeared to be denaturation of the collagen in the superficial grain layer. In the dermis there was evidence of denaturation and some disorganisation of the fibre structure but it was largely intact.

The application of an 80°C scald for 5 seconds to the neck resulted in leather with some dulling of the grain but no scuffing. The histological sections showed that the epidermis was largely intact and there was no sign of denaturation of the collagen in the dermis.

An 80°C scald for 5 seconds to the butt and leg resulted in leather with severe scuffing.

The application of an 70°C scald for 5 or 10 seconds to the breast or butt resulted in leather where there may be some slight dulling of the grain but no obvious scuffing. The application of an 70°C scald for 5 seconds to the leg caused no detectable damage to the leather.

The application of scalds at 65°C, or lower temperatures, resulted in no detectable damage to the leather, irrespective of the duration of scalding.

Abattoir trials

Scalding at 65°C for 1 minute or at 60°C for 2 minutes both resulted in the feathers being very easy to pluck. Also, both treatments resulted in the epidermis coming off from parts of the skin. With 55^{o}C for 2 minutes, plucking was considerably easier than with unscalded birds but not as easy as when higher temperatures were used. There was no obvious damage to the skin. Scalding at 50^{o}C for 2 or 4 minutes resulted in limited improvement in the ease of plucking, compared with the unscalded control.

No obvious gross damage due to scalding was evident on any of the tanned skins. All skins had a number of defects, including scarring, but these could not be related to the scalding.

Histological examination of samples from the skins scalded at 65^{o}C and 60^{o}C, showed that the epidermis had been removed but the was little or no evidence of the denaturation of the dermal collagen. With all other samples there was no evidence of heat damage.

In the second trial, scalding at 67^{o}C or 70^{o}C for 1 minute both resulted in the feathers being very easy to pluck. Also, both treatments resulted in the epidermis coming off from parts of the skin. With 61^{o}C for 1 minute, plucking was considerably easier than with unscalded birds but not as easy as when higher temperatures were used. There was no obvious damage to the skin. Scalding at 56^{o}C for 1 minute did not result in any improvement in the ease of plucking compared with the unscalded control.

All skins in this trial were severely scratched with the damage to the leather mainly concentrated along the backbone. It is possible that the heat at the higher temperatures had exacerbated existing damage, ie in areas where the epidermis and the superficial dermis (the grain layer) had been damaged prior to scalding. The pattern of the damage did not appear to be consistent with different heat sensitivities of the different regions of the skin or through variations in the extent of heating but these cannot be strictly ruled out as possibilities.

In the third trail (60^{0}C for 2 minutes), all scalded birds had areas where the epidermis was coming off but there was no obvious effect of scalding on the appearance of the finished leather. Scalding made it easier to remove the feathers but the workers complained that it made it harder to remove the skins.

• Discussion:

From the histological appearance of emu skins it is obvious why it is relatively easy to detach the grain layer from the underlying dermis during processing. Tanners should be made aware of this and take appropriate care during tanning.

It would seem that to produce significant loosening of the feathers that a temperature of between 60 and 65^{o}C for one minute is required. In the first abattoir trial significant loosening was achieved without obvious damage to the leather but this was probably not the case in the second trial where the birds were much smaller. So there may be an age effect which requires investigation. In the last abattoir trial, scalding at a relatively low temperature (60^{o}C) for a relatively long time (2 min) did achieve feather loosening without detrimental effects on the final leather.

In the second abattoir trial, the maximum damage appears to be centred around the backbone with obviously less damage on the flanks. In the laboratory trials the flanks appeared to be at least as sensitive to heat damage as around the backbone and it would seem probable that the scalding may have exacerbated pre-existing damage such as scratches and recently healed scars.

The fact that we have not seen damage due to scalding in the tanned product, except possibly where the epidermis has been damaged or removed prior to scalding, is perhaps not surprising in view of the isometric thermal contraction behaviour observed with emu skin. The skin has a high denaturation (shrinkage) temperature (66 to 67 ^{o}C) and a high temperature at which the maximum tension occurs (approx. 90 ^{o}C). At temperatures above this, the decrease in tension is slight, indicating that the breakdown of the collagen fibres is slow even at these high temperatures. For comparison, the shrinkage temperatures of skins from rats age 6 and 18 months, are between 60 and 62^{O}C and the temperatures at which maximum tension occurs are 71 and 78^{O}C respectively and the tension decreases rapidly at higher temperatures. Also, it must be remembered that in these studies the collagen in the dermis was not protected from heat by the epidermis which it is in the case of scalding.

At the present time, the question of whether to recommend scalding of birds prior to plucking is unresolved. In summary the advantages and disadvantages of scalding are:

Avantages

1. Scalding makes plucking easier which may enable the number of pluckers to be reduced. Also, easier plucking may facilitate mechanical plucking.

Disadvantages

1. Without extensive modification of the kill area, scalding slows down the kill rate.

2. Scalding makes the skins harder to remove, which increases the potential damage to the skins.

3. Potential heat damage to the skins as there may be a fine line between feather loosening and heat damage to the skin.

4. DPI may not allow the use of the same water for a number of birds because of possible cross contamination.

5. Wet feathers.

• Conclusions and recommendations:

1. For birds of 60 weeks of age or older, scalding at 60^{O}C for 1 or 2 minutes makes plucking easier without having any detrimental effect on the resulting leather.

2. Further scalding trials should be carried out, preferably in conjunction with trials of mechanical pluckers, before any recommendations are made to industry. These should

include an investigation of the effects of animal age.

(ii) Dry plucking

Dry plucking using ‘spinning disc’ machines is sometimes practiced in the poultry industry and in countries which for religious reasons require poultry to be dry plucked. In some European countries dry plucking is also done using conventional ‘rubber finger technology’.

A set of rubber fingers attached to a conventional high speed drill failed to remove the feathers from an emu. Commercial machinery designed for the plucking of poultry after scalding did not successfully remove feathers from dry or wet emus carcases.

A conventional spinning disc plucking machine, supported on a fixed stand, successfully removed the feathers from an emu presented to the discs. A prototype machine which could be presented to a hanging bird was constructed and trialed. It failed to pluck the feathers as well as the standing machine. This was thought to be caused by the lower fan suction provided by the prototype and considerably more engineering and development work is required to adapt this technology to the commercial plucking of emus.

(iii) Plucking after scalding

Emus were plucked after scalding using a large scale poultry plucker adjusted to accommodate an emu carcase. While only partial defeathering was possible, skin areas which came into contact with the rotating fingers were effectively plucked.

25 week old emu carcases were also plucked after scalding using a drum plucker designed for turkeys. While a good level of feather removal was achieved, skin damage to legs and the rump of the bird was recorded.

Emus were plucked after scalding using a large commercial pig de-hairer. A good level of feather removal was achieved but skin damage to the rump of the bird was recorded.

The commercial poultry plucking machines and the pig de-hairing machine failed to remove the feathers from emus which had not been scalded.

Conclusions and Recommendations

It will be possible to defeather emus with or without scalding using existing technology. However, the commercial machinery currently available will require exstensive modification to make it suitable for the plucking of emus.

(3) Eliminate skin and meat stress damage during transport

(i) De-clawing of emu chicks

• Introduction:

Emus grown commercially in large flocks can suffer serious trauma from cuts and scratches caused by the claws of their pen mates during displays of natural aggression, social interaction and transport. In addition some birds are difficult to handle and the claws can inflict serious injury to anyone handling the birds.

De-clawing (toe trimming), which involves removing the toe nail and its growth point, is a recognised procedure in the poultry industry and is approved under the SCA Code of Practice for the Husbandry of Poultry. While de-clawing emus has welfare implications, if done soon after hatch it is unlikely to have a major impact on the birds growth and welfare but will result in significantly less damage to the birds and their skin from fighting and during transport. It will also significantly reduce the risk of injury to operators handling the birds.

The skin of an emu is one of its major products and an A grade salted skin currently sells for about $50 - $60. Unfortunately the skin is quite fragile and down grading as a result of damage is a major problem for the industry. Research and observation has confirmed that the major cause of skin damage is due to scratches inflicted by the birds claws during fighting in the pen and transport.

• Methodology:

A trial to determine the effect of de-clawing emus on (a) the growth, food consumption and welfare of emus to 76 weeks of age and (b) the incidence of damage to emu skins, was completed in February 1994.

Each of the following treatments was applied to 5 replications of 11 birds.

(a) Control

(b) Middle toes de-clawed

(c) All toes de-clawed

The chick's toe nails and the growing point were removed at hatch using a hot blade beak trimming machine.

Chicks were weighed at hatch and at weekly intervals until 4 weeks of age, fortnightly to 18 weeks and then 4 weekly until 76 weeks of age. Food consumption and mortality was recorded at each weighing date. A veterinarian determined the cause of any deaths.

Birds were transported over a distance of 100 kilometres the day prior to slaughter. Skins were carefully graded by a qualified tanner after removal from the bird. Carcase weight and total yield of fat and muscle was determined for each carcase.

• Results :

(a) Growth

De-clawed chicks were slower to start and while their average live weight was consistently lower than the control to 14 weeks of age these differences were small and significant ($p < 0.05$) at two weeks of age only. Growth from 3 weeks of age was similar for all treatments.

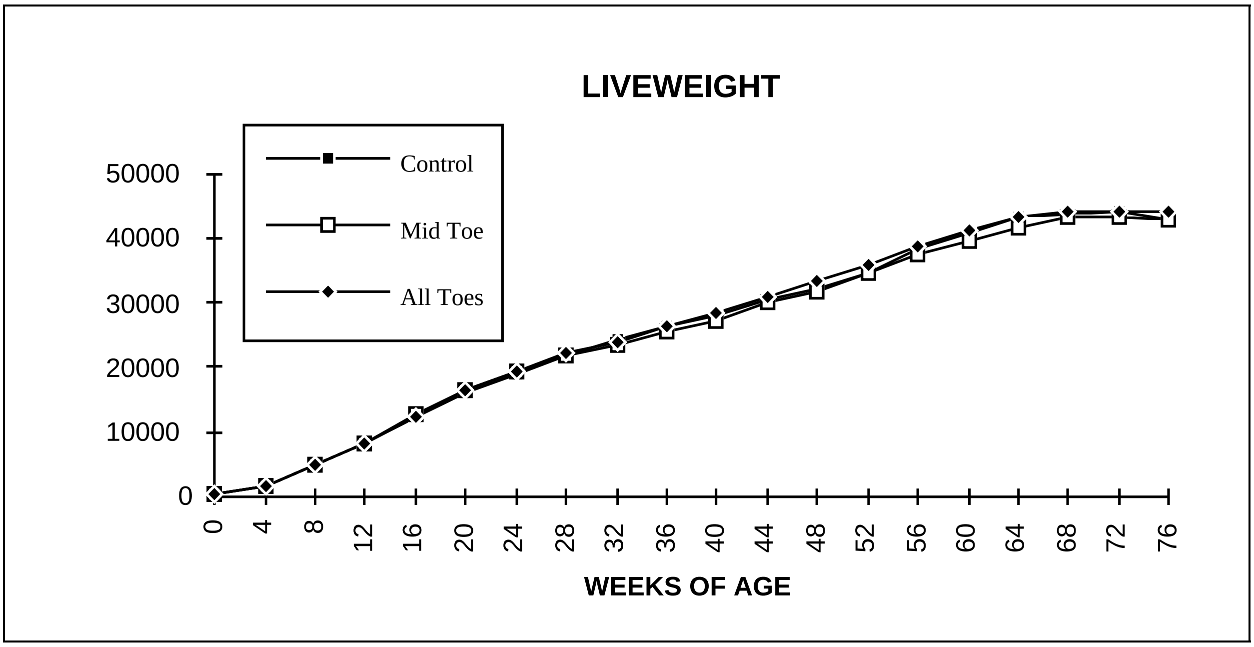
Table (5) Average live weight (grams)

Week of Age

Treatment	**0**	**1**	**2**	**3**	**4**	**6**
Control	411	432	714	1128	1622	3073
Mid-toe	415	415	661	1042	1535	3022
All-toes	417	387	644	1020	1494	2834
SED		18.2	22.6	63.5	94.3	127.8
Probability *		0.116	**0.027**	0.15	.275	.233

* Control versus Mid and All-Toes treatments

Figure 3 Live weight changes 0-76 weeks of age



There were no significant differences between treatments in carcase weight, muscle yield or weight of fat at slaughter as shown in Table 6.

Table 6. Slaughter Yield (kgs/bird)

Treatment	Carcase Weight*	Total Fat	Total Muscle
Control	20.8	9.8	13.0
Mid-toe	21.0	10.1	13.1
All-toes	21.3	10.3	13.3

* Fat removed

(b) Feed Consumption

Birds in the de-clawed treatments ate less feed during the 2nd and 3rd weeks of the trial and this was consistent with the slower early growth recorded.

Table 7. Feed Eaten (g/bird/day)

Weeks of Age

Treatment	**0 - 1**	**1 - 2**	**2 - 3**	**3 - 4**	**4 - 6**
Control	12.5	72.7	114.2	152.4	194.1
Mid-toe	10.0	57.8	83.0	140.7	200.5
All-toes	6.5	52.0	89.5	145.2	200.3
SED	2.21	3.12	13.3	12.88	21.93
Probability *	0.074	**<0.001**	**0.058**	0.453	0.758

* Control versus Mid and All de-clawed treatments.

As the birds reached maturity there was a tendency for the de-clawed treatments to eat less feed and this resulted in the cumulative feed eaten over the total period of the trial reaching significant differences at 44 weeks of age.

Table (8). Cumulative feed eaten (g/bird/day)

Weeks of Age

Treatment	**0-8**	**0-24**	**0-44**	**0-64**	**0-76**
Control	151.8	390.3	484.9	637.3	625
Mid-toe	143.5	386.5	471.6	604.2	597.9
All-toes	144.0	389.9	471.5	608.3	599.6
SED	10.91	9.30	8.4	10.31	11.07
Probability *	0.449	0.768	0.104	**0.008**	**0.026**

* Control versus Mid and All de-clawed treatments

(c) Feed Conversion

The efficiency of conversion of feed to live weight was consistent with the growth and feed consumption recorded. ie the de-clawed treatments recorded significantly better conversion at 2 weeks of age and cumulative conversion was better toward the end of the trial.

(d) Mortality

The chicks were heavily challenged by an outbreak of Aspergillosis at 2 weeks of age and mortality was high. Despite this high level of challenge and the obvious slower early growth demonstrated by the de-clawed birds, mortality between treatments was similar.

