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Growing
Juvenile Ostrich
In a Grazing Environment

A report for the Rural Industries Research and Development Corporation

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FOREWORD

The Australian ostrich industry has recently struggled to establish markets and develop as an alternative animal industry. While many of the problems have been market-related, the lack of technical information regarding the management and growth of ostrich in a farmed environment has also contributed to these difficulties. If the industry is to develop, its conversion from reliance on high-cost prepared rations to one that utilises low-cost but high-quality pasture, is essential.

This project seeks to examine some of the issues relating to the growth of young ostrich, destined for slaughter at approximately 12-14 months of age, in a grazed system.

The report outlines aspects of the current knowledge base with respect to ostrich nutrition, particularly as it relates to the grazed environment. It details grazing experiments undertaken to investigate the growth of juvenile ostrich on Australian pastures and the interaction with and role of supplementation. Additionally, aspects of ostrich behaviour are also examined in an effort to understand the best way to manage juvenile ostrich especially with respect to supplementary feeding.

The report details project results and seeks to utilise these to develop recommendations for the future grazing management of juvenile ostrich.

This report, a new addition to RIRDC's diverse range of over 400 research publications, forms part of our New Animal Products R&D program, which aims to accelerate the development of viable new animal industries.

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Abbreviations

The following abbreviations are used in this report:

ADF - acid detergent fibre
CP - crude protein
DM - dry matter
DMD - dry matter digestibility
ha - hectare
kg - kilograms
M/D - metabolisable energy in dry matter (MJ ME/kg DM)
ME - metabolisable energy
mg - milligrams
MJ - megajoules

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Executive Summary

The Australian ostrich industry has had a short but volatile history with the initial phase of high livestock costs now being passed and the industry seeking to develop a sustainable future. Critical to its success will be the ability of the industry to develop low-cost management systems to produce high-quality hide, skin and feather products. One of these systems could potentially be an extensive grazing system for the growth of young slaughter stock from approximately 4 to 14 months.

In their natural environment of southern Africa, ostrich are largely herbivorous, feeding opportunistically on small vertebrates and invertebrates when available. Under these rangeland conditions, birds feed individually and in groups and the availability and quantity of feed varies dramatically within and between years. Previous work has shown the ostrich to be an avian species adapted to fibre digestion, through the development of sacculated caeca. This provides a suitable environment for microbial fibre digestion, similar to that seen in ruminants. Given these factors, the ostrich would seem an ideal species for production in the high and low rainfall improved pasture environments, typical of many regions in Australia.

While some information is available in the literature regarding ostrich growth and nutrition, little is available to help in the development of these grazing management systems. Most data details results from experiments where birds have been produced in intensive management systems with birds being fed prepared rations. This report details three small experiments which were conducted to investigate issues surrounding the effective management of juvenile ostrich in a grazing system. Specifically, the project's objectives were:

- Evaluate the growth rate of juvenile ostrich in a supplemented grazing environment.
- Develop some understanding of the potential of Australian pastures to support ostrich growth and the way in which changes in pasture quality and quantity impact on growth.
- Evaluate management and other practical issues relating to the growth of juvenile ostrich in a grazing environment.
- Evaluate the efficacy of different commercial rations as supplements for use in a grazing management system.
- Develop an understanding of the behaviour of ostrich in a grazed environment and the implications for this on management.
- Develop some general management guidelines for the extensive production of ostrich.

The first experiment sought to examine the effect of different pasture types and age on growth in grazing management systems. Birds were allocated into six treatment groups based on a combination of age/hatching date and pasture type. Treatment groups entered the experiment in pairs by age group, with one treatment group being allocated to each pasture type. Animal measures of liveweight and growth rate were recorded along with pasture quality (ADF and CP) and pasture growth measurements. All birds were supplemented at a low rate with a commercial ostrich supplement.

A second grazing experiment sought to examine the effect of different supplements on growth rate. Two supplements were used in combination with two pasture types to give four treatment groups. Unfortunately the experiment was abandoned due to external factors.

The third experiment was a small behaviour experiment examining the grazing behaviour of the ostrich and the interaction with the provided supplement. This was carried out using one of the treatment groups from experiment 2, with 4 days behaviour being recorded and analysed.

Experimental results showed that ostrich growth will not be as rapid in a grazing system but will be more cost-effective. High-quality Australian pastures, where clover content in the sward is managed and maintained, will meet most of the nutrient requirements of young growing ostrich. Supplements should focus on the supply of macro- and micro-nutrients (especially calcium, copper and zinc) rather than acting as either protein and/or energy supplements. As a result they may be better supplied in a form which encourages frequent uptake by the animal eg. in water.

The decline in pasture quality in late spring/early summer presents problems for the final stages of bird growth through to the desired age of 14 months. The cost of maintaining birds through the summer, when growth rate slows considerably may not be warranted. As a result, early hatching dates are critical to ensure effective and rapid bird growth. Birds hatched late will not reach suitable weights for slaughter prior to the decline in pasture quality in late spring/early summer.

The critical nutritional factor influencing growth appears to be protein content of the pasture. Another factor is the variability within the population for growth rate. While part of this will be an environmental effect, there may also be a considerable genetic component. This issue of genetic variability needs to be assessed and clear selection strategies must be put into place to ensure that only high quality stock are used as a breeding resource in the future.

As discussed above, the role of supplements needs to be clearly defined. They are probably not best used as protein or energy sources, as careful management of both pasture and husbandry can achieve improved growth rates at little or no cost. However, they do have a role with respect to the supply of macro- and micro-nutrients for which pasture is deficient. This is likely to be especially important in breeding hens, where the requirements for nutrients such as calcium will be considerably higher.

Issues such as palatability need to be further evaluated. Results from experiment 2 suggest there may have been some effect of supplement on bird growth, however in this case, this would not have been due to the ration's protein level as bird growth was higher on the supplement with a lower protein content.

Ostrich utilise the supplement provided in a grazing environment very quickly, and hence methods of supplementation need to be devised whereby the supplementary nutrients can be delivered more evenly over time.

Practical management considerations are also important. It must be realised that the species is effectively 'semi-wild'. There are a number of potential problems that those used to dealing with domesticated livestock species may face. Ostrich move through yards and gates differently to sheep and cattle. They must be moved slowly and with care. Birds should be hooded prior to conducting management practices involving bird handling. This is critical for the safety of both the primary producer and the animal.

Ostrich have a sudden and dramatic flight response and hence a slightly slower movement through the paddock and yards may save considerable time compared to the birds splitting up over the paddock area. Once startled they will move over long distances rapidly, making re-mustering of the group difficult.

Paddocks and yards must be kept clear of sharp corners. Hide value can be considerably reduced by birds catching legs of body on pieces of wire, strainer posts etc.

Many factors contributing to bird mortality are not understood and higher death rates than might be expected in other livestock species are considered normal.

Clearly there is a place for the use of grazing management systems in ostrich production in Australia. Improved pastures provide a suitable environment for the growth of ostrich and while the growth path may not be as rapid as for more intensively managed systems, the grazing system provides a number of cost, welfare and marketing benefits for the industry. With further work in the area of nutrient requirements for ostrich production, suitable supplements can be produced to complement the nutrients supplied by pasture ensuring efficient and cost-effective systems for ostrich production.

1. INTRODUCTION

The ostrich is a largely herbivorous, flightless bird, native to Africa, which has formed the basis of a farming industry in southern Africa for over one hundred years. The objective of a modern ostrich farm is to convert feed into skin, meat and feather products through an effective management system. Typically, management systems used for ostrich production in Australia have relied on significant inputs of commercially formulated pellets, although some producers have also utilised pasture as a feed source. Given the level of understanding of pasture production in Australia and the land area available as high quality improved pastures, expanded use of this low-cost feed source has the potential to play a significant role in the further development of the ostrich industry. However, there is currently limited information available with respect to the nutritional management of ostrich in a grazed environment.

The following brief review forms a background against which the project is set and serves as an introduction to ostrich nutrition and nutritional management.