Table 9. Summary of Mortality to 76 weeks of Age (55 birds/treatment)

Mortality	Control	Mid toe	All toes
Hatch problems	1	1	2
Leg cull	0	4	4
Aspergillosis	8	12	9
Deaths 10-76 weeks	6	4	6
Total	**15**	**21**	**21**

(e) Skin Quality

De-clawing dramatically improved skin quality as shown in Table 10.

Table 10. Skin grading at slaughter (percentage)

	GRADE				
Treatment	**A**	**B**	**C**	**D**	**E**
Control	9	26	25	20	20
Mid-toe	26	10	16	22	26
All-toes	50	22	6	9	13

Chi squared analysis (number of A grade skins)

Control versus Mid-de-clawed — Not Significant

Control versus All-toes de-clawed — Significant $P < 0.01$

Mid-toe versus All-toes de-clawed — Significant $P < 0.1$

(d) Assessment of nerve endings

To determine whether the de-clawing procedure may cause the development of traumatic neuromas, abnormal tangles of regenerative nerve fibres that can spontaneously discharge and cause chronic pain in amputated limbs, toe stumps taken from mature birds being submitted for analysis by a neuro scientist (C.A. Lunam et al). No evidence of neuroma formation was found in the samples submitted.

• Method:

At 70 weeks of age emus de-clawed and housed under conditions similar to those applied to the trial birds were slaughtered and the mid toe of 3 birds was immediately excised and immersed in Zamboni's fixative for several weeks. The mid toes of 2 emus from the same hatch which had not been de-clawed were collected in the same manner. After fixation, each toe stump was cut into 1 cm lengths, most of the hard keratin peeled from the toes and the central core of the phalangeal bone excised. The tissue segments were decalcified in ethylenediaminetetra-acetic acid for 10 - 14 days. Some segments were processed by routine wax-embedding and 10μm thick transverse sections stained with either haematoxylin and eosin(H&E), or Verhoeff and van Gieson(V&VG) for microscopic visualisation of the structures of the toe stump. Most segments were processed for the identification of nerve fibres using triple silver impregnation stain on frozen transverse-sections of 40μm thickness. Sections were collected at 500μm intervals through each segment.

• Results:

Tissue types, sensory receptors, blood vessels and nerve bundles were clearly identified using H&E, and V&VG stains. The epidermis consisted of two distinct layers, a thick stratum germinativum and a dense corneum. Differences were observed in the dermal-epidermal junction between the dorsal and the ventral margins of the toe. Dermal papillae, though numerous at the ventral region of the toe were absent at the dorsal margin where the keratin had become dense to form scales. The dermis consisted of dense irregular collagen and elastin fibres that encapsulated the bone of the distal phalanx. Herbst corpuscles were observed in the dermis close to the lateral margins of he dorsal scales of all toes. The dermis was well supplied with blood vessels, these were particularly numerous in the ventral dermis.

An extensive mass of chondroid-like tissue was present immediately ventral to the tendon of the flexor digitorum longus muscle. This cartilage-like tissue contained abundant elastic fibres.

Silver staining confirmed the distribution and size of nerve bundles observed with conventional staining. The distribution of nerves in the de-clawed toes was comparable to that in the intact toe. Nerve bundles mostly accompanied the larger blood vessels. Within nerve bundles, fibres were aligned parallel to one another. Nerves were rarely observed near the dermal-epidermal junction. Intra-medullary nerves were present in the bone of the distal phalanx.

Neuromas were not observed in any histological sections taken through the extent of the distal 4cm of each de-clawed toe.

• Discussion :

Assessment of the nerve endings suggests that growing birds which have been de-clawed should not experience chronic pain and no difference between the mobility of clawed and de-clawed birds was observed.

The lower feed consumption of the de-clawed birds over the growing period which represented a feed cost saving of $3-4 per bird could not be explained but is thought to have been the result of a lower maintenance requirement caused by their less aggressive behaviour and apparent lower levels of stress and trauma as a result of claw damage.

The de-clawing operation dramatically improved the quality of skins taken from emus. At current prices the improvement in skin quality resulted in a $20 increase in the average value received for the skins taken from birds with all toes de-clawed.

• Implications and recommendations:

De-clawing has welfare implications and cannot be endorsed as a recommended husbandry practice until it is included in the National Code of Practice for the Welfare of Animals - Husbandry of Captive Bred Emus. The procedure has been demonstrated to the RSPCA in Western Australia and although they have not endorsed the procedure they are not critical of it if the procedure is carried out according to methods recommended by the Agriculture Western Australia. The technique has also been demonstrated to the Sub Committee on Animal Welfare (SCAW) and a paper has been prepared seeking reaction from SCAW members to the inclusion of de-clawing in the National Code of Practice.

(ii) Modify and evaluate stock crate design

• Introduction:

Emus are not long removed from the wild and are temperamental and can be difficult to handle. Proper transport facilities are important for the animal's welfare, economic considerations and the safety of the operator. Damage to the birds during transport is manifested in abrasions on the skin and high pH values in the meat. Values of pH above 6 are generally associated with dark cutting meat which is unattractive to consumers and has a reduced shelf life because the lower acid level is more conducive to bacterial growth.

A prototype stock crate was constructed to allow for evaluation of a number of factors thought to reduce stress and damage during transport. The crate has a steel frame with ply wood sides with a tarpaulin over the top so the birds are completely enclosed. Holes have been cut in the ply sides and air scoops fitted to improve ventilation and the crate is painted white to keep it cool.

There is still discussion within the industry on the best layout inside the stock crate. Some crates have single compartments for each bird, while other have no partitions at all. The prototype crate was built so that various configurations could be tested for ease of loading and level of skin and meat damage. The crate has 4 single pens across the front and the remainder of the crate can be divided internally with movable partitions to produce 1 large pen or up to eight small pens(approx 1.2mx1.1m). A false ceiling can be suspended in the pens to determine the effect of ceiling height. Some producers believe that if the emu can not raise its head to full height it is less likely to jump and since emus jump to kick, damage from fighting in the truck can been reduced.

• Method:

A total of 140 de-clawed emus were transported to slaughter over 2 slaughter dates in December 1994. As well as the 4 single bird pens, the stock crate was partitioned into 4 larger pens (1.1m x 2.4 m). Within these pens, bird density (5, 6 or 7 birds per pen) and ceiling height (H = full height or L = 1.4 m) was altered as follows:-

Slaughter date 1 -

Load 1- 4 birds in single pens (4S); 5 birds per pen, low ceiling (1.4m) (5L) ; 5 birds per pen, high ceiling (5H); 6 birds per pen, low ceiling (6L) and 6 birds per pen, high ceiling (6H).

Load 2- 4S; 6L; 6H; 7L;7H

Load 3- 4S; 5L; 5H; 7L; 7H

Slaughter date 2 -

Repeat of the above.

The birds were transported for 11/2 hours on the day prior to delivery to the abattoir. The birds were kept in a common pen at the research station overnight with the exception of the birds transported in the single pens which were penned separately. All birds were then delivered to the abattoir the following day. At the abattoir, the emus were processed conventionally and their skins were graded prior to salting, as A, B, C, D or E based on the extent and location of skin damage resulting from transport . Damage which occurred during skinning was not taken into account when determining the grade. The sex of each bird was also recorded during processing.

The emus were boned and packed the following day. The ultimate pH of the meat from birds processed on the first slaughter day, was determined, using a pH meter.

• Results:

(a) Skin grade

There was no difference in the distribution of skin grades between birds of different sexes.

Table 11 % Skin grade versus sex

Skin grade

Sex	A	B	C	D	E
Female	54	21	17	2	5
Male	55	18	18	5	4

Ceiling height had no effect on skin quality.

Table 12 % skin grade versus ceiling height

Skin grade

Ceiling height	A	B	C	D	E
High	51	19	23	4	3
Low	54	22	13	4	6

Chi square analysis showed no significant differences in the distribution of skin grades between emus transported at the different densities. However there is an indication that the skin of birds transported at the density of 7 birds per pen (.48 sq meters per bird) were more heavily damaged that those of birds transported at the lower densities.

Table 13 % skin grade versus stock density

Skin grade

Density	A	B	C	D	E
Single	62	17	17	0	4
5/pen	61	15	18	3	3
6/pen	60	19	17	2	2
7/pen	39	25	20	8	8

(b) Muscle pH

The mean pH value of meat from birds in each treatment group is shown in Table 14.

Table 14 Mean pH versus transport treatment

	Control	Single	5H	5L	6H	6L	7H	7L
pH	5.610[a]	5.870[b]	5.677[a]	5.688[a]	5.639[a]	5.662[a]	5.661[a]	5.709[a]
glycogen g/100g	0.377	0.088	0.283	0.306	0.294	0.292	0.365	0.170

Means with different superscripts, differ significantly at the 5% level.

The only statistically significant difference in the analysis, is that the pH of meat from the birds in the single pens was higher than that from birds in the other pens.

There was no difference in pH of meat from male and female birds and no effect of ceiling height on ultimate pH.

• Discussion and recommendations:

The results indicate that there would be no benefit in transporting de-clawed emus in single sex groups and also show no improvement in skin quality, from reducing the ceiling height in the stock crate to 1.4 metres. Conversely it does show that double deck transport is an option provided adequate ventilation is given.

There is an indication that a pen area below .45 square metres per birds will result in increased skin damage. This is likely to arise because birds which sit or fall are less likely to get to their feet and are damaged by the feet of the other birds.

The pH results confirm the observation that birds in single pens travel poorly and appear to attempt to join their pen mates. This results in additional stress for the birds which was confirmed by the high muscle pH and low muscle glycogen. The skins of the birds transported in single pens, were no better than those from birds carted at the higher densities. Considering the stress and financial losses incurred as well as the difficulty of loading and unloading birds, it is not recommended to transport birds in single pens. The only exception is especially fractious birds that are likely to cause damage and stress to other birds if penned with them for transport.

(4) Determine the cost of supplying emus for different end uses.

a) Finishing diets for Maximum Fatness

(i) Conduct preliminary fatness trial

• Background

Emu fat is currently worth $20 per kilo at the point of slaughter and with a feed conversion of about 8 kilos of feed to every kilo of gain during the fattening phase, it is economically sensible to feed emus for maximum fatness as opposed to muscle yield.

Current practice is to feed emus low energy poultry type rearing rations with the aim of producing slaughter weight birds at 55 to 70 weeks of age. Fatness is determined by age and body weight with birds entering a fattening phase at about 40 weeks of age. Live weight peaks in December/January at around 68 weeks of age.

The high price being paid for fat suggests there will be a profit advantage in growing birds faster or with a higher percentage of carcase fat.

Previous work has shown that the time available to fatten a bird is limited by season to December of the year following hatch. This means that the rate of fattening becomes important for achieving high body weights and fatness in late hatched chicks.

The rations currently being fed are unlikely to be limiting in protein but are relatively low in energy and a growth response to energy could be expected. In poultry the amount of carcase fat can be influenced by the protein : energy ratio of the diet fed during the finishing phase. Emus could respond similarly and it seemed likely that we could increase the live weight and/or fatness of mid to late hatched emus by 3 - 5 kilos by feeding high energy diets with low protein : energy ratios.

• Method:

A small pilot trial (42 birds) to determine the response of 50 week old emus to dietary energy was commenced in August 1993.

Each of the following treatments were applied to 2 replicates of 7 birds

1. Control (low energy with a generous lysine : energy ratio). (10.5 MJ energy/kg, 14.6% protein, 0.7% lysine) Control

2. High energy with a lysine : energy ratio as in 1. (14.0 MJ energy/kg, 17.5% protein, 0.94% lysine) High Energy

3. High energy with 0.7 X lysine : energy ratio of rations 1 & 2 (14.0 MJ energy/kg, 13.1% protein, 0.67% lysine) High Energy/Low Protein

The specific rations are shown in Table 15.

Table 15.

Ingredient	Treatment 1 Control	Treatment 2 HE	Treatment 3 HE/LP
Wheat	40.5	33.5	56
Oats	15	3.5	4
Barley	10		
Groats		45	27
Bran	7		
Pollard	7		
Lupin	15		
Meatmeal		10	4.8
Poultymeal	1		
Fishmeal			
Bloodmeal		2.5	
Limestone	0.85		1.0
Dicalc.P.	2.80		0.85
Canola oil		5	5.7
Salt	0.3	0.15	0.25
Lysine	0.14	0.1	0.16
Methionine	0.15	0.21	0.12
Min/Vit Premix	0.25	0.25	0.25

Calculated Analysis	Control	HE	HE/LP

Energy MJ	10.5	14.0	14.0
Protein %	14.6	17.5	13.1
Lysine %	0.70	0.94	0.67
Lysine/Energy (g/MJ)	**0. 67**	**0. 67**	**0. 47**
Methionine %	0.35	0.47	0.33
TSAA %	0.67	0.78	0.61
Threonine %	0.49	0.61	0.43
Tryptophan %	0.16	0.19	0.14
Fibre %	6	2	2
Calcium %	1	1	1
Available Phos.	0.56	0.47	0.4
Sodium %	0.15	0.15	0.15

Treatments were applied to each replicate on August 18, at 51 weeks of age. Birds were allowed to become accustomed to the new diets and surroundings for 1 week and live weight and food consumption was recorded at 52, 56, 60, 64 and 68 weeks of age. All birds were slaughtered the day after the 68 week weighing and carcase weight and yield of fat and muscle determined.

• **Results:**

(a) Live weight recorded is shown in table 16.

Table 16. Live weight

(kg/bird)

	51 weeks	52 weeks	56 weeks	60 weeks	64 weeks	68 weeks

CONTROL	33.9	33.2	35.8	38.0	41.9	44.0
HE	33.9	33.6	38.1	41.6	43.4	43.0
HE/LP	35.2	35.7	40.1	42.9	43.6	44.4
s.e.d.			1.715	1.757	3.57	2.57
Probability*			0.156	0.127	0.638	0.921

*Control Versus High Energy treatments

The birds fed high energy diets gained weight quickly and their live weights commenced to plateau at around 60 weeks of age. The birds fed the low energy ration gained weight at a slower rate but approached similar live weight at 68 weeks of age.

Figure 4.

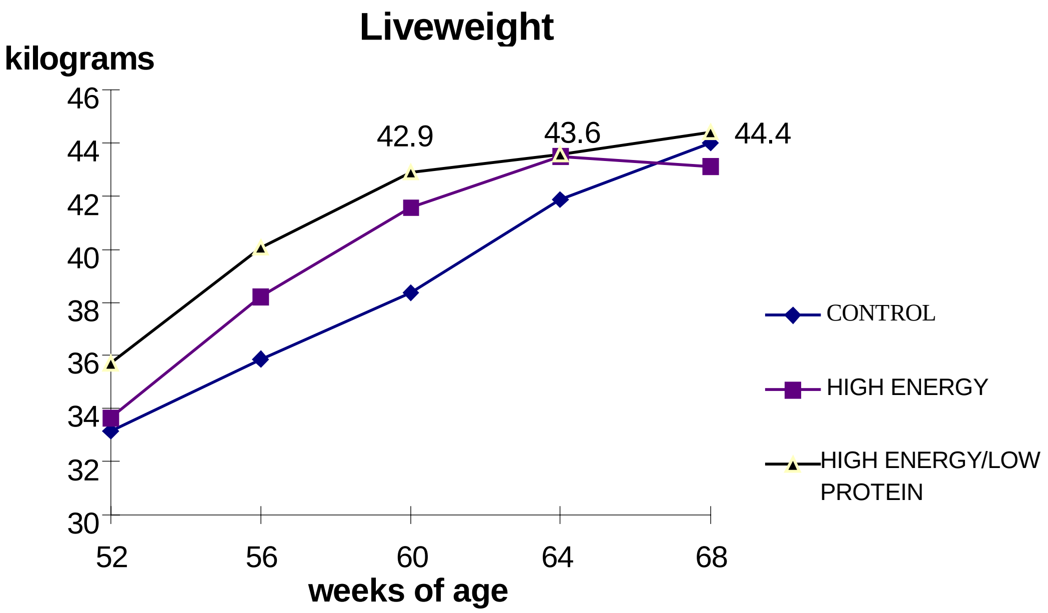


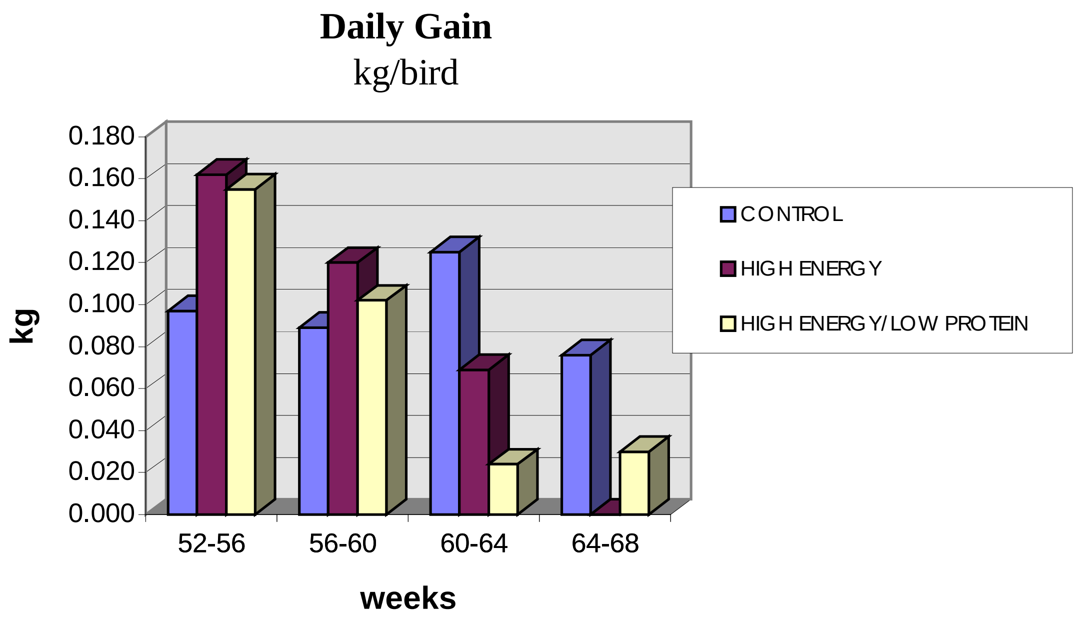
Table 17. Average Daily Live weight Gain

Grams/bird/day

	51 - 52 w	52 - 56 w	56 - 60w	60 - 64w	64 - 68w
CONTROL	-111	97	89	125	76
HE	-44	161	121	67	-13
HE/LP	+69	155	102	24	30
s.e.d.		36.5	21.6	66.1	39.6
Probability*		0.19	0.36	0.30	0.20

*Control Versus High Energy treatments

Figure 5.



The small number of birds used, meant that no significant differences in live weight and daily gain for each measurement period were recorded but birds fed the high energy diets gained weight at a faster rate($P<0.05$) to 60 weeks of age (Table 18).

Table 18. Cumulative Live weight Gain

Grams/bird/day

	52 - 56 w	52 - 60w	52 - 64w	52 - 68w
CONTROL	97	93	104	97

HE	161	141	117	84
HE/LP	155	128	94	78
s.e.d.	36.5	7.8	23.8	8.5
Probability*	0.19	0.025	0.94	0.17

*Control Versus High Energy treatments

(b) Feed consumption

Table 19 Daily Feed Consumption

Grams/bird/day

	51 - 52w	52 - 56 w	56 - 60w	60 - 64w	64 - 68w
CONTROL	965	1051	1001	1175	952
HE	726	960	835	597	499
HE/LP	1200	983	773	536	538
s.e.d.		142	49.5	180.8	79.9
Probability*		0.59	0.04	0.06	0.03

High energy Versus Low energy

Feed consumed on the high energy diets was less from 56 weeks of age ($P< 0.05$).

Figure 6.

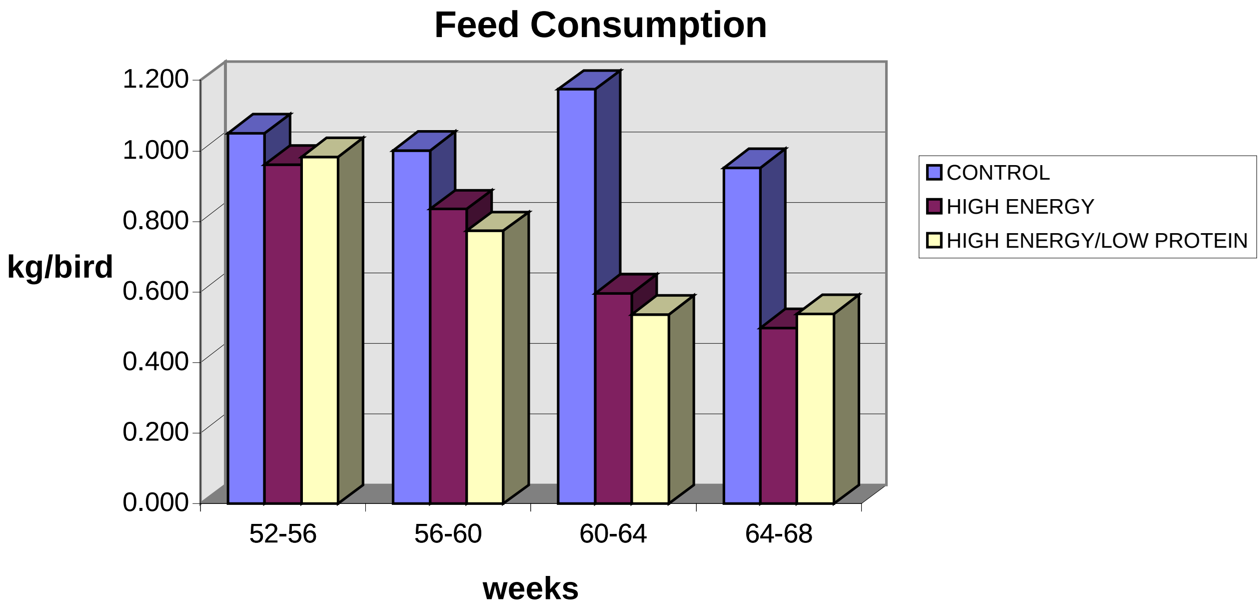

Feed Consumption
kg/bird
1.200
1.000
0.800
0.600
0.400
0.200
0.000
52-56
56-60
60-64
64-68
weeks
CONTROL
HIGH ENERGY
HIGH ENERGY/LOW PROTEIN

Table 20. Cumulative Daily Feed Consumed

Grams/bird/day

	52 - 56 w	52- 60w	52 - 64w	52 - 68w
CONTROL	1051	1026	1076	1045
HE	960	898	797	723
HE/LP	983	878	764	708
s.e.d.		61.2	69.0	37.3
Probability*		0.121	0.04	0.01

*Control Versus High Energy Treatments

(c) Conversion of feed to live weight gain

Table 21. Progressive Feed Conversion

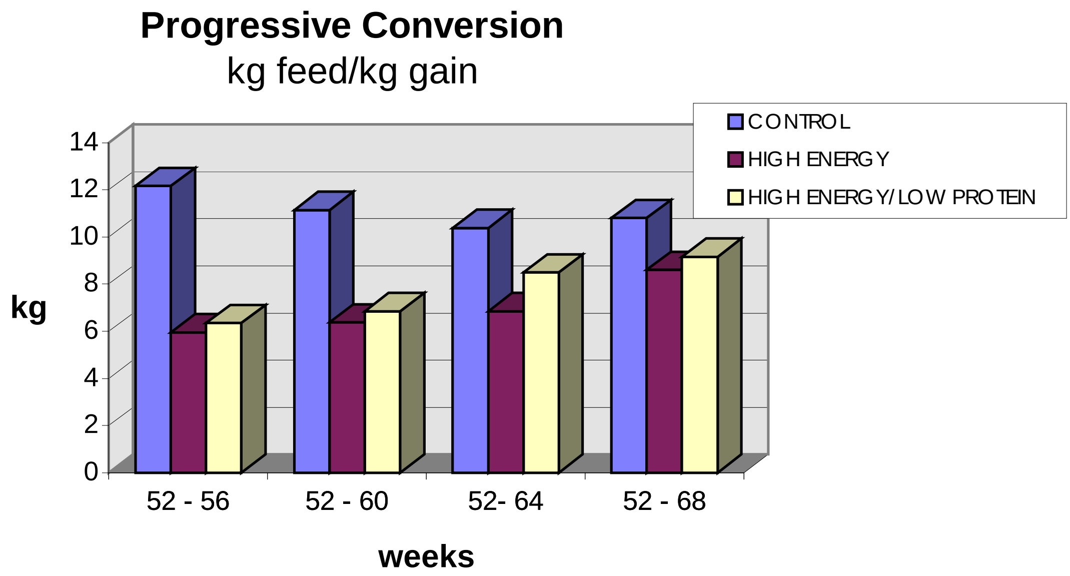
(kg feed/kg gain)

	52 - 56 w	52 - 60w	52 - 64w	52 - 68w
CONTROL	12.2	11.1	10.4	10.8
HE	5.9	6.4	6.8	8.6
HE/LP	6.3	6.8	8.5	9.2
s.e.d.	2.65	0.43	1.26	0.46
Probability*	0.12	0.007	0.13	0.04

*High energy Versus low energy

Conversion of feed to live weight was lower ($P < 0.01$) during the 52-60 week period for the birds fed the high energy diets.

Figure 7.



(d) Carcase characteristics

It was not possible to slaughter the birds on treatments 2 & 3 at 60 weeks of age as they approached peak fatness and all treatments were slaughtered together at 68 weeks of age. This gave the control birds fed the low energy diet, sufficient time to achieve their maximum fatness and all treatments recorded similar levels of fat (9.58 kg/bird - without visceral fat) and meat (13.58 kg/bird) at slaughter.

Table 22. Carcase Details

68 weeks of Age

(kg)

	Number slaughtered	Live weight	Carcase Wt (fat free)	Total Fat	Total Muscle	Total H1/4 Bone
CONTROL	8	45.0	22.2	9.57	14.2	3.54
HE	14	43.0	21.8	9.33	13.9	3.67
HE/HP	13	44.1	21.3	9.58	13.8	3.59

• **Discussion:**

This work suggested that farmers growing birds for slaughter can finish emus to high levels of fatness in 8 - 10 weeks by feeding high energy fat supplemented diets. While these diets will be $50 - $60 per tonne dearer, the rapid growth and improved feed conversion obtained should result in a feed saving of around $15 per bird.

It also presents an opportunity to finish later hatched chicks quickly before season reduces appetite and imposes a live weight ceiling on these birds.

(b) Chemical composition of growing emus

• Background:

The quality of the diet which must be fed to an animal greatly influences the cost of feeding and an estimate of the emus nutritional requirements for each growth phase was needed before an estimate the cost of growing birds for different end uses could be made.

The nutritive requirements of growing emus has not been determined and current feeding recommendations are based on our knowledge of poultry nutrition. Researchers have made estimates of the nutritional requirements of ostriches and turkeys by applying nutritional theory to measurements of growth rate and changes in body composition as they grow toward maturity under non-limiting conditions. The body of an animal can be considered to be the sum of the weights of protein, ash, water and lipid with the small amount of carbohydrate present being ignored. The rate at which these chemicals are deposited by the bird can be used to predict its protein, amino acid, mineral and energy requirements. Predictions can then be verified experimentally.

• Method:

One hundred emu chicks hatched on August 28-29, 1992 were weighed and allocated to each of nine, 4.65 m x 1.83 m pens within an insulated, naturally ventilated chicken brooder house, on the basis of weight strata such that all pens contained an equal number of chicks from each strata. 6 chicks were sacrificed at hatch for chemical analysis.

They were housed on clean hardwood sawdust and fed the equivalent of 1 kilogram per head of a standard chick starter ration followed by station mixed emu chick ration ad-lib. A brooder temperature of 27° Celsius was maintained until 4 weeks of age. Chicks were moved to 3 m x 20 m outside pens at 8 weeks of age and into 20 m x 30 m pens at 20 weeks.

Six chicks, 3 male and 3 female, of group average body weight were sacrificed at 2, 4, 10, 20, 40, 50 and 70 weeks of age.
Birds were killed by cervical dislocation or electrocution, weighed to determine total weight and plucked to determine feather weight. The gut contents of each bird was expelled and feather free empty body weight determined (FFEB). Each FFEB was repeatedly passed through an electrical mincer to ensure thorough mixing before sampling for chemical analysis of each bird. Feathers (F) from each bird were dried to determine moisture and chemical analysis was determined on a composite feather sample for each age.

• Measurements:

Initial chick weight;

Body weight each week to 4 weeks of age, each fortnight to 10 weeks and 4 weekly until slaughter;

Food consumed at equivalent intervals and mortality;

Whole body and feather samples were analysed for moisture, fat, protein, amino acids, ash and minerals.

Results:

Details of the performance data recorded for the flock are given in table 23.