1.1 Feed digestion in ostrich

The digestive physiology of the ostrich is unique amongst avian species. Compared to the domestic fowl, the gastrointestinal tract of the ostrich is without a crop, has extremely well developed sacculated caeca and, unlike other ratite birds has an unusually long colon (Swart *et al*., 1993a). Beyond this it is similar to other birds.

The gastrointestinal tract begins with a proventriculus. The proventriculus is a thick-walled organ that lies between the oesophagus and the gizzard. The proventriculus has a lumen which allows the storage of food (Hastings, 1991). In ostriches and emus, the large physical capacity of the proventriculus takes the place of some of the storage capacity of the absent crop (Sigler, 1995). Food enters the proventriculus and the gastric juices containing hydrochloric acid and pepsin, an enzyme secreted to break down protein, reduces the feed into more digestible fractions (Sigler, 1995). This process is rapid, so minimal digestion occurs at this stage of the digestion process.

From the proventriculus the digesta moves into the gizzard. The gizzard is formed with strong muscle and contains small stones and grit ingested at various times by the bird. Muscle contractions cause the stones to further grind digesta, making it small enough to enter the small intestine. The small intestine contains the enzymes trypsin, lipase and amylase that have been secreted by the pancreas, beginning the process of true digestion of nutrients. Along with these enzymes, others are secreted by the intestinal wall to assist in proteolysis and the digestion of fats and carbohydrates into smaller compounds (Sigler, 1995). The small intestine is the site where the majority of amino acids, fats, soluble carbohydrates, fat-soluble vitamins and minerals are absorbed.

The remaining fibrous insoluble materials then pass onto the hindgut which consists of the paired caeca and the large intestine (Sigler, 1995). With the aid of the caeca and the large intestine, ostriches are able to utilise feeds with a high fibre content due to the microbial population at this site. This gives the species a well developed mechanism for the effective digestion of plant fibre, and more specifically hemicellulose and cellulose. As a result, it plays a similar role to the rumen in ruminant animals. The hindgut is large and functional in the ostrich in comparison to the other ratite birds (emu, cassowary and rhea). The large intestine is approximately three times as long as the small intestine. Here the microbial population function to breakdown the insoluble fraction of carbohydrates into volatile fatty acids (VFA's) which can potentially be used by the ostrich as an energy source. The rate of passage (39 to 48 hours) through the large intestine is slow compared to emus (5 to 6 hours) (Sigler, 1995), further aiding microbial degradation. Digesta then passes in to the rectum, where it then is evacuated from the ostrich through the proctodeum (Jenson *et al.*, 1992).

1.2 Ostrich digestion and suitability to a pasture diet

Adult ostriches have been found to digest starch as effectively as poultry but digest fibre more efficiently (Cilliers *et al*., 1994). Ostriches can degrade fibrous foods as their hindgut is a suitable site for the digestion of fibre, providing an appropriate environment for fermentative microflora (Swart *et al*., 1993a). This process is not as effective as in ruminants however, with the efficiency of utilisation of the volatile fatty acids produced being comparatively low (Swart *et al*., 1993b). In another experiment, Swart *et al.*, (1993c) showed metabolizable energy (ME) utilisation to decrease with decreasing energy or increasing crude fibre content of the diet.

The volatile fatty acid production rates in the hindgut are typical of those in the forestomach of ruminants and ruminant like herbivores. The adsorption and oxidative metabolism of end products from cellulose fermentation contribute to the ME requirements of the growing ostrich. Swart *et al*. (1993c) found the theoretical energy contribution could be as high as 76% of the ME requirements of the growing ostrich and is in agreement with that reported for adult ruminants above 100kg live mass.

Swart *et al* (1993a) looked at the influence of live mass, rate of passage and site of digestion on energy metabolism and fibre digestion in the ostrich. The study found ostriches to effectively digest plant fibre, more specifically hemi-cellulose (66%) and cellulose (38%). Since slow rates of digesta passage are generally associated with increased digestion, increased fermentative microbial activity and increased water absorption, together with electrolyte absorption (Swart *et al*, 1993a). The long retention time in the gastro-intestinal tract together with advantageous pH values provide a suitable environment for fermentative microflora especially in the hindgut of ostriches (Swart *et al*, 1993b). Additionally, the grinding of feed particles in a relatively strong acid environment (pH 1.2 - 2.1) in the proventriculus and gizzard, is suggested to play a major part in the exposure of fibre fractions to microbial fermentation in the lower intestinal tract.

Fibre digestibility has been shown to increase with age of bird to about 17 weeks after which there is no further increase (Angel, 1993). While this may have an affect on the nutritional management of young chicks, it would not be expected to influence the birds in the present study. Above this age it has been reported that for diets containing less than 16% crude protein, body weight gain decreases as does the feed conversion ratio and hence efficiency of feed use (Gandini, 1986). As a result, the investigation of dynamic pasture systems where both feed availability and quality (including protein level) vary, would appear to be warranted.

1.3. Ostrich Growth & Nutrition

The objective of a modern ostrich production system is to convert feed to skin, meat and feather products (Swart *et al.,* 1993d). The gross efficiency of ME utilisation changes as the proportion of energy directed towards protein and fat deposition changes throughout the life of the growing (maturing) animal (Swart *et al*, 1993). Table 1.1 shows the energy and amino acid requirements of birds in the 4-14 month age group (ie. those examined in this study). Indicative feed intake values are also provided in Table 1.2. Total energy requirements peak at approximately 300 days although after this time liveweight continues to increase. Table 1.3. show the peak rate of growth to come between 120 and 180 days. Increases in energy requirements after this time presumably reflect the increase in the maintenance requirements of the bird.

Table 1.1. Ostrich growth and nutrient requirements from approximately 4 to 14 months (mean of values provided by Smith *et a*l. (1995) and Cilliers and Hayes (1996)).

Age (days)	Liveweight (kg)	Feed intake (kg/day)	Energy requirements (MJ/day)	Lysine requirement (g/day)	Methionine and cystine requirement (g/day)	Arginine requirement (g/day)
120	26.8	0.9	12.5	9.1	5.0	8.5
150	37.9	1.3	15.7	11.7	6.4	10.9
180	50.0	1.6	18.6	14.1	7.8	13.4
210	60.8	1.7	18.9	14.5	8.1	13.9
240	70.4	1.8	19.0	14.7	8.3	14.3
270	79.1	1.9	19.4	15.3	8.7	14.9
300	87.4	1.9	19.9	15.8	9.1	15.7
330	92.5	2.3	17.8	14.2	8.3	14.4
360	95.9	2.3	16.8	13.5	7.9	13.8
390	99.4	2.4	17.1	13.9	8.2	14.3
420	102.7	2.4	17.4	14.3	8.5	14.6

NB. Values for energy and amino acid requirements reported per kg DM intake in Smith *et al*. (1995). These have been converted to g/day using the intake figures provided in the paper.

In their natural habitat, ostrich favour open plains offering short herbage and pasture species for foraging. This is ideal for ostriches as this environment provides the required omnivorous diet. The majority of the diet consists of pasture species, with birds selecting food of relatively high quality and metabolising it for growth and also reserves for times of drought (Berendsen, 1995). The minor part of the ostrich diet consists of the small invertebrates found in these grasslands.

It has been estimated that under mixed grazing conditions with other wildlife species in Namibia, wild ostrich will not suffer from energy deficiencies, but rather protein deficiencies may be present in dry seasons (Berry and Louw, 1982). Where available in wild rangeland environments, ostriches have been found to select in favour of green annual grasses and forbs. However, these species may only have 30% dry matter and hence mature birds may need to consume 5 to 6 kg of ‘wet’ feed per day (Milton *et al*., 1994).