Table 23. Flock Performance

Age	Live weight kg	Period	Feed g/b/d	Efficiency g/g
0 days	0.423			
11 days	0.625	0 - 11 days	35	2.0
18 days	0.993	11 - 18	88	1.7
25 days	1.472	18 - 25	140	2.1
6 weeks	2.772	4 - 6 weeks#	142	1.6
8	4.559	6 - 8	260	2.2
10	5.84	8 - 10	369	4.1
12	7.71	10 - 12##	374	3.0
14	9.34	12 - 14	561	3.7
16	12.10	14 - 16	604	3.8
20	15.86	16 - 20	631	4.7
24	19.08	20 - 24	597	5.2
28	21.43	24 - 28	545	6.7
32	23.74	28 - 32	545	6.7
36	26.06	32 - 36	614	7.7
40	27.83	36 - 40	604	10.3
44	30.65	40 - 44	820	8.4
48	33.01	44 - 48	851	10.3
51	33.41	48 - 51	829	14.8
56	35.86	51 - 56	1051	10.9
60	38.40	56 - 60	1001	11.2
64	41.86	60 - 64	1175	9.4
68	43.98	64 - 68	952	12.6
70	42.00	68 - 70	742	

* Calculated Poultry ME of 10.25 MJ/kg
# respiratory challenge at 4 weeks
moved to outside pens

The flock experienced a commonly seen respiratory challenge which caused a slight check to growth at 3 - 4 weeks of age. No obvious growth checks occurred after this age and live weights recorded for the flock were typical of those recorded for other flocks grown at the research station.

The chemical composition of emu, emu body protein and emu feather is given in tables 24 - 29.

Table 24. Chemical Composition of Emus (Mean ± SD)

	UNITS	DAY OLD	12 DAYS	4 WEEKS	10 WEEKS	20 WEEKS	40 WEEKS	50 WEEKS	70 WEEKS	SED (time)
LIVEWEIGHT	g	402.8 ±7.3	660 ±11.0	1427 ±96	5874 ±452	15750 ±510	26783 ±1074	34116 ±3807	40683 ±3406	
FFEB	g	390.3 ±8.0	578 ±10	1321 ±94	5612 ±432	15275 ±468	25036 ±974	32780 ±3335	37775 ±2811	
FEATHER* (F)	g	11.7 ±1.4	13.2 ±3.5	17.7 ±3.3	103 ±15	232 ±29	593 ±13	581 ±38	769 ±98	
EB	**g**	**402 ±7.3**	**591.2 ±13**	**1337 ±92**	**5715 ±480**	**15507 ±476**	**25629 ±969**	**33361 ±3356**	**38544 ±2876**	
PROTEIN										
FFEB conc	g/kg	125.7 ±5.2	136.8 ±11.1	152.8 ±5.6	166.2 ±7.8	153.8 ±8.4	212.9 ±9.1	196.4 ±6.9	190.4 ±10.3	4.78
FFEB protein	g	49	79	202	933	2349	5330	6438	7192	
F protein conc	g/kg	821	784	780	780	781	809	780	849	
F protein	g	1 0	10	14	80	181	480	453	653	
EB Protein	**g**	**59**	**89**	**216**	**1013**	**2531**	**5810**	**6891**	**7845**	
LIPID										
FFEB conc	g/kg	167.8 ±12.4	74.9 ±14.2	86.2 ±23.6	156.8 ±16.3	219.9 ±8.4	126.1 ±16.9	203.4 ±36.2	266.1 ±43.3	14.02
EB Lipid	**g**	**65**	**43**	**114**	**880**	**3359**	**3157**	**6667**	**10052**	

Cont. next page

WATER										
FFEB conc	g/kg	667.8 ±9.0	741.1 ±11.7	705.7 ±25.1	622.6± 9.8	572.9± 8.9	599.7 ±12.9	543.9 ±30.0	496.3 ±37.7	12.1
FFEB water	g	261	428	932	3494	8751	15014	17829	18748	
F conc	g/kg	99	102	105	105	100	110	123	63	
F water	g	1	1	2	11	23	65	72	48	
EB Water	**g**	**262**	**430**	**934**	**3505**	**8774**	**15079**	**17901**	**18796**	
ASH										
FFEB conc	g/kg	23.5 ±1.3	29.5 ±3.1	35.6 ±2.0	41.8 ±4.6	40.9 ±2.2	48.0 ±4.8	43.9 ±1.5	41.2 ±2.8	1.76
FFEB ash	g	9	17	47	235	625	1202	1439	1556	
F conc	g/kg	12	17	17	18	25	13	13	12	
F ash	g	0	0	0	2	6	7	8	9	
EB Ash	**g**	**9**	**17**	**47**	**236**	**631**	**1209**	**1447**	**1566**	
TOTAL	g	395	580	1311	5634	15294	25255	32906	38259	

* Feather samples taken at 4 and 10 weeks of age were omitted from the chemical analysis and the values of feathers at remaining ages were used to derive the tabled values.

EB = Whole body with gut contents removed
F = Feather
FFEB = Whole body plucked and gut contents removed

Table 25. Amino acid composition of emu FFEB protein (g/16gN)

	Day old	**12 days**	**4 weeks**	**10 weeks**	**20 weeks**	**40 weeks**	**50 weeks**	**70 weeks**	**SED**
Cystine	1.25 ± 0.21	1.12 ± 0.11	0.99 ± 0.07	0.82 ± 0.14	0.90 ± 0.08	1.10 ± .09	1.14 ± 0.05	1.12 ± 0.10	0.07
Aspartic acid	8.27 ± 0.15	8.00 ± 0.50	7.80 ± 0.35	7.76 ± 0.26	7.94 ± 0.41	8.27 ± .13	8.18 ± 0.13	8.16 ± 0.20	0.17
Methionine	1.70 ± 0.20	1.63 ± 0.12	1.59 ± 0.08	1.53 ± 0.21	1.79 ± 0.10	1.96 ± .08	1.99 ± 0.06	1.83 ± 0.09	0.08
Threonine	4.25 ± 0.12	3.86 ± 0.22	3.80 ± 0.23	3.79 ± 0.14	3.87 ± 0.20	4.01 ± .08	3.99 ± 0.05	4.04 ± 0.12	0.09
Serine	5.39 ± 0.25	4.60 ± 0.30	4.44 ± 0.25	4.28 ± 0.10	4.29 ± 0.22	4.18 ± .06	4.17 ± 0.08	4.19 ± 0.09	0.11
Glutamic Acid	12.85 ± 0.18	12.86 ± 0.72	12.59 ± 0.54	12.37 ± 0.46	12.82 ± 0.67	13.14 ± .20	12.98 ± 0.21	13.22 ± 0.29	0.27
Proline	6.77 ± 0.26	6.72 ± 0.41	6.64 ± 0.42	6.79 ± 0.45	7.03 ± 0.46	6.83 ± .63	6.93 ± 0.08	6.31 ± 0.84	0.31
Glycine	8.20 ± 0.52	9.38 ± 0.59	9.23 ± 0.54	9.42 ± 0.18	9.72 ± 0.74	9.55 ± .21	9.58 ± 0.21	9.53 ± 0.31	0.27
Alanine	6.32 ± 0.13	6.56 ± 0.34	6.45 ± 0.30	6.59 ± 0.18	6.82 ± 0.36	6.97 ± .11	6.98 ± 0.10	6.99 ± 0.07	0.13
Valine	4.30 ± 0.11	3.92 ± 0.21	3.85 ± 0.23	3.81 ± 0.19	3.90 ± 0.18	4.05 ± .06	4.05 ± 0.04	4.06 ± 0.12	0.09
Iso Leucine	3.50 ± 0.08	3.23 ± 0.18	3.10 ± 0.16	3.17 ± 0.18	3.26 ± 0.17	3.34 ± .05	3.34 ± 0.04	3.44 ± 0.13	0.08
Leucine	7.40 ± 0.17	6.86 ± 0.40	6.62 ± 0.36	6.64 ± 0.30	6.83 ± 0.33	7.09 ± .11	7.05 ± 0.09	7.14 ± 0.23	0.16
Tyrosine	3.30 ± 0.09	2.93 ± 0.22	2.76 ± 0.15	2.73 ± 0.14	2.79 ± 0.15	3.02 ± .10	2.98 ± 0.05	3.01 ± 0.08	0.08
Phenylalanine	4.05 ± 0.08	3.84 ± 0.20	3.54 ± 0.73	4.08 ± 0.19	4.29 ± 0.16	4.76 ± .10	4.78 ± 0.26	4.88 ± 0.18	0.17
Lysine	6.05 ± 0.15	5.30 ± 0.28	5.24 ± 0.25	5.54 ± 0.30	5.85 ± 0.32	7.00 ± .14	6.98 ± 0.07	7.33 ± 0.25	0.17
Histidine	2.25 ± 0.05	2.13 ± 0.10	2.13 ± 0.16	2.37 ± 0.12	2.58 ± 0.11	2.51 ± .04	2.55 ± 0.04	2.71 ± 0.11	0.07
Arginine	6.39 ± 0.25	6.65 ± 0.38	6.59 ± 0.25	6.63 ± 0.22	6.75 ± 0.35	6.84 ± .13	6.85 ± 0.07	6.89 ± 0.12	0.14

Table 26. Amino acid composition of emu feather protein

(g/16gN)

	Day old	12 days	4 weeks	10 weeks	20 weeks	40 weeks	50 weeks	70 weeks	Average
Cystine	7.39	7.55	7.57	7.70	8.01	7.37	6.91	6.29	7.35
Aspartic acid	8.54	8.49	8.54	8.54	8.63	7.94	7.76	7.98	8.30
Methionine	0.32	0.34	0.34	0.34	0.36	0.28	0.27	0.24	0.31
Threonine	5.39	5.42	5.46	5.54	5.71	5.51	5.17	5.24	5.43
Serine	15.88	15.42	15.75	15.81	16.15	14.68	13.78	14.61	15.26
Glutamic Acid	9.38	10.15	9.83	9.87	10.09	8.79	8.58	8.59	9.41
Proline*	16.19	16.85	16.76	16.74	17.71	10.98	11.74	12.56	14.94
Glycine	8.13	7.33	7.68	7.54	7.39	6.85	6.80	7.01	7.34
Alanine	4.08	4.04	4.07	4.07	4.10	3.84	3.66	3.86	3.97
Valine	6.80	6.48	6.66	6.70	6.76	6.91	6.51	6.70	6.69
Iso Leucine	4.07	4.27	4.20	4.24	4.33	4.27	4.10	4.32	4.22
Leucine	10.58	10.16	10.38	10.36	10.39	9.92	9.60	10.03	10.18
Tyrosine	7.13	6.22	6.62	6.46	6.34	5.52	5.73	6.18	6.28
Phenylalanine	4.46	4.41	4.45	4.48	4.53	4.49	4.43	4.61	4.48
Lysine	1.46	2.10	1.80	1.81	1.86	1.41	1.28	1.43	1.64
Histidine	0.80	0.85	0.83	0.83	0.87	0.59	0.48	0.51	0.72
Arginine	6.91	6.79	6.90	6.94	7.11	6.56	6.43	6.80	6.80

*Proline analysis reported to 20 weeks of age were later found to be high.

Table 27. Amino acid composition of emu EB protein

(g/16gN)

	Day old	12 days	4 weeks	10 weeks	20 weeks	40 weeks	50 weeks	70 weeks
Cystine	2.26	1.86	1.41	1.36	1.41	1.62	1.52	1.55
Aspartic acid	8.31	8.06	7.85	7.82	7.99	8.24	8.15	8.15
Methionine	1.48	1.48	1.51	1.43	1.68	1.82	1.88	1.69
Threonine	4.44	4.04	3.91	3.93	4.00	4.13	4.07	4.14
Serine	7.10	5.86	5.16	5.20	5.14	5.04	4.80	5.06
Glutamic Acid	12.28	12.55	12.41	12.17	12.62	12.78	12.69	12.83
Proline	8.31	7.89	7.29	7.58	7.79	7.17	7.24	6.83
Glycine	8.19	9.14	9.14	9.27	9.55	9.32	9.40	9.32
Alanine	5.95	6.27	6.30	6.39	6.62	6.71	6.76	6.73
Valine	4.71	4.22	4.03	4.04	4.11	4.29	4.21	4.28
Iso Leucine	3.59	3.35	3.17	3.25	3.34	3.42	3.39	3.51
Leucine	7.92	7.24	6.86	6.94	7.09	7.32	7.22	7.38
Tyrosine	3.92	3.31	3.01	3.03	3.05	3.23	3.16	3.28
Phenylalanine	4.11	3.90	3.60	4.11	4.31	4.73	4.76	4.85
Lysine	5.30	4.93	5.02	5.24	5.57	6.53	6.60	6.84
Histidine	2.01	1.98	2.04	2.25	2.46	2.35	2.42	2.52
Arginine	6.48	6.67	6.61	6.65	6.78	6.82	6.82	6.88

Table 28. Amino acid in emu EB protein as a ratio to lysine

(g/16gN)

	Day old	12 days	4 weeks	10 weeks	20 weeks	40 weeks	50 weeks	70 weeks
Cystine	43	38	28	26	25	25	23	23
Aspartic acid	157	163	156	149	144	126	123	119
Methionine	28	30	30	27	30	28	28	25
Threonine	84	82	78	75	72	63	62	60
Serine	134	119	103	99	92	77	73	74
Glutamic Acid	232	255	247	232	227	196	192	188
Proline	157	160	145	145	140	110	110	100
Glycine	154	186	182	177	172	143	142	136
Alanine	112	127	125	122	119	103	102	98
Valine	89	86	80	77	74	66	64	63
Iso Leucine	68	68	63	62	60	52	51	51
Leucine	149	147	137	132	127	112	109	108
Tyrosine	74	67	60	58	55	49	48	48
Phenylalanine	78	79	72	78	77	72	72	71
Lysine	100	100	100	100	100	100	100	100
Histidine	38	40	41	43	44	36	37	37
Arginine	122	135	132	127	122	104	103	101

Table 29. Percentage of minerals in emu EB ash

	Day Old	12 Days	4 weeks	10 weeks	20 weeks	40 weeks	50 weeks	70 weeks
Phosphorus	14.1	15.9	17.0	16.7	13.8	17.6	17.3	16.3
Potassium	5.2	6.4	5.8	4.3	3.9	4.4	4.2	4.3
Sodium	5.9	4.8	3.9	2.8	2.3	2.2	2.2	2.4
Calcium	23.6	25.0	27.5	28.6	24.6	31.8	31.5	29.8
Magnesium	.703	.860	.855	.790	.677	.813	.806	.761
Sulphur	.001	.001	.001	.000	.000	.000	.000	.000
Copper	.013	.013	.007	.003	.003	.003	.003	.003
Iron	.224	.150	.120	.179	.146	.207	.215	.227
Manganese	.002	.006	.005	.004	.004	.003	.003	.003
Zinc	.080	.076	.068	.062	.057	.076	.078	.076

Significant differences in FFEB protein, lipid, water and ash were recorded at the different sampling ages.