Table 1.2. Growth and dry matter intake values for ostriches (Degan *et al*., 1991)

Age[#]	**120**	**150**	**180**	**210**	**240**	**270**	**300**	**330**	**360**
Liveweight (kg)	40.48	51.54	61.24	71.76	79.46	86.4	91.9	96.7	99.91
Dry matter intake (kg/day)	1.15	1.48	1.77	2.05	1.86	1.97	1.89	1.91	1.96

[#]Age has been adjusted to align with values in table 1.1.

Table 1.3. Growth rate of ostrich (g/day)

Age	**120**	**150**	**180**	**210**	**240**	**270**	**300**	**330**	**360**	**390**	**420**
Degan *et al.* (1991)	419	397	346	355	296	248	196	171	115	-	-
Smith *et al.* (1995)	300	367	420	375	330	305	287	177	120	120	117

In a commercially farmed operation, farmers have many options for the nutritional management of their ostrich. The changing feed conversion ratios of ostriches need to be considered when making decisions regarding the feeding and/or disposal of stock. Table 1.4 shows two sets of data illustrating the decline in feed conversion efficiency between the ages of 4 and 14 months. These compare to conversion efficiencies in sheep of 7.69:1 at 210 days and 20:1 at 420 days (Thompson *et al*., 1985). Especially important is the rapid decline after the birds reach 10 or 11 months of age. Growers need to carefully consider this in terms of the potential interaction between pasture quality, hatching date and feed conversion efficiency and the problems that may arise when trying to feed birds on poorer quality pasture during summer.

Table 1.4. Feed conversion rates of ostrich (kg feed intake/kg liveweight gain)

Age	**120**	**150**	**180**	**210**	**240**	**270**	**300**	**330**	**360**
Degan *et al.* (1991)	2.74	3.73	5.11	5.78	6.28	7.95	9.62	11.14	17.10
Smith *et al.* (1995)	3.8	-	5.5	-	-	-	10	-	-

1.4 Ostrich growth and feeding

Efficient diet formulation is essential for profitable ostrich production (Swart *et al*., 1993d). This is true even where the ration is provided only as a supplement in a grazed environment as these ‘concentrate’ rations often contain expensive ingredients such as trace elements and minerals. The nutritional value of many feed constituents for ostriches is, however, still unknown, making effective least cost diet formulation difficult. Present growth and finishing diets for ostriches are often based on nutritional standards and energy values of ingredients derived for poultry (Swart *et al.*, 1993c) and pigs. This approach may, however, result in unrealistic estimates of the nutritional value of feed constituents for ostriches.

Vitamin requirements for ostriches are detailed in Table 1.5. It should be noted that such values in the literature do not necessarily represent true requirements, but rather what has been provided in prepared ostrich rations to date. This further underlines the problems which still exist in the areas of feed formulation and nutrition as they apply to ostrich.

Table 1.5. Mineral and vitamin contents of various ostrich feeds (Kriebich and Sommer (1995)).

Vitamin	mg/kg feed
Vitamin E	43-50
Vitamin K	3-4
Thiamine	4-6
Riboflavin	9.6-14.4
Pantothenic acid	19-27
Choline	1430-1980
Pyroxidine	5-9
Niacin	57-86
Biotin	0.2
Folic Acid	1.5-2.0

Requirements for macro- and micro-nutrients and comparison values for sheep and cattle are provided in Table 1.6. Ostrich requirements appear to be considerably higher than those for sheep and cattle. How values vary due to stage of growth or other physiological characteristics such as breeding is still unclear.

Table 1.6. Mineral requirements of ostrich compared to sheep and cattle

	Ostrich	Sheep[@]	Cattle[@]
Major elements (g/kg feed)			
Ca	9-10[#]	1.5-4.0	2.0-4.0
P	3.2-3.6[#]	1.3-2.5	1.8-3.2
Na		1.0	1.5
Cl		1.0	2.0
K		4.5	5.0
S		2.0	1.5
Mg		1.2	1.9
Minor elements (mg/kg feed)			
Fe	100.0-180.0[*]	40.0	40.0
Zn	80.0-125.0[*]	20.0-30.0	20.0-30.0
Mn	75.0-120.0[*]	15.0-25.0	15.0-25.0
Cu	8.0-18.0[*]	5.0	5.0-12.0
Co	0.5[*]	0.11	0.11
I	0.5-2.0[*]	0.50	0.50
Mo	-	0.10	0.10
Se	0.2-0.4[*]	0.05	0.05

[#] Smith et al. (1995)
*Kriebich and Sommer (1995)
[@]Caple (1989)

While the authors have been unable to find information relating to vitamin levels in Australian pasture, some data for the macro- and micro-nutrient levels is available. This is detailed for grasses in Table 1.7 and for legumes in Table 1.8. While it appears clear that pasture would meet the requirements of both sheep and cattle (Table 1.6.), its ability to meet the needs of the growing ostrich is unclear. The role of the grazing supplement for ostrich therefore needs to be carefully defined and the product carefully formulated.

Table 1.7. Perennial grass mineral concentrations in winter (g/kg DM) (Paynter, 1989)

Species	Ca	Mg	K	Na
Phalaris	3.22	3.81	12.4	12.4
Cocksfoot	3.89	3.00	15.5	7.1
Fescue	3.51	2.92	14.1	5.9
Perennial ryegrass	3.82	2.82	15.4	6.0

N.B. Values represent the means of 5, 3, 3, and 6 cultivars for phalaris, cocksfoot, fescue and perennial ryegrass respectively.

Table 1.8. Legume mineral concentrations in winter (g/kg DM – Ca to Cu and mg/kg – Mn to Mo) (Paynter, 1989).

Species	Ca	Mg	P	K	Na	S	Cu	Mn	Fe	Zn	Mo
Sub clover	6.1	2.0	2.4	18.8	1.6	1.5	5.2	210	199	26	1.1
White clover	7.2	2.3	2.5	24.8	0.9	1.5	5.5	183	358	17	2.9

N.B. Values represent the means of 3, and 5 cultivars for sub-clover and white clover respectively.

There are varied opinions as to appropriate pellet size for ratite feeding. Many producers prefer dry mash feeds for ratite chicks as these products will pass through the proventriculus and ventriculus with ease (Jenson, *et al* 1992). For juvenile birds, pelletised food is consumed with ease as the pellets will disintegrate in the moist environment of the digestive tract and will pass without extensive physical digestion.

The growth rates of ostrich chicks have been found to vary due to stage of maturity and the sex and origin of the bird (du Preez *et al*., 1992). This may provide scope for the manipulation of growth rate in management groups based upon age or sex, allowing marketable live weight to be reached at different times and hence ensuring consistent delivery of slaughter birds throughout the year.

1.5 Water

Water comprises more than 50% of the body mass of ostriches which makes it the most essential component of their diet. Water should always be available to birds but requirements are extremely variable due to changes in ambient temperature, type of base feed consumed, their stage of production, growth rate and water quality (Sigler, 1995). In general, it is common for ostrich producers to have water on offer that is equal to at least twice the amount of dry feed consumed (Sigler, 1995).

1.6 Grazing behaviour and pasture selection

Ostriches display unique behaviour patterns that can be studied and used as a basis for the development of sound management practices. The pastures in most parts of Australia are well managed and of high quality. With the ostrich industry being so young in Australia, using a cost-effective feeding regime is vital. Using pasture as a predominant food source along with a low-cost supplement, is one way to keep production costs to a minimum. For such a system to be utilised efficiently, a knowledge of the way ostriches utilise pasture when being fed on a minimal amount of supplement would be valuable.

1.6.1 Native grazing habitat & dietary interests

Ostriches adapt to a wide variety of environments. In the wild, the ostrich is adapted to the extreme desert environments found in Africa where the daytime temperatures are high but can fall below freezing at night. In their native habitat, ostriches favour open plains offering short herbage and pasture species for foraging. The majority of the ostrich diet consists of pasture species, selecting food of relatively high quality and metabolising it for growth and building reserves for times of drought (Berendsen, 1995). The tendency for ratites to display broad dietary interests in the wild has been observed by Grzimek (1972). He found that ostriches are adaptable grazers which will not only eat a wide variety of grasses, but will forage occasionally on bushes and trees. The wild diet is frequently supplemented with small animals, including invertebrates and small vertebrates (Grzimek, 1972).