Discussion:

Body composition

When compared to the chick and goose the initial protein content of emus is low while the fat content is high.

Table 28. Initial Protein and Fat Content of Emu, Chick and Goose

gm/Kg of Gain

	Emu	Chick*	Goose**
Protein	125.0	154.2	140.0
Fat	167.0	45.8	95.0

* Martin et al; ** Nitsan et al.

Similarly the percentage fat in the gain recorded to 20 weeks of age is high, 218.1 g/kg, and the percentage protein is relatively low, 163.7 g/kg of gain. Young emus therefore have substantial reserves of fat (22.0 percent of empty live weight) as they enter there first autumn - winter season. Maturing emus also reach high levels of fatness as they approach sexual maturity in the December following their year of hatch and individuals have been recorded to be as high as 329.4g fat/ kg of feather free empty body.

It is apparent that emus have evolved to be able to take advantage of the relative abundance of food which can occur in their environment during winter-spring, the hatching period, (Davies 1978) by laying down large reserves of body fat before entering the autumn winter period which corresponds to a period of low and often unreliable food supply.

This suggests that it may be possible to make substantial feed savings by limiting the birds intake of feed energy to reduce fat deposition during the initial growth period.

Feather

The determined amino acid composition of emu feather protein was similar to that reported in the literature for other species of birds, (Cilliers,1994, Hurwitz et al, 1983, Nitsan et al, 1981 and Emmans, 1989) with the exception of leucine which appeared to be higher in emu feathers.

The relative weight of feathers in emus is considerably lower than that in broilers and turkeys: 12 - 29 g/kg live weight in the emu, compared to 37 to 61 g/kg in chicks and 46 to 69 g/kg in turkeys (Moran, 1977) and only a relatively small amount (2 - 9 %) of the body protein is present as feather protein (table 3). This compares to 11 - 17% for chicken and 23 - 24% for the goose (Fisher and Scougall, 1982). This implies that the emu may have a lower requirement for the sulphur containing amino acids methionine, lysine and cystine which are present at high concentrations in feather protein.

Minerals

The ash content of 23.5 g/kg is similar to the value of 23.0 g/kg given by Nitsan for the goose and higher than the 16 g/kg given by Edwards (1973) for meat chickens but low when compared to the pullet chickens' 54.2 g/kg determined by Martin et al, (1994).

Balance of amino acids

In Table 31, the results for amino acids, relative to lysine, are compared to ostrich and chicken information. With the exception of Cystine and Glycine - Proline, the data between species is consistent. Therefore, in the absence of information showing that the emus' ability to utilise nutrients from feed sources differs to that of poultry, the past use of amino acid patterns derived for poultry to formulate diets for emus appears justified.

Table 31. Amino acid patterns relative to lysine

	Emu	Ostrich [1]	Chicken [2]	Chicken Feed [3]
Age	20 weeks	10 weeks	10 weeks	6 - 8 weeks
Cystine	25	15	39	33
Aspartic acid	144			
Methionine	30	30	32	38
Threonine	72	55	64	80
Serine	92	49		
Glutamic Acid	227			
Proline	140			
Glycine	172		175	87*
Alanine	119	94		
Valine	74	66	90	73
Iso Leucine	60	58	74	71
Leucine	127	103	128	125
Tyrosine	55	47	53	
Phenylalanine	77	67	79	125**
Lysine	100	100	100	100
g/16gN	(5.57)	(6.34)	(5.55)	(4.72)
Histidine	44	41	37	41
Arginine	122	107	96	107

* Glycine + Serine , Phenylalanine + Tyrosine 1. Cilliers, 1994. 2. Fisher and Scougall, 1982. 3.NRC

Estimation of Dietary Requirements

A Gompertz model of the form used by Martin et al (1993) was fitted to the tabled data to predict the potential weight of body component on any day after hatching (BP_t), using three parameters and the variable time (t):

$$BP_t = BP_m \exp[-\exp((\ln(-\ln BP_0/BP_m)) - B_{bp}t))] \text{ (kg)}$$

where: BP_m = mature body protein (or other component) weight (kg); BP_0 = body protein weight at hatching (kg): t = time after hatching; B_{bp} = rate of maturing of body protein (d^{-1}). Differentiation of this equation will derive the daily rate of protein deposition (dBP/dt) as follows:

$$dBP/dt = BP_m.B_{BP}.u.\ln(1/u)$$

Where: u = BP_t/BP_m, the degree of protein maturity.

Table 32. Gompertz constants BP_m B_{BP}

	BP_m	SE	B_{BP}	SE
FFEB protein (g)	7339	±169	.010292	±.000376
Feather protein (g)	669.9	± 55.7	.008223	±.000925
EB* protein (g)	7999	±173	.010100	±.000343
EB ash (g)	1544.6	± 43.4	.012066	±.000618
Empty body (g)	39892	±1165	.009826	±.000425

*Empty Body - feathered body with gut content removed

Table 33. Predicted and observed values of FFEB protein, F protein and EB ash

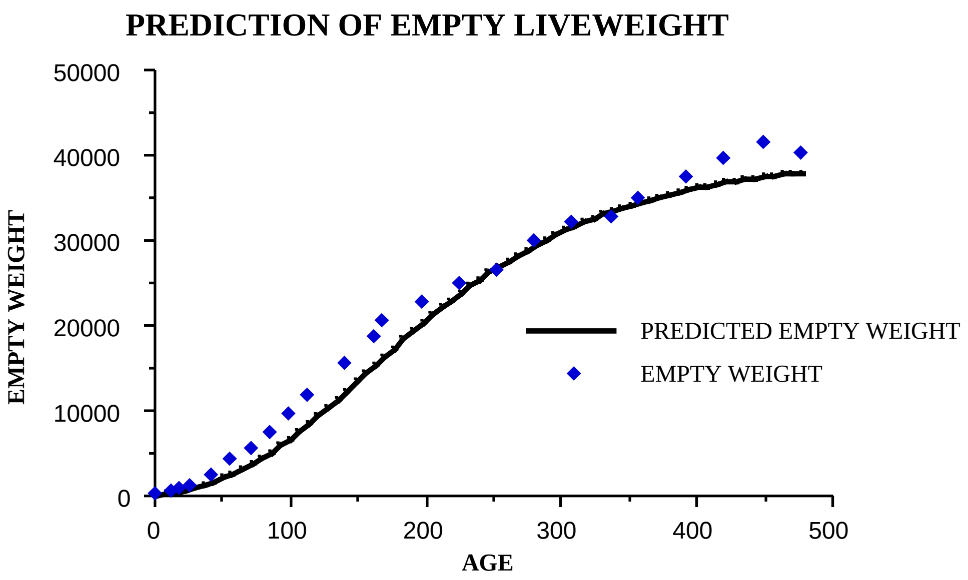
Age (days)	FFEB protein (g)		Feather protein (g)		EB ash (g)	
	predicted	observed	predicted	observed	predicted	observed

0	49.1	49.1	9.6	9.6	8.9	8.9
12	87.7	79.1	14.3	10.4	17.9	17.3
28	172	202	23	13.8	39	47.3
70	642	933	62	80	169	236
140	2243	2349	175	181	596	630
280	5543	5330	438	480	1296	1209
350	6402	6438	528	453	1432	1447
490	7106	7192	621	653	1523	1566

The Gompertz function derived, estimated the growth of body and feather protein and ash to 70 days of age poorly but corresponded closely to observed data after this age. It failed to describe the observed pattern of lipid growth. An increase in the number of data points in the early growth phase and dividing growth into a number of phases (Emmans 1989) could be expected to increase the accuracy of the Gompertz model. The application of alternate growth functions and multiphase analysis (Kwakkel et al, 1993) also warrants investigation.

Gompertz functions derived from live weight for age data collected from the flock from which the emus subjected to analysis were sampled, also failed to describe the total growth of emus accurately with fitted values to 24 and from 35 - 44 kilograms live weight being consistently smaller than those observed (Figure 8.).

Figure 8



This deviation can be explained by the rapid deposition of fat by emus during the spring - early summer season which corresponds to the 10 - 25 week and 35 - 70 week growing periods.

Estimation of protein and amino acid requirements

Protein derived from dietary source is used by birds for growth of body protein and its maintenance, growth of feather and feather maintenance.

Growth of body protein

Emmans and Fisher (1986) proposed that the problem of predicting body growth rate can be approached in one of the following ways:

(1) by predicting the growth of the empty, feather free body as a whole;

(2) by predicting, separately, the growth of the 4 chemical components of the FFEB (water, lipid, protein, ash and a small amount of carbohydrate) ; or

(3) by predicting the growth of one of these components and predicting the others in relation to this component.

The prediction of nutitional requirement normally involves the application of a growth model and the Gompertz function is commonly used. As the Gompertz function, using the data available, predicted the growth of emu empty body and its components poorly, in this study, growth of FFEB protein and ash was predicted from growth data of emus collected from flocks reared at Medina Research Centre (Table53) and values of the concentration of the protein and amino acids at each age graphically interpolated from the chemical analysis shown in tables 24 - 28. Growth of feather protein was predicted using the Gompertz function with a knowledge that it would represent only a small error.

Maintenance of body protein

The amount of protein (amino acids) required to maintain the body was estimated using Emmans and Fisher's (1986) adaptation of Taylors (1970) size scaling rule :

$$\text{Maintenance Protein} = 8.\ BP_m^{0.73}.\ BP_t/BP_m \ \text{(g/day)}$$

where : BP_m = body protein at maturity and BP_t/BP_m the degree of maturity of body protein at time t.

At present the amino acid composition of maintenance protein is poorly defined. Fisher, (1987) recommended a specific amino acid profile be used for the conversion of maintenance protein requirements to maintenance amino acid requirements. Emmans, 1989 assumed that maintenance protein has an amino acid composition similar to that of body protein. This is contrary to Hurwitz (1983) and Leveille et al (1960) who found that the fractional amino acid requirements for feather and maintenance in adult birds were similar. Boorman and Burgess (1986) in consideration of problems associated with estimating maintenance protein concluded that estimates tend only to be guides as to the range in which requirements might fall and adopts the method of Fisher (1983) and Fisher and Emmans (1982). This method was also adopted by Cilliers (1994) and Martin, et al (1994) and is adopted here.

Maintenance of feather protein.

Emmans (1989) concluded that the problem of predicting feather loss and feather maintenance requirement warranted further investigation but assumed a rate of loss which is proportional to feather weight at 0.01/day. While this figure was used in this study it should be noted that emus do not shed feathers during growth but there is obvious loss of feather from the tips of the featherettes from normal wear and tear. Feathers are also lost during bouts of aggression and fighting within the pens as the birds reach sexual maturity at 40 weeks of age and when pair bonds begin to establish at around 70 weeks of age.

Required daily intake of digestible amino acid

A degree of inefficiency occurs when dietary digestible amino acids are converted to actual protein tissue with the result that tissue requirements need to be scaled by a coefficient for net efficiency of utilisation before they can be expressed as actual dietary requirements. There is still uncertainty as to the appropriate value to be used (Fisher 1980; Fisher,1987; Boorman and Burgess, 1986) but it is thought to be higher for the more stable amino acids such as Lysine and lower for the more labile such as Cystine and be in the range of 0.85 to 0.65 of digestible amino acids (Boorman and Burgess 1986; Fisher 1987). Cilliers (1994) has published estimates for ostrich which range from 0.968 for Serine, 0.733 for lysine to 0.569 for Cystine and Leucine with a mean of 0,747. The value derived by Cilliers (1994) for each amino acid was adjusted for a digestibility of 0.85 (Boorman, 1986) and 90% dry matter and used to produce a table of estimated dietary requirements. (Table 34).

Table 34. Estimated dietary crude protein and amino acid requirements of emus

(g/bird/day)

AGE (weeks)	C. Protein	Lysine	Methionine	TSAA	Threonine	Isoleucine	Leucine
0 - 2	4.1	0.23	0.06	0.21	0.20	0.17	0.46
2 - 3	14.9	0.86	0.25	0.59	0.69	0.59	1.54
3 - 4	21.1	1.21	0.35	0.79	0.97	0.82	2.13
4 - 6	30.1	1.74	0.49	1.07	1.37	1.18	3.01
6 - 8	37.9	2.21	0.60	1.30	1.73	1.49	3.80
8 - 10	48.9	2.91	0.65	1.52	2.23	1.93	4.90
10 - 12	43.5	2.64	0.68	1.54	2.00	1.75	4.41
12 - 16	53.0	3.28	0.86	1.93	2.45	2.13	5.43
16 - 20	54.1	3.35	0.93	2.15	2.54	2.22	5.65
20 -24	55.9	3.47	0.99	2.37	2.66	2.32	5.94
24 - 28	54.4	3.42	0.97	2.42	2.63	2.27	5.86
28 - 32	62.1	4.03	1.12	2.78	3.01	2.60	6.69
32 - 36	63.2	4.21	1.16	2.89	3.08	2.67	6.86
36 - 40	67.8	4.74	1.26	3.15	3.33	2.87	7.38
40 - 44	80.7	5.84	1.53	3.60	3.97	3.40	8.84
44 - 48	92.9	6.79	1.80	4.10	4.55	3.87	10.10
48 - 52	94.9	6.92	1.85	4.27	4.64	3.99	10.29
52 - 56	94.6	6.95	1.82	4.23	4.63	3.98	10.30
56 - 60	92.6	6.81	1.75	4.09	4.55	3.94	10.11
60 - 62	90.1	6.65	1.67	3.96	4.44	3.86	9.87
62 - 63	98.5	7.37	1.83	4.25	4.85	4.21	10.77

In order to convert the estimate of daily dietary requirement to a concentration within the feed we must be able to estimate food intake.

In 1993/94 we conducted a trial to determine the response of young growing emus to dietary energy (detailed below). A summit diet calculated to contain 13.5 MJ of energy based on poultry values was diluted in energy by the removal of added fat and the dilution of the diet to achieve 4 dietary energy levels, 13.5, 12.5, 11.5 and 10.5 MJ/kg of diet. A fifth diet of 13.5 MJ formulated to contain a 25% higher amino acid to energy ratio was fed to ensure that protein was not limiting and fractions of the summit diet were offered separately either as a protein or energy source as a sixth ration. Four replications of 10 birds were fed the diets from 3 - 63 weeks of age. Diets were reformulated at intervals in accord with the recommendations developed by Agriculture Western Australia. All treatments grew similarly and ate similar amounts of calculated energy for the period of the trial ie. energy intake per unit of gain was consistent across all 5 diets .

There was no response to the additional protein fed in the fifth diet.

Calculation of dietary energy intake from records of feeding trials conducted in 1992 and 1993 confirmed that emus grew similarly in terms of weight for age and ate similar amounts of energy per unit of gain. There was however, an indication that they were able to derive a slightly greater amount of energy from higher fibre diets (21% neutral detergent fibre) than the poultry ME values calculated for these diets.

Average energy intake at each age for the 5 diets was used to derive the nutrient requirement of emus as a percentage of an 11.5 MJ diet.

Table 35. Estimated nutrient requirements of emus

(g/100g of an 11.5 MJ diet)

AGE (weeks)	C. Protein	Lysine	Methionine	TSAA	Threonine	isoleucine	leucine	feed g/b/day
0 - 2	11.9	0.65	0.18	0.59	0.58	0.50	1.31	35
2 - 3	17.0	0.98	0.28	0.67	0.79	0.67	1.74	88
3 - 4	15.1	0.87	0.25	0.57	0.69	0.59	1.52	140
4 - 6	13.7	0.79	0.22	0.48	0.62	0.54	1.37	220
6 - 8	14.6	0.77	0.23	0.50	0.67	0.58	1.47	259
8 - 10	13.3	0.71	0.18	0.41	0.61	0.53	1.33	368
10 - 12	11.6	0.64	0.18	0.41	0.54	0.47	1.18	374
12 - 16	9.4	0.53	0.15	0.34	0.44	0.38	0.97	561
16 - 20	9.0	0.50	0.15	0.36	0.42	0.37	0.94	603
20 -24	8.9	0.50	0.16	0.38	0.42	0.37	0.94	630
24 - 28	9.1	0.52	0.16	0.41	0.44	0.38	0.98	597
28 - 32	11.4	0.67	0.21	0.51	0.55	0.48	1.23	545
32 - 36	11.6	0.70	0.21	0.53	0.57	0.49	1.26	544
36 - 40	11.0	0.69	0.21	0.51	0.54	0.47	1.20	614
40 - 44	13.4	0.87	0.25	0.60	0.66	0.56	1.46	604
44 - 48	11.3	0.75	0.22	0.50	0.55	0.47	1.23	820
48 - 52	11.2	0.73	0.22	0.50	0.54	0.47	1.21	851
52 - 56	11.4	0.76	0.22	0.51	0.56	0.48	1.24	829
56 - 60	8.8	0.58	0.17	0.39	0.43	0.37	0.96	1051
60 - 62	8.8	0.58	0.16	0.39	0.43	0.38	0.96	1026
62 - 63	8.4	0.56	0.16	0.36	0.41	0.36	0.92	1175

Given the difficulties of estimating maintenance requirement, the uncertainty which surrounds values adopted for the efficiency of conversion of dietary protein and amino acids to body protein and the significant differences in the amino acid pattern of body protein at different ages, the figures presented can only be considered as a guide to possible requirements and could form a starting point for response trials to determine true requirements. It should also be noted that the estimate relates solely to an average bird within each period of time and takes no account of the expected variable response of individual birds within a flock. The characteristic shape of most response curves shows that there is a continuing response to intake of a nutrient in excess of that required for maximum response by the "average" individual.

The majority of diets fed at our research centre have been formulated in accord with our suggested restraints for the formulation of emu rations. The use of these restraints will result in diets to 40 weeks of age which, when compared to the above estimate, appear to be in excess of the emus' protein, methionine and TSAA requirements but could be marginal in leucine.

Table 36. Suggested Nutritional Restraints Compared with Estimated Requirement (g/100g)

	0-8 weeks	Estimate 4 - 6 weeks	8-20 weeks	Estimate 12 -16 weeks	20-40 week	Estimate 28 - 32 weeks	40-70 week	Estimate 52 - 56 weeks
Protein >*	16.5	13.7	16.5	9.4	15	11.6	13	11.4
Lysine	0.92	0.79	0.75	0.53	0.69	0.67	0.55	0.76
Methionine >	0.37	0.23	0.37	0.15	0.35	0.21	0.28	0.22
TSAA >	0.69	0.48	0.49	0.34	0.46	0.51	0.36	0.51
Arginine >	0.83		0.78		0.72		0.57	
Isoleucine >	0.46	0.54	0.43	0.38	0.39	0.48	0.31	0.48
Isoleucine <	0.70	0.54	0.57	0.38	0.52	0.48	0.42	0.48
Leucine >	0.95	1.37	1.02	0.97	0.94	1.23	0.75	1.24
Leucine<	1.58	1.37	1.29	0.97	1.19	1.23	0.95	1.24
Phenylalanine>	0.64		0.52		0.48		0.39	
Threonine>	0.55	0.62	0.45	0.44	0.41	0.55	0.33	0.56
Tryptophan .	0.17		0.14		0.13		0.10	
Valine >	0.63		0.61		0.56		0.45	
Valine <	0.86		0.70		0.65		0.52	

*> greater than; < less than

Beyond 40 weeks of age the estimated lysine and threonine requirements exceed the levels found in diets formulated using the suggested restraints.

This does indicate that the use of lower levels of methionine and TSAA and higher levels of leucine in emu diets warrants investigation. The lower level of methionine indicated is of significance in respect to the formulation of cheaper diets, is consistent with the low feather protein requirement of emus, and work in this area is recommended. However, it is considered that requirements, particularly for leucine, from 40 weeks of age has been grossly overestimated by the methodology used. At this age the protein required for body maintenance exceeds that required for growth and the difficulties of estimating maintenance (Boorman and Burgess, 1986 ; Fisher, 1987) could be expected to increase the error of estimation. The amino acid profile of protein required for maintenance also becomes critical and it is of interest to note that Fisher, (1987) recommends an amino acid profile for the maintenance protein of chickens which is relatively lower in leucine, threonine and isoleucine than chicken body protein.

Low protein (10.6%), 13.5 MJ diets formulated to contain 0.42g lysine/MJ of ME, with the same recommended amino acid profile relative to lysine, have been fed from 40 weeks of age to slaughter at our research centre and have achieved expected live weight gains and yields of muscle and fat (unpublished). This supports the finding that beyond 40 weeks of age emus have a relatively low requirement for protein and the feeding of low protein finisher diets is recommended.

Estimation of dietary mineral requirements

The Gompertz function did not predict EB ash content well and an estimate of the mineral requirements of emus was made using known growth data (Table 53), graphic interpolation of the determined mineral analysis (Tables 24 & 29), the published values for the efficiency of utilisation of minerals by poultry and an estimate of maintenance needs (1 percent of body content). The application of recorded feed energy consumption data allowed the calculation of the level of each mineral required in an 11.5 MJ diet.

Table 37. Estimated mineral requirements of emus

Age	Calcium		Phosphorous		Manganese		Zinc		Copper	
Weeks	g//b/d	Conc %	g/b/d	conc %	g/b/d	ppm	g/b/d	ppm	g/b/d	ppm
0 - 2	0.21	0.60	0.12	0.35	0.00031	8.86	0.0030	86.93	0.0005	15.25
2 - 3	1.05	1.20	0.66	0.75	0.00024	2.68	0.0030	34.56	0.0004	4.25
3 - 4	1.08	0.77	0.51	0.36	0.00023	1.64	0.0029	20.87	0.0001	0.98
4 - 6	1.28	0.58	0.88	0.40	0.00042	1.91	0.0057	26.05	0.0002	0.77
6 - 8	2.56	0.99	1.54	0.60	0.00057	2.21	0.0079	30.41	0.0004	1.36
8 - 10	3.73	1.01	2.34	0.64	0.00057	1.54	0.0078	21.21	0.0004	1.04
10 - 12	4.20	1.12	2.16	0.58	0.00063	1.69	0.0081	21.64	0.0004	0.98
12 - 16	3.64	0.65	2.41	0.43	0.00061	1.09	0.0090	15.98	0.0005	0.86
16 - 20	3.56	0.59	2.42	0.40	0.00071	1.17	0.0105	17.38	0.0005	0.89
20 -24	4.22	0.67	2.35	0.37	0.00074	1.18	0.0130	20.64	0.0007	1.05
24 - 28	4.74	0.79	3.49	0.58	0.00080	1.35	0.0165	27.64	0.0007	1.17
28 - 32	6.15	1.13	4.04	0.74	0.00083	1.52	0.0183	33.62	0.0008	1.46
32 - 36	5.84	1.07	5.09	0.94	0.00082	1.51	0.0209	38.40	0.0009	1.59
36 - 40	6.20	1.01	5.84	0.95	0.00083	1.35	0.0214	34.91	0.0008	1.36
40 - 44	5.53	0.92	5.24	0.87	0.00094	1.56	0.0218	36.16	0.0010	1.66
44 - 48	5.31	0.65	5.10	0.62	0.00094	1.15	0.0226	27.55	0.0009	1.05
48 - 52	5.22	0.61	4.80	0.56	0.00096	1.13	0.0201	23.59	0.0009	1.02
52 - 56	4.17	0.50	4.87	0.59	0.00100	1.21	0.0235	28.31	0.0011	1.28
56 - 60	5.24	0.50	5.76	0.55	0.00109	1.04	0.0238	22.69	0.0011	1.02
60 - 62	5.41	0.53	5.50	0.54	0.00112	1.09	0.0256	24.93	0.0010	0.94
62 - 63	5.45	0.46	5.15	0.44	0.00119	1.01	0.0272	23.15	0.0011	0.98

The data suggests a peak requirement for calcium and phosphorus from 10 - 40 weeks of age. This corresponds to the period during which a 2 - 3 percent incidence of bent and bowed tibia has been recorded in flocks at the research centre fed diets containing 0.9 - 1% calcium and 0.4% available phosphorous.

While the estimated requirement for zinc is consistent with those recommended for other avian species the data suggests a low requirement for manganese and copper. This is contrary to recommendations that higher levels of these elements be fed to emus. Angel, (1993) reported on nutrient profiles of emu and ostrich eggs as indicators of nutritional status of the hen and chick. She observed low manganese levels in both emu and ostrich eggs despite a diet value of 195 ppm manganese. A study of baseline values for skeletal (leg bone) growth, calcification, and soft tissue (liver) mineral accretion (Scheidler et al., 1994) also suggested that low manganese levels may be contributing to leg trauma problems in emus and ostriches.

Birds in this trial were fed 100 ppm, 10 ppm and 80 ppm of supplementary manganese, copper and zinc respectively and this estimate of requirement indicates that low tissue levels of manganese and copper may represent normal values for emus and are not indicative of a nutritional deficiency.

Losses from bent and deviated legs is of major concern to to the emu industry and further research in this area is recommended.

(c) Response of growing emus to dietary energy

• Background:

Currently there is little information on the true nutritional requirements of emus and they are fed diets which range from a mixture of grains to complete diets based on our knowledge of poultry. Industry practice was to feed a low energy starter diet, of similar specification to a chicken starter diet, for 7 to 10 days followed by a 16 percent protein diet to 16 to 20 weeks of age. A lower protein grower diet is then fed to market weight.
To design an optimum feeding regime for emus we need to know their protein requirement in terms of optimal amino acid balance, their growth response to different concentrations of a well balanced protein mixture, any interaction with the energy content of the diet and the birds response to dietary energy.

The recommendations for the balance of amino acids to the energy content for diets currently being recommended have been based on those determined for broiler chickens. Previous work has suggested that while the balance of amino acids being recommended appears justified the recommended dietary levels are probably in excess of what emus require. Although this suggests that similar growth could be achieved by feeding cheaper rations of lower protein specification, the saving in feed ingredient cost would be in the order of only $5.00 per bird to 55 weeks of age.

Emu fat is an important product and strategies to maximise its production should result in increased returns to the industry. In most animals, fatness is influenced strongly by the energy content of the diet and a knowledge of how emus respond to dietary energy will enable us to design feeding regimes to maximise fat production.

Earlier work (not published) suggested that young emus would respond to high energy diets and the feeding of diets containing optimum concentrations of dietary energy could be expected to achieve higher body weights at a given age. If these higher growth rates are maintained to slaughter age it should enable birds to be slaughtered earlier or at higher weights at the same age. With the current price of emu meat and fat being around $10 per kilogram this extra live weight should result in a net gain of $10 to $15 per bird at slaughter. ie. a knowledge of the birds response to dietary energy could result in a better economic return than knowledge of its precise protein requirement.

Emus are seasonal breeders and chicks are hatched from July to November each year. Their appetite is also strongly influenced by season. Appetite increases sharply in August to September and peaks in November to December before declining sharply until the next spring. This places the later hatched chicks at a distinct disadvantage in respect to reaching maximum slaughter weights in the December following the birds year of hatch, ie at 13 to 17 months of age. Live weight will decline over the following 6 to 7 months as the birds go through their first breeding season. This suggests that there would be a considerable advantage in growing birds faster, particularly later hatched birds, to achieve higher body weights before December and that these gains could more than offset the additional cost of the high density diets.

A trial to determine the growth response of emus to diets of different energy concentration was commenced in August 1993. Each dietary treatment was fed to 4 replications of 10 chicks. The trial was continued until the birds reached slaughter weight at 62 weeks of age.

• Methodology:

Six treatments x 2 hatch dates x 2 replications of 10 emu chicks. N = 240.

Individual birds represented the experimental unit for carcase weight, weight of fat and lean muscle determinations.

A pen was the experimental unit used to measure live weight, food consumption.

Six treatments:

- Tr1 = High energy "summit" diet of 13.5 MJ energy/kg diet;
- Tr2 = Summit diet diluted to 12.5 MJ/kg;
- Tr3 = Summit diet diluted to 11.5 MJ/kg;
- Tr4 = Summit diet diluted to 10.5 MJ/kg;
- Tr5 = Summit diet formulated with a 15 percent higher lysine to energy ratio;
- Tr6 = Summit diet, with the oil and whole grain fraction fed separately to the concentrate or protein fraction.

Diet five was designed to test that the summit diet is not limiting in protein.

Diet six determined if emus have the ability to self select a balanced diet which promotes rapid growth.

The summit diet commenced with a lysine to energy ratio of 0.8g lysine/MJ energy, with other essential amino acids maintaining minimum ratios to lysine as recommended for broiler chickens. The lysine:energy ratio was decreased at intervals as the birds protein requirement, as predicted from body composition analysis being carried out in a separate study, decreases with age.