The intensity of utilisation by grazing livestock usually varies among plant communities and the diet selection process involves a hierarchy of grazing decisions. However, the feed intake of ostriches does not always follow convention. For ratites, certain parts of the plant are nutritionally more attractive than others. Jenson *et al.* (1992) found that ratite juveniles which are introduced to pasture with mature grass growth may occupy themselves by eating grass seed heads and flowers before the resort to eating green blades. This may be explained by the fact that seed heads have more concentrated nutrition and the flowers visually attractive.

1.6.2 Feeding

Ostrich chicks begin feeding approximately 5 days after hatching. Most chicks require encouragement or need to be taught how to peck at food. In the wild, chicks learn to eat by mimicking their parents, and in an artificial incubation system, an older chick is used as a ‘teacher’ so the young chicks learn to feed (Jenson *et al*., 1992).

Pecking and feeding makes up a large part of the ratites’ daily behaviour. Ratites not only consume food by pecking and swallowing, but also examine of their environment by picking them up with their beaks (Jenson *et al*., 1992). This allows the birds to evaluate the density and probably the taste and smell of these small objects (Jenson *et al*., 1992).

Usually pastoral feeding is done whilst standing or walking. Feeding is a plucking process whereby the grass and other vegetable matter is ripped up with the beak (Berendsen, 1995). After several plucking motions the ostrich will wobbles it head, and this procedure is repeated several times until enough food is gathered in the throat (Berendsen, 1995), and the food is then swallowed.

1.6.3 Ostrich feeding in their natural environment

As mentioned previously, ostriches are omnivorous. In the wild they live on grasses, insects, small mammals and lizards (Kreibich and Sommer, 1995). The natural habitat of an ostrich comprises dry, semi arid country which offers only poor grazing conditions. The ostrich is well adapted for such conditions and are able to find sufficient sustenance where cattle and sheep would perish.

Ostriches can spend long periods of time foraging in the wild. As a single bird, an ostrich may forage for 65% of their time, but when foraging as part of a group, this time increased to 85% (Degan *et al.*, 1989). If food is in abundance, the time spent foraging is reduced (Bertram, 1980).

Outside the breeding season, mature ostriches tend most often to be solitary birds (Bertram, 1992). On average, birds have been observed to spend 29% of its time alone, 37% with one companion, 19% with two companions and 15% with three or more (Bertram, 1992). Juveniles on the other hand, tend to be more gregarious and have been noted to form large groups.

1.6.4 Farming environment

Ostrich farming originated in Africa, where many of the largest ostrich farms are found and where much of our current understanding of ostrich nutrition has been generated. In South Africa most ostriches graze on lucerne crops. However in some areas lucerne crops may not be available, and clover may be used as an alternative (Kreibich and Sommer, 1995).

Lucerne requires some supplementation to satisfy the ostrich energy requirements. Feeding supplements to grazing animals reduces their grazing time, particularly when a concentrate ration is used (Arnold, 1981). In Africa, the most popular supplement use is whole or roughly ground maize. However, ostriches are easily adapted to most feeds, so farmers have the option to choose a supplement that is of the same energy value but is more easily accessed in their area and hence cheaper to buy.

Information on the amount of time ostriches devote to feeding activities in a farmed environment is limited however, a study by Degan *et al.* (1989) which looked at the time-activity budget of ostriches, gives some idea of how ostriches feed in a farming situation. Here, the ostriches spent 11.3% of their active time either consuming concentrate feed or foraging on the ground. While the birds spent 24% more time feeding on the concentrate than pecking at the earth in this example the concentrate feed was the only feed source provided, yet the birds continued to graze despite their being no pasture on offer.

1.6.5 Resting

Berendsen (1995) observed ostriches to spend approximately 27% of their time resting. Upon nightfall, 80% of the flock were resting, with birds lying close to each other and only a small number eating or standing watch.

1.6.6 Standing

An ostrich with its head up has excellent powers of observation (Bertram, 1980). The eyesight of ostriches is powerful, as their eyes are proportionately the largest of all terrestrial animals (Jenson *et al.*, 1992). When standing, ostriches are constantly on watch, their eyes positioned so that they have full view of their surroundings. Berendsen (1995), observed birds holding the same body and head position for long periods of time, with only an alarming noise turning their heads. On average, a herd may spend 18% of its time standing each day (Berendsen, 1995).

1.6.7 Unusual Responses

Confusion and fear caused by potential predators or threats easily triggers the members of a social unit of ostriches to disperse in various directions. Sauer (1966) found adult males frequently herd the other members of their social group in their own escape directions by elaborate displays. When the danger and disturbance have passed, members of the group quickly find their way back to unite the social unit. Protection is gained almost entirely by diluting the predators success (Bertram, 1978). If in a group there is one or more ostrich whose head is up, the vulnerability of the group is decreased, because sudden movement by one bird would be rapidly detected by others (Bertram, 1980). This dramatic flight activity particular problems for the ostrich grower with respect to bird containment and safety.

1.7 Conclusion

For the prospective ostrich grower, especially one who may wish to utilise a pasture dominant management system, sound information for nutritional management is often limited. The interaction of behaviour must be considered given that species is still effectively semi-wild.

This project attempts to contribute to understanding in these areas through the evaluation of the growth of juvenile ostrich in a supplemented grazing environment, identifying those factors which are key to effective animal management.

2. OBJECTIVES

The project sought to contribute to the development of grazing management systems for the growth of ostrich slaughter stock from the age of 4 to 12 months. Specifically, the project sought to:

- Evaluate the growth rate of juvenile ostrich in a supplemented grazing environment.
- Develop some understanding of the potential of Australian pastures to support ostrich growth and the way in which changes in pasture quality and quantity impact on growth.
- Evaluate management and other practical issues relating to the growth of juvenile ostrich in a grazing environment.
- Evaluate the efficacy of different commercial rations as supplements for use in a grazing management system.
- Develop an understanding of the behaviour of ostrich in a grazed environment and the implications for this on management.
- Develop some general management guidelines for the extensive production of ostrich.

It must be stressed that the scope of the project allowed only an initial evaluation of these areas, however the results act as useful directives for future research and development and allow a more informed approach to the management of this ‘new’ livestock species.

3. Methodology

3.1. Experimental site

The experiments were conducted on the University of Tasmania Farm, Cambridge, Tasmania. Cambridge is in a region known as the Coal River Valley, approximately 22km north-east of Hobart, a relatively warm and dry area of the state, with a long history of dryland cropping and livestock farming.

Average rainfall of the Coal River Valley varies between 520 mm and 630 mm per annum, and is evenly distributed throughout the year, with slightly higher figures for October, November, and December. January to March is relatively dry (Davey and Maynard, 1992).

January and February are the warmest months with mean maximum daily temperatures of around 22^{0} C, while July has the lowest mean daily temperatures of around 3.9^{0} C. Throughout June, July and August the area is frost prone, with an average of nine frosts recorded annually, and day length is short (as low as nine hours). Day length increases to fifteen and a half hours later in the year (Davey and Maynard, 1992).

Apart from being relatively warm and dry, the area can be very windy. The prevailing wind is north-westerly, funnelled north-south by the valley (Davey and Maynard, 1992).

The soils of the region are diverse, ranging from windblown sands to heavy, cracking clays. Changes in the soil type often occur over short distances, however most of the soils posses high levels of clay in the subsoil (Davey and Maynard, 1992).

The area has a valuable water resource in the form of the south-east Irrigation Scheme which was introduced in 1986. The scheme has increased the opportunity for producers to diversify into cash crops, the sown areas expanding annually since the scheme commenced (Davey and Maynard, 1992). This irrigation facility was used in both the pasture establishment phase of the program and also to provide additional water for the 'irrigated pasture' type, specifically to ensure the maintenance of the white clover pasture component.