The rations fed to treatments 1 to 5 were diluted in energy by the removal of fat from the summit diet and the inclusion of hard wood sawdust so as to maintain the same balance of both the ingredients used and the ratio of lysine to other essential ingredients.

Rations were formulated using the nutritional restraints tabled below.

Table 38. Suggested nutritional restraints for the formulation of emu rations

	0-8 weeks	8-24 weeks	24-40 week	40-70 week
Protein % >	16.5	16.5	15.0	13.0
g Lysine/MJ energy	0.80	0.65	0.60	0.48
AA Ratio to Lysine				
Lysine	1.00	1.00	1.00	1.00
Methionine >	0.40	0.50	0.50	0.50
TSAA >	0.75	0.66	0.66	0.66
Arginine >	0.90	1.04	1.04	1.04
Isoleucine >	0.50	0.57	0.57	0.57
Isoleucine <	0.76	0.76	0.76	0.76
Leucine >	1.03	1.36	1.36	1.36
Leucine<	1.72	1.72	1.72	1.72
Phenylalanine>	0.70	0.70	0.70	0.70
Threonine>	0.60	0.60	0.60	0.60
Tryptophan .	0.19	0.19	0.19	0.19
Valine >	0.68	0.81	0.81	0.81
Valine <	0.94	0.94	0.94	0.94
Energy MJ >	11.0	10.5	11.0	11.0
Fat % >	4.0	4.0	4.0	4.0
Linoleic Acid % >	1.0	1.0	1.0	1.0
Fibre % >	4.0	4.0	4.0	4.0
Calcium >%	1.2	1.2	1.2	1.2
Available Phosp >	0.65	0.60	0.40	0.40
Available Phosp <	0.80	0.80	0.80	0.80
Sodium >	0.16	0.16	0.16	0.16

Table 39. Rations fed from 3 - 8 weeks of age

Ingredient	ration 1	ration 2	ration 3	ration 4	ration 5	ration 6
Wheat	67.2	67.2	67.2	67.2	58.0	67.2*
Groats	3.5	3.5	3.5	3.5	8.2	3.5
Lupin	9.20	9.20	9.20	9.20	10.2	9.2
Fishmeal	2.5	2.5	2.5	2.5	5.0	2.5
Meatmeal	10.00	10.00	10.00	10.00	10.0	10.00
Bloodmeal	1.50	1.50	1.50	1.50	3.0	1.50
Dicalc phos	0.35	0.35	0.35	0.35		2.25*
Canola oil	5.00	2.00			5.00	5.00*
Salt	0.22	0.22	0.22	0.22	0.05	0.22
Lysine	0.16	0.16	0.16	0.16	0.072	0.16
Methionine	0.23	0.23	0.23	0.23	0.27	0.23
Min vit	0.25	0.25	0.25	0.25	0.25	0.25*
Choline	0.20	0.20	0.20	0.20	0.20	0.20
Sawdust			7.75	17.60		
Total	100.20	100.00	103.06	112.91	100.24	100.00
Calculated analysis						* fed separately
Energy MJ	13.5	12.5	11.5	10.5	13.5	
Lysine %	1.08	1.08	1.05	0.96	1.24	
Protein %	19.5	19.5	18.98	17.32	22.3	
Methionine%	0.51	0.51	0.50	0.45	0.61	
TSAA%	0.81	0.81	0.79	0.72	1.24	
Threonine%	0.67	0.67	0.65	0.60	0.80	
Tryptophan%	0.20	0.20	0.19	0.18	0.24	

Calcium%	1.00	1.00	1.00	1.00	1.00	
Avail. Phos%	0.55	0.55	0.55	0.55	0.55	

Table 40. Rations fed from 8 -24 weeks of age

Ingredient	ration 1	ration 2	ration 3	ration 4	ration 5	ration 6
Wheat	66.75	66.75	66.74	66.72	58.30	66.75
Oats	7.00	7.00	7.00	7.00	7.60	7.00
Groats	2.00	2.00	2.00	2.00	5.70	2.00
Lupin	5.00	5.00	5.00	5.00	6.40	5.00
Meatmeal	10.00	10.00	10.00	10.00	10.00	10.00
Fishmeal					3.40	
Bloodmeal	2.00	2.00	2.00	2.00	2.00	2.00
Lime sand	0.50	0.50	0.50	0.50	0.40	0.50
Dicalc phos	0.87	0.87	0.88	0.90	0.47	0.87
Canola oil	5.00	2.00			5.00	5.00
Salt	0.14	0.14	0.14	0.14	0.08	0.14
Lysine	0.09	0.09	0.09	0.09	0.02	0.09
Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Min vit	0.45	0.45	0.45	0.48	0.45	0.45
Sawdust		3.00	7.75	17.60		
Total	100.00	100.00	102.75	112.60	100.02	100.00
Calculated analysis						
Energy MJ	13.5	12.5	11.5	10.5	13.5	
Lysine %	0.88	0.88	0.86	0.78	1.01	
Protein %	17.20	17.20	16.74	15.27	19.5	
Methionine%	0.44	0.44	0.43	0.39	0.51	
TSAA%	0.72	0.72	0.70	0.64	0.80	
Threonine%	0.58	0.58	0.56	0.51	0.69	

Tryptophan%	0.18	0.18	0.17	0.16	0.20	
Calcium%	1.20	1.20	1.20	1.20	1.20	
Avail. Phos%	0.60	0.60	0.60	0.60	0.06	

Table 41. Rations fed from 24 -40 weeks of age

Ingredient	ration 1	ration 2	ration 3	ration 4	ration 5	ration 6
Wheat	69.70	69.70	69.70	69.70	71.50	69.70
Oats	10.00	10.00	10.00	10.00		10.00
Lupin	2.80	2.80	2.80	2.80	10.50	2.80
Meatmeal	10.00	10.00	10.00	10.00	10.00	10.00
Bloodmeal	1.64	1.64	1.64	1.64	2.00	1.64
Lime sand	0.33	0.33	0.33	0.33	0.32	0.33
Dicalc phos	0.18	0.18	0.18	0.18	0.15	0.18
Canola oil	4.50	1.50			4.60	4.50
Salt	0.17	0.17	0.17	0.17	0.17	0.17
Lysine	0.06	0.06	0.06	0.06	0.087	0.06
Methionine	0.17	0.17	0.17	0.17	0.224	0.17
Min vit	0.45	0.45	0.45	0.45	0.45	0.45
Sawdust		3.00	8.98	18.93		
Total	100.00	100.00	104.48	114.43	100.00	100.00
Calculated analysis						
Energy MJ	13.5	12.5	11.5	10.5	13.5	
Lysine %	0.81	0.81	0..78	0..71	1.01	
Protein %	16.51	16.51	15.80	14.43	19.5	
Methionine%	0.40	0.40	0.40	0.40	0.51	
TSAA%	0.68	0.68	0.68	0.68	0.80	
Threonine%	0.55	0.55	0.55	0.55	0.69	
Tryptophan%	0.17	0.17	0.17	0.17	0.20	
Calcium%	1.00	1.00	1.00	1.00	1.07	
Avail. Phos%	0.48	0.48	0.48	0.48	0.48	

Table 42. Rations fed from 40 - 62 weeks of age

Ingredient	ration 1	ration 2	ration 3	ration 4	ration 5	ration 6
Wheat	65.13	65.13	65.13	65.13	62.75	65.13
Oats	10.00	10.00	10.00	10.00	10.00	10.00
Barley	9.00	9.00	9.00	9.00	9.00	9.00
Lupin	1.00	1.00	1.00	1.00	1.00	1.00
Meatmeal	7.70	7.70	7.70	7.70	10.00	7.70
Bloodmeal					1.00	
Lime sand	0.64	0.64	0.64	0.64	0.37	0.64
Dicalc phos	0.65	0.65	0.65	0.65	0.15	0.65
Canola oil	5.00	2.37			4.90	5.00
Salt	0.23	0.23	0.23	0.23	0.18	0.23
Lysine	0.09	0.09	0.09	0.09	0.06	0.09
Methionine	0.11	0.11	0.11	0.11	0.14	0.11
Min vit	0.45	0.45	0.45	0.45	0.45	0.45
Sawdust		2.63	6.00	16.00		
Total	100.00	100.00	101.00	111.00	100.00	100.00
Calculated analysis						
Energy MJ	13.5	12.5	11.5	10.5	13.5	
Lysine %	0.65	0.65	0..64	0.59	0.74	
Protein %	13.70	13.70	13.56	12.16	15.4	
Methionine%	0.32	0.32	0.31	0.29	0.371	
TSAA%	0.46	0.46	0.45	0.41	0.63	
Threonine%	0.45	0.45	0.44	0.41	0.51	
Tryptophan%	0.14	0.14	0.17	0.13	0.16	
Calcium%	1.00	1.00	1.00	0.99	1.00	
Avail. Phos%	0.47	0.48	0.48	0.43	0.47	

The formulation of the Energy and Protein components fed to treatment 6 birds was varied in an attempt to increase the consumption of the protein fraction of the diet.

Table 43. Formulae of Energy and Protein components of diet 6

	3 - 8 weeks	8 - 24 weeks	24 - 40 weeks	40 - 62 weeks
Energy Component				
Wheat	91.65	84.56	81.18	92.53
Canola oil	6.82	8.81	12.74	7.10
Dicalc.Phos.	1.53	6.30	5.74	
Min/vit	0.60	0.21	0.22	0.24
Chol. chloride	0.50	0.12	0.12	0.13
Protein Component				
Barley				30.44
Oats				33.82
Wheat			27.91	
Groats	12.66	9.55		
Lupin	33.27	23.87	13.03	3.38
Meatmeal	36.17	47.73	46.52	26.04
Fish meal	9.04			
Lime sand		2.39	1.54	2.16
Dicalc. phos.		4.16	0.84	2.21
Bloodmeal	5.42	9.55	7.63	
Salt	0.40	0.67	0.79	0.78
Lysine	0.58	0.44	0.28	0.30
Methionine	0.83	0.95	0.79	0.37
Min/Vit	0.30	0.38	0.37	0.27
Chol.Chloride	0.22	0.32	0.31	0.23
Total	100.00	100.00	100.00	100.00

- **Detailed Methods:**

All chicks were weighed at hatching and 10 chicks were allocated to each of 24, 4.65 m x 1.83 m pens within a insulated, naturally ventilated chicken brooder house. Chicks were allocated on the basis of weight strata such that all pens contained a similar number of chicks from each strata. Chicks came from two separate hatches, six weeks apart, August and October, to supply 2 replications per treatment at each hatch. Treatments were randomly assigned to pens.

All chicks were de-clawed, housed on clean hardwood sawdust and fed a standard emu chick starter mash before being fed the experimental mash diets ad-lib. The first 5 kilograms of experimental diet was added at 2 weeks of age as a mix with an equivalent weight of starter ration so as to provide a transitional period. A brooder temperature of 27 degrees Celsius was maintained until 4 weeks of age. Chicks were moved to 3 m x 20 m outside pens at 10 weeks of age and into 20 m x 30 m pens at 20 weeks.

At 62 weeks of age, on November 9, 1994 (hatch 1, August hatched) and five weeks later on December 14, 1995 (hatch 2, October hatched), the birds were slaughtered and live weight, fat weight, carcase and muscle weight recorded.

• Measurements :

Initial chick weight; live weight each fortnight to 10 weeks and 4 weekly until slaughter; food consumed at equivalent intervals and mortality was recorded. Dead birds were refrigerated and submitted for post mortem examination by a veterinarian.

Abattoir
The birds were processed, boned and carcase weight, body and gut fat weight, weight of lean meat recorded.

Live weight

While the birds fed the higher energy diets, treatments 1 and 5, were consistently slightly heavier no significant effect of dietary energy level on live weight to 62 weeks of age was shown. Birds allowed to select between an energy and protein source (treatment 6) grew poorly and from 8 weeks of age their live weight was lower ($p<0.01$).

Table 44. Average Live weight of Treatments

grams/bird

Weeks of Age	13.5 MJ T1	12.5 MJ T2	11.5 MJ T3	10.5 MJ T4	13.5 MJ T5	Free Choice T6
0	421	417	422	419	427	415
2	593	565	596	583	586	583
3	1012	938	1035	989	995	1028
4	1583	1500	1586	1502	1527	1582
6	3047	2920	3075	3009	3115	2647
8	4822	4665	4788	4726	4901	3834
10	6913	6850	6902	6856	7178	5473
12	9309	8928	9127	9133	9771	6779
16	12708	12465	12500	12499	13284	9021
20	16510	16189	16234	16117	17168	11703
24	20183	19670	19298	19932	20560	14108
28	22769	22194	22121	22401	23155	16013
32	25741	24821	24889	24939	25883	18078
36	28081	26592	26536	26704	28004	19257
40	29678	28315	28115	28268	29588	20462
44	32247	30917	29734	30185	32476	22346
48	35669	34048	33060	33333	34630	25413
52	39335	37538	35613	36485	38208	28795
56	42159	40180	38611	39466	41338	31288
62	44816	41361	41749	42424	43172	33792

Rate of Live Weight Gain

Dietary energy had no effect on rate of gain for the periods 3 - 8, 8 - 24, and 40 - 62 weeks of age. A dietary energy of 13.5 MJ resulted in better growth than 11.5 or 10.5 MJ during the 24 - 40 weeks of age period. Birds fed free choice recorded lower rates of gain for all periods except during the 40 - 62 weeks of age fattening period.

Table 45. Rate of Live Weight Gain

gm/bird/week

	3 - 8 weeks	8 - 24 weeks	24 - 40 week	40 - 62 week
T1 13.5 MJ	757 b*	925 b	596 c	751
T2 12.5 MJ	759 b	903 b	516 bc	641
T3 11.5 MJ	748 b	894 b	469 b	727
T4 10.5 MJ	753 b	918 b	482 b	761
T5 13.5 MJ	773 b	949 b	538 bc	677
T6 F Choice	554 a	609 a	357 a	678
LSD P< 0.05	51	65	92	NS

* Means with common subscript are not different (P > 0.05)

Feed

Lower levels of feed intake were recorded for the free choice treatment at all ages. Feed intake of treatments 1 - 5 were consistent with the energy content of the diet ie. higher levels of feed intake were recorded on the lower energy diets and birds ate to a consistent energy intake.

Table 46. Feed Eaten

grams/bird/day

	3 - 8 weeks	8 - 24 weeks	24 - 40 week	40 - 62 week
T1 13.5 MJ	208 a*	452 b	520 b	789 b
T2 12.5 MJ	238 b	503 c	549 b	831 b
T3 11.5 MJ	231 b	513 c	606 c	903 c
T4 10.5 MJ	258 c	587 d	624 c	1050 c
T5 13.5 MJ	204 a	468 b	530 b	777 b
T6 F Choice	203 a	332 a	404 a	594 a
LSD P< 0.05	28	33	50	83

* Means with common subscripts are not different (P > 0.05)

Energy intake

The intake of energy for all growth periods were similar for all treatments with the exception of the free choice fed birds which ate less. During the 24 - 40 week growth period the lower level of energy eaten by birds fed treatment 4, the low energy diet, approached significance and this was consistent with the lower rates of gain recorded for the treatment (table 43.).

Table 47. Calculated Intake of Energy

Megajoule/bird/day

	3 - 8 weeks	8 - 24 weeks	24 - 40 week	40 - 62 week
T1 13.5 MJ	2.8	6.1 b*	7.0 b	10.6 b
T2 12.5 MJ	3.0	6.3 b	6.9 b	10.4 b
T3 11.5 MJ	2.8	5.9 b	6.9 b	10.4 b
T4 10.5 MJ	2.7	6.2 b	6.5 b	11.0 b
T5 13.5 MJ	2.7	6.3 b	7.1 b	10.5 b
T6 F Choice	2.8	4.6 b	5.5 a	8.7 a
LSD P< 0.05	NS	0.71	0.62	1.1

* Means with common subscripts are not different (P > 0.05)

Utilisation of Energy

Free choice fed emus ate more energy for each kilogram of live weight gain for growth periods to 24 weeks of age. Significance was lost for the 24 - 40 week growth period and the efficiency of energy utilisation during the 40 - 62 week finishing period was similar for all treatments.

Table 48. Conversion of Energy Intake

Megajoule/kilogram of live weight gain

	3 - 8 weeks	8 - 24 weeks	24 - 40 week	40 - 62 week

T1 13.5 MJ	25.8 a*	44.4 a	83.3	102.5
T2 12.5 MJ	28.0 b	46.9 a	89.0	114.6
T3 11.5 MJ	24.6 a	45.5 a	89.0	112.1
T4 10.5 MJ	24.4 a	45.4 a	89.9	110.9
T5 13.5 MJ	24.7 a	45.1 a	89.4	111.2
T6 F Choice	35.1 c	50.0 b	97.9	96.3
LSD P< 0.05	2.7	3.1	NS	NS

* Means with common subscripts are not different (P > 0.05)

Conversion of Feed to Live weight

For treatments 1 - 5 the conversion of feed to live weight was consistent with the birds eating more of the low energy feeds to achieve similar levels of live weight gain for treatments. Free choice fed birds showed poor feed conversion during the 3 - 8 week period. Free choice birds converted efficiently during the 40 - 62 week finishing period.

Table 49. Conversion

Kilogram of feed / kilogram of live weight gain

	3 - 8 weeks	8 - 24 weeks	24 - 40 week	40 - 62 week
T1 13.5 MJ	1.925 a*	3.300 a	6.18 a	7.57 ab
T2 12.5 MJ	2.225 bc	3.725 b	7.12 ab	9.17 c
T3 11.5 MJ	2.150 b	4.000 c	7.72 bc	9.75 cd
T4 10.5 MJ	2.400 c	4.325 d	8.57 c	10.57 d
T5 13.5 MJ	1.825 a	3.325 a	6.60 ab	8.22 b
T6 F Choice	2.525 c	3.625 b	7.15 ab	6.57 a
LSD P< 0.05	0.217	0.239	1.134	1.20

* Means with common subscripts are not different (P > 0.05)

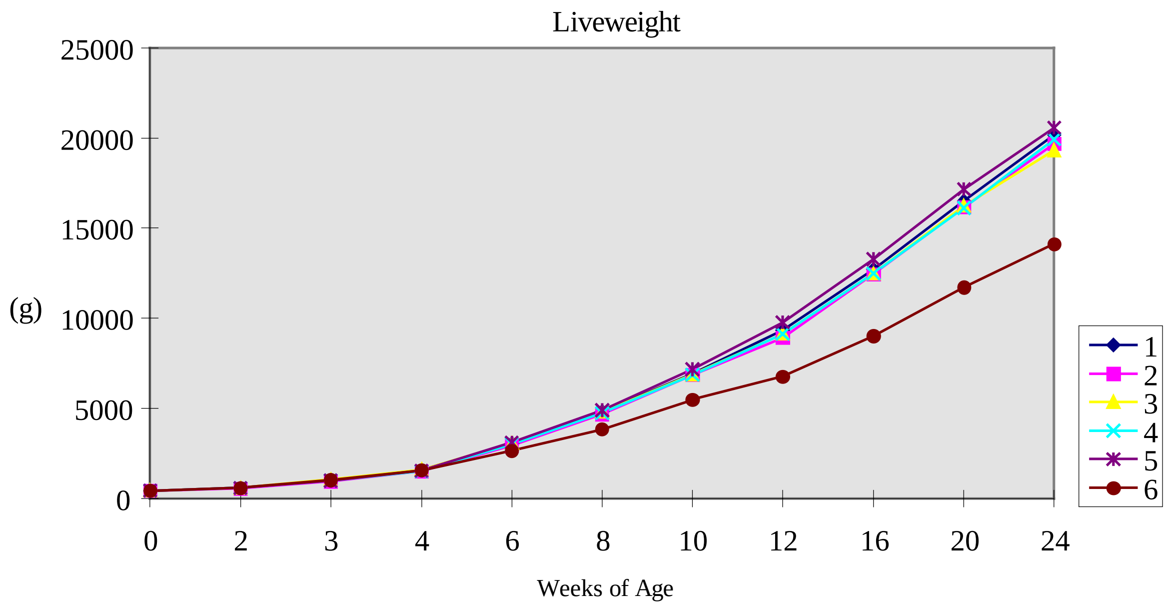
Diet selection of Free Choice Fed Emus

Table 50 shows that while emus selected a diet high in energy, younger birds selected higher levels of protein which is consistent with their higher requirements. Despite this, growth on the diets selected to 24 weeks of age was poor.

Table50. Calculated Nutrient Content of Diet Selected by Choice Fed Emus

	3 - 8 weeks	8 - 24 weeks	24 - 40 week	40 - 62 week
Protein %	15.7	13.8	13.5	10.7
Energy Mj	13.8	13.8	13.7	14.7

Lysine %	0.78	0.61	0.58	0.35
Methionine %	0.38	0.31	0.30	0.19
TSAA %	0.65	0.57	0.56	0.43
Calcium %	0.86	0.62	0.52	0.07
Avail Phos %	0.54	0.45	0.27	0.20



When fed the energy concentrate separately from the protein fraction of the diet, treatment 6 birds initially selected a similar energy intake to birds fed treatments 1 to 5 and in doing this they selected a lower intake of protein and essential amino acids ie. they appeared not to have a rational appetite for protein. This lower intake of protein and essential amino acids is considered to have resulted in the slower growth of the emus fed treatment 6. Table 51 lists the calculated intake of selected nutrients by the free choice fed birds compared to those recorded for treatment 1.

Table 51. Selected Intake of Protein, Lysine and Amino Acids by Choice Fed Emus

	Energy(MJ)		Protein(g)		Lysine(g)		Methionine(g)	
Period	Ration 1	Choice 6	Ration 1	Choice 6	Ration 1	Choice 6	Ration 1	Choice 6
3-4 W	19.2	19.2	27.5	33.8	1.52	2.01	0.73	0.95

4-6 W	26.1	27.0	37.5	29.0	2.07	1.38	1.00	0.68
6-8 W	34.6	33.3	49.8	33.3	2.75	1.51	1.32	0.76
8-10 W	45.0	38.4	57.2	50.9	2.92	2.63	1.46	19.2
10-12 W	47.2	34.6	60.0	36.8	3.07	1.69	1.54	0.86
12-16 W	70.6	34.7	90.0	40.2	4.59	1.94	2.30	0.98
16-20 W	65.8	53.2	83.8	50.9	4.28	2.18	2.40	1.12
20-24 W	66.6	50.4	84.8	47.4	4.33	2.00	2.17	1.03

The grain fraction of the diet was fed whole and large amounts of undigested grain was evident in the birds droppings. This apparant poor utilisation of whole grain may have contributed to the poor growth and feed conversion (tables 44, 45, 48 and 49) recorded during the early growth period. Growth and feed conversion improved after 24 weeks of age when the decision was made to hammermill the grain fraction before feeding.

Slaughter

Slaughter data was analysed on the basis of individual live weight rather than average pen results. The free choice fed birds were smaller and yielded less product than the ration fed birds. There were differences recorded for live weight between other treatments but this did not translate into significantly higher yields of fat or muscle. Fighting and aggression just prior to slaughter increased variation between replications. Live weight and product yield of the birds fed the 10.5 MJ diet was similar to those fed the 13.5 MJ diets. Muscle yield of treatments 1 - 5 was remarkably similar and the greatest variation was seen in the amount of fat produced.

Table 52. Carcase Measurements

kilogram/bird

	Live weight	**Carcase****	**Total Fat*****	**Muscle**
T1 13.5 MJ	45.01 c*	21.24 b	10.06 b	12.93 b

T2 12.5 MJ	42.12 b	20.37 b	8.94 b	12.46 b
T3 11.5 MJ	42.14 b	20.83 b	8.97 b	12.81 b
T4 10.5 MJ	43.95 bc	21.09 b	9.51 b	12.80 b
T5 13.5 MJ	44.07 bc	20.96 b	9.93 b	12.80 b
T6 F Choice	34.18 a	16.15 a	6.84 a	9.65 a
LSD P< 0.05	2.78	1.40	1.36	0.80

* Means with common subscripts are not different (P > 0.05)
** Without fat
*** Visceral fat not collected.

Hatch date

The mid August and early October hatches used are considered to be mid season hatches and no interaction between hatch date and treatment was recorded for any of the parameters measured.

• Conclusions:

While higher levels of dietary energy consistently resulted in higher live weights and yielded more fat at slaughter, the differences were not statistically proven. Emus eat to an energy requirement and diets containing a calculated energy content of 10.5 Mj/kg do not limit energy intake or live weight gain except during the 24 - 40 week growth phase. Lower rates of gain were recorded for birds fed 11.5 and 10.5 Mj diets during this period which corresponds to the seasonal autumn winter decline in the appetite of emus. This higher rate of gain is likely to have been caused by the maintenance of a higher level of fatness rather than a higher rate of muscle gain. This work did not support the previous preliminary finishing trial which suggested that higher energy diets would result in rapid fattening after the seasonal increase in appetite occurs. Birds in this trial however, were reared on a consistent dietary energy level from 3 weeks of age. Birds used in the preliminary fattening trial had been reared on a low energy diet, 10.25 Mj /kg, and consumed large amounts of energy and gained weight rapidly for a short period after being switched to the high energy diets.

Emus allowed to select between a protein concentrate and grain energy source selected a high energy diet with a relatively low level of protein. There was an adjustment of protein intake with age but the diet selected to 24 weeks of age, which contained whole wheat, did not support optimum growth. Free choice feeding beyond this age does appear feasible and further research is warranted.

Treatment 5 demonstrated that the nutritional restraints used to formulate the different diets fed were adequate in protein.

• Recommendations:

Emu rations be formulated on the basis of least cost per unit of energy to meet the nutritional restraints listed in table 38.

Emus less than 24 weeks of age be fed a complete, mixed diet.

Grains fed to emus be milled.

Emus reared on low energy diets be finished rapidly, with a considerable saving in cost, by feeding high energy fat supplemented diets for 8 - 10 weeks prior to slaughter.

Research be undertaken to verify the nutritional theory which suggests that emus can be fed lower protein diets from 4 weeks of age. This would cheapen production cost by $3.00 - $5.00 per bird.

Performance and yield data tabled below be used to calculate the cost of producing mid season, August to October, hatched emus for different end uses.

Considerations

The appetite and growth of emus is influenced by season. Weight for age of early and late hatched birds is therefore influenced by hatch date and the cost of growing early hatched birds to maximum fatness is greater because they will need to be slaughtered at an older age to achieve maximum fatness. Information on the interaction between hatch date, live weight and product yield will be needed before a truly optimum strategy for the production of emus can be formulated.

The current stocks of emus are genetically diverse and show a high level of variation for most parameters measured. This, together with the birds natural aggression when developing social order within pens, indicates that well designed, large scale trials are needed to detect economically significant treatment effects of less than 5 - 7 percent.

The recommended feeding option for growing emus coming from this work is:

- Feed a complete mixed ration formulated to the restraints given in the report.
- Diets fed from 6 - 40 weeks of age be formulated on a least cost per unit of energy basis.
- Birds, which are older than 40 weeks of age, be finished quickly from July 15 each year by the feeding of a high energy, (13 - 14 Mj), finisher diet for 8 - 10 weeks prior to slaughter.

Table 53. Live weight, Feed Consumption and Products of emus.

Age	Live weight*		Feed**		Product*		
		Gain	Period	Cumulative	Meat	Fat	Skin
(weeks)	(g)	(g/b/d)	(g/b/d)	(kg)	(kg)	(kg)	(m^2)
0 - 2	506	14	35	0.490			
2 - 3	797	59	88	1.106			
3 -4	1285	80	140	2.086			
4 - 6	2311	106	220	5.16			
6 - 8	3927	124	259	8.79			
8 - 10	5869	153	368	13.94			
10 - 12	7791	121	374	19.18			
12 - 16	10666	145	561	27.03			
16 - 20	14567	134	603	35.4	4.500	0.950	0.37
20 - 24	18189	125	630	53.1	6.050	1.600	0.39
24 - 28	21224	92	597	69.8	7.400	1.800	0.44

28 - 32	23836	95	545	85.1	8.650	2.150	0.46
32 - 36	26154	71	544	100.3	9.750	2.500	0.55
36 - 40	27955	58	614	117.5	10.750	3.000	0.57
40 - 44	29877	80	604	134.4	11.600	3.280	0.58
44 - 48	32535	110	820	157.4	12.350	3.680	0.59
48 - 52	35709	117	851	181.2	12.900	4.670	0.60
52 - 56	38801	104	829	204.4	13.400	6.500	0.61
56 - 60	41475	87	1051	233.8	13.750	9.000	0.62
60 - 62	43191	72	1026	248.2	13.900	10.400	0.63
62 - 64	44036	60	1175	264.7	14.000	10.650	0.63
64 - 66	43500	-38	615	273.3	14.000	9.800	0.64
66 - 68	43000	-35	540	280.8	14.500	8.500	0.64

* Mid point ** Poultry value ME of 11.5 MJ/kg diet.

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