3.2. Experimental design

3.2.1. Experiment 1

The experiment had a 3 x 2 factorial design, with main effects of age (3 groups) and pasture type (2 types; 'dryland' and 'irrigated'). All birds were supplemented throughout the experiment. Details of the supplement and supplementation rates are provided later in this section.

The experimental calendar for experiment 1 was as follows:

Date	Task
May 29, 1997	First age group of birds delivered to the University Farm and allocated to treatment groups Supplement fed at 0.5kg/head/day of (Froms Ent Ostrich Grower Pellets).
June 27	Second age group of ostriches delivered to the University Farm and allocated to a treatment site. All birds weighed. Supplement fed at 0.5kg/head/day (Froms Ent Ostrich Grower Pellets).
July 15	Increased supplementation rate to 1kg/head/day for all treatment groups.
July 31	Third age group delivered to the University Farm and allocated to treatment groups.
September 25	Reduced supplement rate of all treatment groups to 0.5kg/head/day.
February 26, 1998	Final weighing of ostriches, experiment completed.

3.2.2. Experiment 2

The experiment had a 3 x 2 factorial design, with main effects of supplement (3 supplements) and pasture type (2 types; 'dryland' and 'irrigated'). It should be noted that treatments for this experiment were altered during the experimental period, with the adjusted design being a 2 x 2 factorial experiment, with the number of supplements evaluated being reduced from three to two.

The experimental calendar for experiment 2 was as follows:

Date	Task
Pre-treatment period (between experiments)	
March 10, 1998	Sheep entered into the experimental site to graze mature pasture.
March 26	Irrigation began on treatment paddocks 4,5 & 1.
April 12	Sheep removed.
Experiment 2	
April 1	First intake of ostriches, delivered to the University Farm. Supplemented at 0.5kg/head/day (Froms Ent Ostrich Grower Pellets).
April 23	Second intake of ostriches. All birds allocated a treatment site, weighed and continued supplementation with Froms Ent Ostrich Grower Pellets at 0.5kg/head/day.
June 23	Treatment allocated new supplements of Lucerne Pellets, Froms Ent Grower Pellets, and Froms Ent Grower Breeder 2, and supplementation rate increased to 1kg/head/day.
June 29	Ostrich deaths at experimental site. Ostriches allowed to graze entire area and grouped together as one mob.
July 30	Ostriches re-allocated into treatments and new supplement of Froms Ent Grower Breeder 2 (2 treatment groups; 1 for each pasture type) and Complete Horse Meal (2 treatment groups; 1 for each pasture type) at 1kg/head/day.
August 4	New birds allocated to treatments where deaths had occurred.
August 24	Supplementation rates reduced to 0.5kg/head/day.
October 22	Experiment terminated, ostriches sold.

3.2.3. Grazing behaviour experiment

Grazing behaviour assessments were undertaken during the period in which experiment 2 was being conducted. Birds were assessed in one of the dryland treatment paddocks making the behaviour assessments functionally part of experiment 2. For the purposes of this report it is discussed separately however. Further details of the experimental methods are provided later in this section.

3.3. Animals

3.3.1. Experiment 1

Ninety birds were loaned to the project by Tasmanian ostrich growers, the majority of these coming from the Coal River Valley region. The birds were randomly selected, with the genotypes included in the trial listed in Table 3.1.

Table 3.1. Ostrich genotypes included in the experimental program.

Ostrich Genotype	% Flock
Grey	70%
Red	4%
Black	2%
African	3%
Australian	3%
Black hybrid	10%
Red hybrid	2%

The age of individual ostrich on entering the trial was between 80 and 105 days. There were three intakes of birds, with each intake being divided into two treatment groups. These intake reflect the spread of hatching dates from late spring, through summer and into autumn. Sex of the birds was not determined for this trial.

3.3.2. Experiment 2

Birds in Experiment 2 were 95% grey genotype and 5% hybrid.

3.3.3. Grazing Behaviour

Fifteen juvenile birds were used in the experiment. Birds were between 9 and 11 months old and predominantly ‘grey’ genotype. The ostriches had been grazing together at this site for approximately 6 months prior to the behaviour experiment.

3.4. Pasture

3.4.1. Pasture Type

Two different pasture types, a dryland and irrigated pasture, were sown prior to the commencement of the experiment. Both types are typical of pastures that can be found in temperate southern Australia. The dryland pasture is typical of that found in drier areas of south-eastern Australia where annual rainfall is less than 600 mm. The irrigated pasture is typical of more intensive higher rainfall grazing areas where annual rainfall exceeds 700 mm. Table 3.3 details the species and pasture plant cultivars included in the experiment and the rate at which each species was sown.

Table 3.3. Species and rates of sowing during pasture establishment

Dryland Pasture Type		Irrigated Pasture Type	
Species	**Sowing Rate (kg/ha)**	**Species**	**Sowing Rate (kg/ha)**
Perennial Ryegrass (*Lolium perenne)* cv. Jackaroo	5	Perennial Ryegrass (*Lolium perenne*) cv. Ellet	10
Cocksfoot *(Dactylis glomerata)* cv. Porto	3	White Clover *(Trifolium repens)* cv. Tahora	4
Subterranean Clover (*Trifolium subterranean*) cv's Denmark and Karridale	4		

The experimental site had previously been used for intensive cropping. Preparation of the site included the application on 200 kg/ha of high grade super phosphate and a pre-emergent herbicide. The pasture was direct-drilled into the residue of the previous years barley crop and irrigated through the pasture establishment phase. Irrigation after this phase was then restricted to the 3 irrigated pasture treatments during summer, receiving a total of 2.07 megalitres.

3.4.2 Pasture measurement and analysis

3.4.2.1. Pasture growth rate

Six pasture exclusion cages were randomly placed around each treatment paddock. Exclusion cages consisted of 'weldmesh' rolled to make a round cage of approximately 0.45 m^2 in area. The top of the cages were covered in chicken mesh so that the ostriches were unable to graze the excluded area. Cages were anchored to the ground using wire hooks.

Plate 3.1. Pasture exclusion cage.

Each cage was defoliated when placed in the paddock, and then at two-monthly intervals. A bimonthly defoliation regime was used as the growth rate was too slow during winter to allow collection of adequate samples. Samples were collected using garden shears, the samples then being placed into paper bags for drying.

3.4.2.2. Pasture sample analysis

Random samples were taken in a diagonal direction across each of the treatment paddocks. Each sample was taken using garden shears within a week of weighing the birds. Samples were weighed wet and then dried at approximately 70^0C for a week. The samples were ground using a hammer mill to a particle size of less than 2 mm.

Following drying, the pasture was weighed again and dry matter levels of the pasture calculated. Organic matter was determined by ashing the samples at 500^oC for three hours. Organic matter is the portion of the sample lost during this process, with the inorganic material remaining.

Nitrogen levels were determined using the Kjeldahl method, the total nitrogen value gained then being multiplied by a factor of 6.25 to determine crude protein.

Acid detergent fibre (ADF) was used as a means of assessing fibre content in the samples. The ADF technique is designed to separate cell contents and other soluble plant material from the insoluble the ligno-cellulose complex (fibre) which constitutes a large portion of cell walls. Triplicate 1 to 1.5 g of air dry feed sample were placed into a flat-bottomed spherical refluxing container. To each container 100 ml of acid detergent solution (20 g cetyl trimethylammonium bromide in 1l 1N H2SO4) and 2ml of Dekalin (decahydronapthalene) were added. The containers were connected to the refluxing apparatus, and the heat was controlled so as to bring the contents to the boil in 5-10 minutes. As boiling began the heat was reduced to prevent foaming. A slow and even rolling boil was then maintained for 60 minutes.

The solution was then filtered through a previously dried and weighed sintered glass crucible using minimum suction. After removing the refluxing solution, the fibre mat was washed with two washes of acetone, and then two washes of hot distilled water, breaking up the dry fibre mat with a glass stirring rod, between each washing. After the four washings, the crucibles were dried at 100oC for three hours or overnight. Crucibles were then placed into a desiccator and allowed to cool before being weighed. Acid detergent percentage was then calculated.

Dry matter digestibility (%) of the feed samples, was estimated using the equation of Oddy et al. (1983), shown below.

$$Dry\ Matter\ Digestibility(\%) = 83.58 - (0.824 \text{ x } ADF\%) + (2.626 \text{ x } CP\%)$$

where ADF% = acid detergent fibre % and CP% = crude protein % (nitrogen % x 6.25).

These values were then used to estimate the metabolisable energy per kg of dry matter (M/D) using the equation shown below (SCA, 1990). It should be noted that both these equations have been derived for use in ruminant species and are therefore not necessarily applicable to this work. However given the absence of improved methods, they provide some useful context and framework for analysis.

$$M / D = (0.156 \text{ x } DMD\%) - 0.535$$

3.4.3. Botanical composition

Botanical composition was measured in each of the treatment paddocks. The rod-point method (Little and Frensham, 1993) was used, where a rod was tossed randomly across each of the individual treatment paddocks each month. The species touching/closest to each end of the rod was recorded. Twenty measurements were taken from each paddock and recorded on a botanical composition sheet.

3.5. Feed supplements

3.5.1. Experiment 1

A supplement known as 'Froms-Ent Ostrich Grower Pellets®' (Pivot Nutrition, Launceston, Tasmania) was used. This is a high protein pellet and the standard choice of supplement for ostrich growers in Tasmania. The supplement was purchased as a 10 mm pellet in 40 kg bags.

Birds were fed the supplement 3 times per week (Monday, Wednesday and Friday) in troughs mounted on the gate and fence, approximately 1.5 m above the ground. Birds were fed 0.5 kg/head/day from the commencement of the experiment until the 15th July 1997. At this stage the supplementation rate was increased to 1.0 kg/head/day until the 25th September 1997, due to slow pasture growth and cool ambient conditions. After this date, the supplementation rate then returned to 0.5 kg/head/day for the remainder of the experiment.

3.5.2. Experiment 2

Three supplements were initially chosen for use in the second experiment. The 'Froms-Ent Ostrich Grower®' pellet was used again, along with 'Froms-Ent Grower-breeder No. 2 Ostrich Pellet®' and lucerne pellets (all Pivot Nutrition, Launceston, Tasmania). Both supplements were presented to the birds as a 10 mm pellet. Following experimental difficulties supplements were changed to 'Froms-Ent Grower-breeder No. 2 Ostrich Pellet®' and 'Complete Horse Meal' with added zinc bacitracin (both Pivot Nutrition, Launceston, Tasmania). The pellet was provided in the usual form while the horse mix came as a loose mixture of chaffs, grains and other ingredients.

Table 3.4. Nutritional composition of supplements (CP = crude protein, CF = crude fibre)

Supplement	ME MJ/kg	Crude Fat %	CP %	CF %
From' s Ent Ostrich Grower Pellets	9.996	4.519	21.99	6.817
From's Ent Grower Breeder No 2	9.906	4.181	12.263	6.428
Complete Horse Meal	11.115	4.854	10.781	13.431

Table 3.5. Macro- and micro-nutrient levels of supplements.

Nutrient	From' s Ent Ostrich Grower Pellets	From's Ent Grower Breeder No 2	Complete Horse Meal
Ca (%)	1.758	3.796	1.021
P (%)	1.076	1.172	0.605
Mg (%)	-	-	0.588
Cu (mg/kg)	72.834	40.942	-
I (mg/kg)	4.429	1.510	-
Fe (mg/kg)	153.742	66.354	-
Mn (mg/kg)	479.408	214.237	-
Se (mg/kg)	0.480	0.335	-
Zn (mg/kg)	277.359	124.055	-
Lysine (%)	1.211	0.618	0.408
Methionine + cystine (%)	0.832	1.468	-

As for the first experiment, the ostriches were fed three times per week, however in experiment 2 the supplement was trailed onto the ground to try and eliminate the problem of dominant birds limiting the access of others to the supplement. The birds were placed on a ration of 0.5kg/head/day on commencement of the experiment until 25th June. Both supplements were then increased to 1.0kg/head/day until 24th August, when the supplement was returned to 0.5kg/head/day.

3.5.3 Grazing Behaviour

As stated previously, the experiment was functionally part of experiment 2, birds being supplemented with Complete Horse Meal®, in the treatment group being studied. The rest of supplementation and means of provision were as for experiment 2.

3.6. Assessment of ostrich growth

On entering the project birds were weighed using Sunbeam™ Ezyweigh® Sheep Scales. At this stage, individual ostriches identified through the attachment of a neck tag and then allocated to a treatment on a stratified liveweight basis. This was used to establish an even grazing pressure (based on live weight) across the treatments.

Plate 3.2. Ostrich weighing

Liveweight was measured at 4 weekly intervals. Each treatment group was herded into a central holding yard where the scales were located at the end of a race. Each bird was individually weighed to an accuracy of 0.1 kg which enabled the determination of current liveweight and also growth rate.

Plate 3.3. Hooding ostrich prior to weighing.

Standard methods for handling ostriches were used with a hood being placed over each individual ostrich head which allowed the bird to be guided quietly onto the scales.

3.7. Facilities

3.7.1. Fences and Yards

The experimental site was fenced into six 2.5 ha treatment paddocks (see Plate 3.2) with an additional area of approximately 230m^2 used for central handling yards which included a race and scales for the monthly weighing. The yards also had sides to approximately 1.8 m with panels of 'Colourbond' sheeting separated by small gaps (see Plate 3.1).

Plate 3.4. Aerial view of the experimental site. Fence lines have been superimposed and handling yards can be seen at the centre of the facility.

Fences were 1.5 meters high and consisted of Waratah® Titegrip® 8/120/30 with treated posts and star pickets. Paddocks were designed to funnel into the central handling yard.

Water was provided in round 200 litre water troughs with automatic refill apparatus attached.

It should be noted that pasture and water were offered to all treatment groups *ad libitum.*

3.8. Assessment of grazing behaviour

Considerable effort was made to ensure that behaviour was not altered due to experimental factors. Several methods were trialed to establish the best means of recording ostrich grazing behaviour by video. A site approximately 100 m from the boundary fence of the paddock in which the birds were grazing was used to film the birds.

A Sony video camera was set on a tripod to record the ostriches grazing on Video 8 tape. The camera had a view of 90% of the paddock. Field staff were used to ensure the camera was in place and filming the birds at all times, with the camera being moved to keep the birds in the field of view at all times. 32 hours of footage were taken over a one week period. Filming began by 8.30am and finished at around 5.00pm on each of 4 days. Tape was unavailable for analysis for the period 8-10am on Day 1. At the end of each day, the Video 8 tapes were copied to standard VHS tapes, ready for viewing.

The videos were viewed using Apple Video Player (Apple Computers) on a Macintosh desktop computer system. At five minute intervals, still images were captured from the video and the activity of every ostrich was categorised and recorded on a spreadsheet. Days were divided into 3 time windows for analysis; 8-10am, 10am-2pm and 2-5pm. This allowed the proportion of time the whole population spent undertaking each activity in each time window to be assessed.

It should be noted that there is a one day gap between the data reported for day 3 and that reported for day 4. This was due to inclement weather preventing filming.

Plate 3.5. Grazing ostrich

4. RESULTS

4.1. Experiment 1

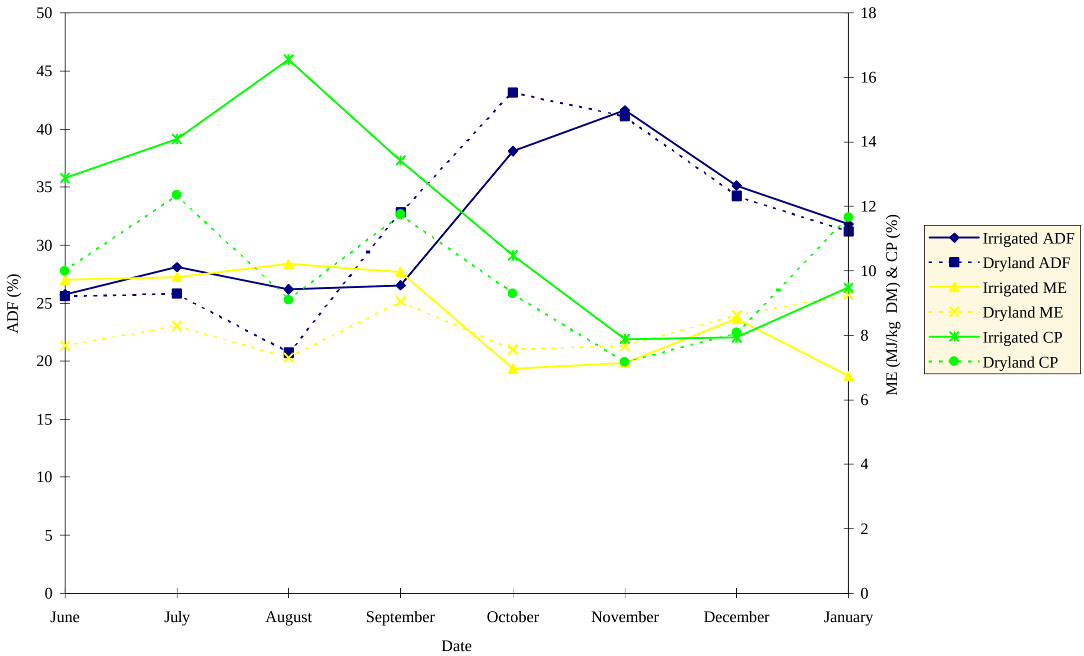
4.1.1. Weather

Rainfall and temperature data can be seen in Figure A1.1 in Appendix 1. The low temperatures from June to August caused pasture growth to slow dramatically. During this time, minimum soil temperatures are often around or below 0°C. The other point to note is the low rainfall in December 1997 and January 1998 which saw the accumulation of considerable levels of standing dry feed in the experimental paddocks.

4.1.2. Pasture Quality

Pasture quality indicators (CP, ADF and estimated ME) for the two pasture types from June 1997 to February 1998 are shown in Figure 4.2. The largest difference between the two pasture types is in the level of CP, especially during August. Generally the dryland pasture type is higher in fibre and lower in crude protein, although the level of ME in the pastures is similar throughout the experimental period. For both characteristics, levels were usually slightly higher in the irrigated pasture than in the dryland pasture. It should be noted however, when considering these values, that means for estimating DMD and ME have been derived for ruminants and are hence not necessarily applicable to this study.

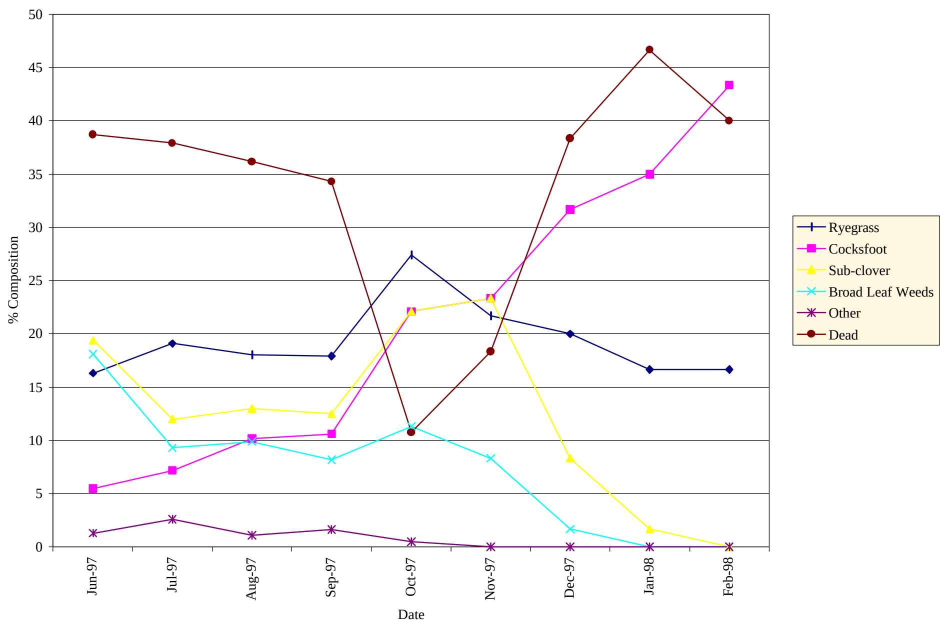
Figure 4.2. Comparison of pasture quality measures for irrigated and dryland pastures.



4.1.3. Pasture composition

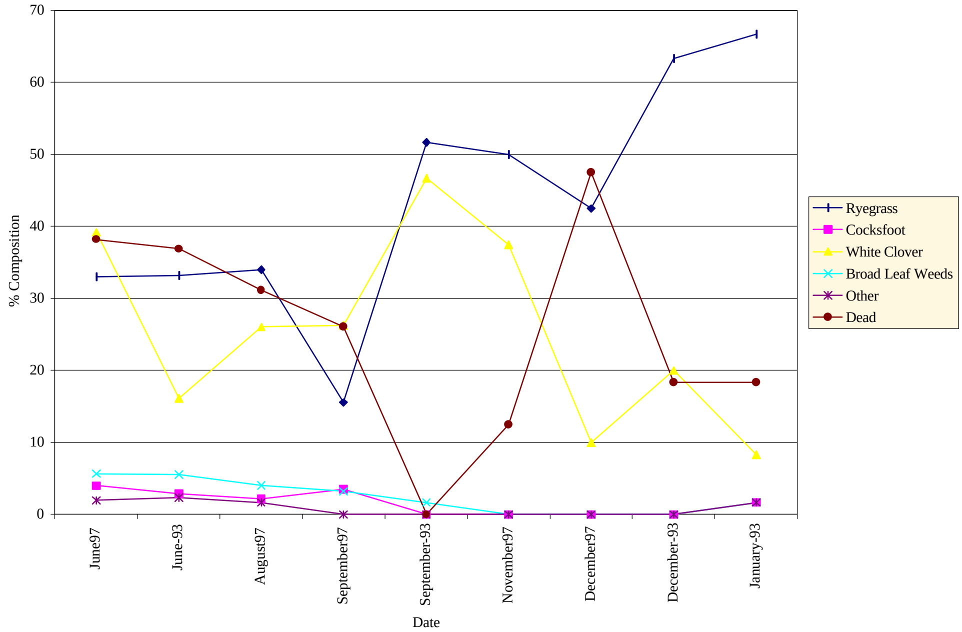
Pasture composition has been divided into grass, clover and other components for the purpose of comparison between the pasture types. Figures 4.3 and 4.4. detail the changes in botanical composition in each of the two pasture types. These figures represent means of three treatment paddocks. Specific comparisons for each type of pasture species are illustrated for further information in Figures A2.1 to A2.3. These are included to help identify the specific factors which may have contributed to the overall changes in pasture quality and quantity.

Figure 4.3. Species composition changes in dryland pasture



The dryland pasture contained a reasonable level of dead material throughout the experiment (Figure 4.3), the lowest level occurring during the spring growth flush in October and November. Through winter levels of sub-clover and ryegrass remained approximately constant and sub-clover content declined considerably after the spring growth peak, reflecting a response to the dry seasonal conditions. It is interesting to note the response in the cocksfoot proportion of the pasture following the spring growth peak and its continued increase during the dry summer.

Figure 4.4. Species composition changes in irrigated pasture



There is a significant contrast between the pasture composition of the dryland and irrigated pastures. The irrigation applied to the irrigated pasture (Figure 4.4) saw higher levels of ryegrass and clover maintained in the pasture and hence lower levels of dead material through the dry summer.

The contrasting effects of the spring flush and the summer dry can be seen in the clover populations in Figures 4.3 and Figure 4.4 and are considerably different to those seen amongst the grass species. While the level of clover in the pasture increases during spring, it then declines significantly when the feed begins to 'dry-off' during summer.

4.1.4. Pasture Growth Rate

The mean pasture growth for each pasture type can be seen in Figure 4.5. The figure displays the classic growth peak during September and October which contributes to the accumulation of dry standing feed through summer. Both pasture types exhibit the growth peak although it is more marked in the irrigated pasture. It is interesting to note the secondary growth peak in January and February following rain, and the marked response in the dryland pasture, probably due to a response in cocksfoot as seen in Figure 4.3.

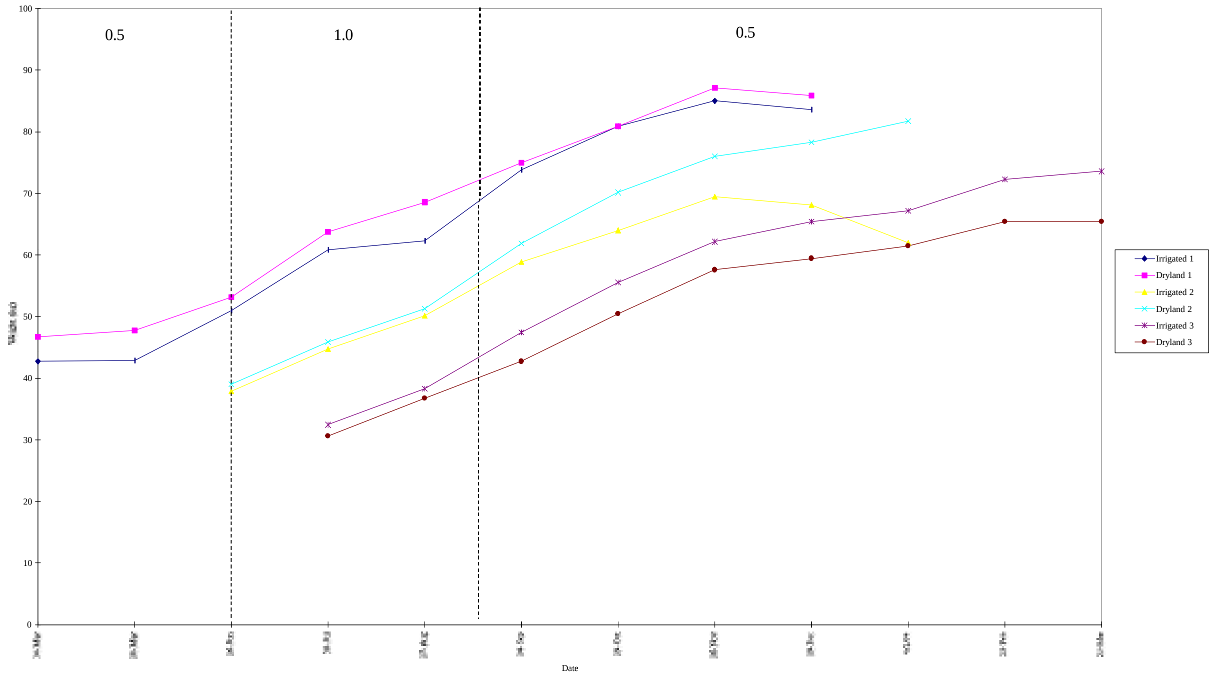
Figure 4.5. Mean pasture growth for each pasture type during experiment 1.

4.1.5. Ostrich Growth

4.1.5.1. Live weight

The staggered entry of the treatment groups into the experiment can be clearly seen in Figure 4.6.

Figure 4.6. Mean liveweight of each treatment group. (Vertical broken lines indicate changes in level of supplementation, rates indicated at the top of the figure.)



It is interesting to note the heavier liveweights at the end of the growth path for the dryland treatment groups in the first two paired treatments, but the heavier irrigated treatment group in the final pair. While this was no doubt due to the slightly heavier weight upon entry of these groups, the difference was sustained and increased in the later two treatment pairs.

A multiple analysis of variance with time as a repeated measure was used to assess whether the main treatments of paddock type and age had an effect on liveweight. Paddock type was not found to effect liveweight however age was significant ($p<0.001$) with older birds being heavier. There were also significant interactions for time and age ($p<0.01$) and for time and pasture type ($p<0.001$) indicating that the effect of age and pasture type on liveweight were not constant throughout the experimental period. This came about as the irrigated birds are lighter first two age groups but heavier in the last.

To further understand the influence of age on liveweight all data points were collated. The scatter plot shown in Figure 4.7. shows the considerable variability within the population for the relationship between age and liveweight. For example bird liveweight ranged from approximately 20 to 65 kg at 200 days, and 30 to almost 100 kg at 400 days. Age explained only 39% of the variation seen in liveweight and hence further analysis is clearly needed to understand the factors influencing liveweight and hence growth. The differences are further highlighted by Plate 4.1. which shows birds in the same treatment group and of approximately the same age, but with significantly different body sizes.

Figure 4.7. Relationship between live weight and age for both pasture treatments throughout the experiment. (Regression equation and r^2 are shown to the right of the plot)

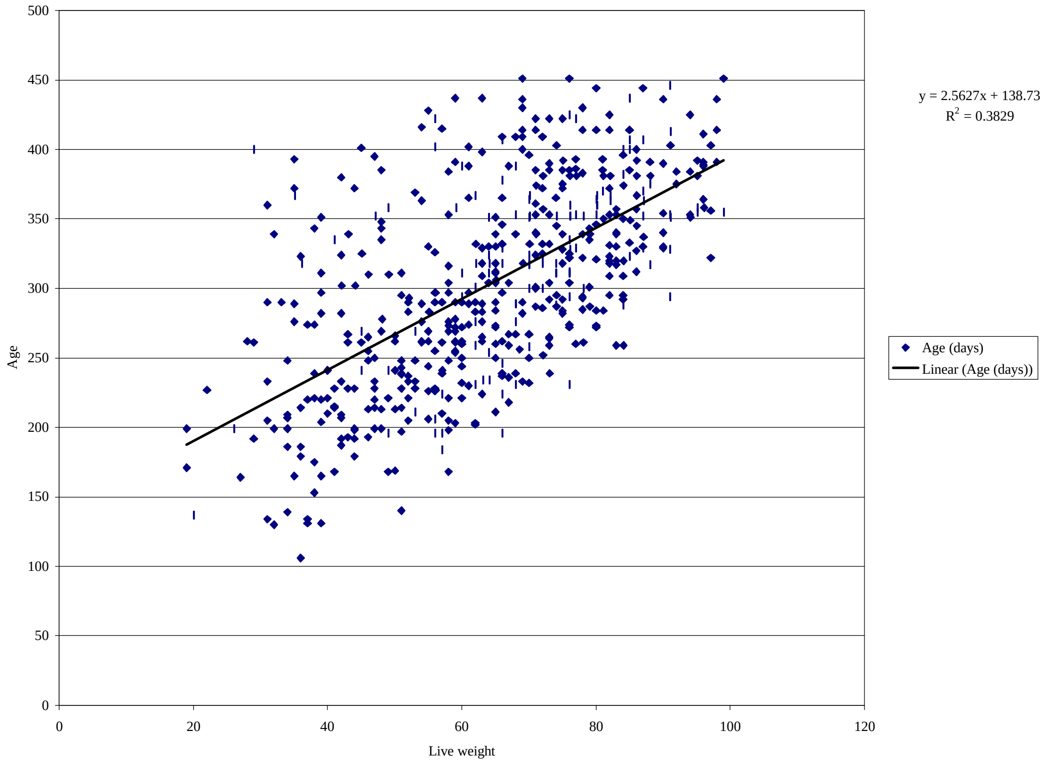
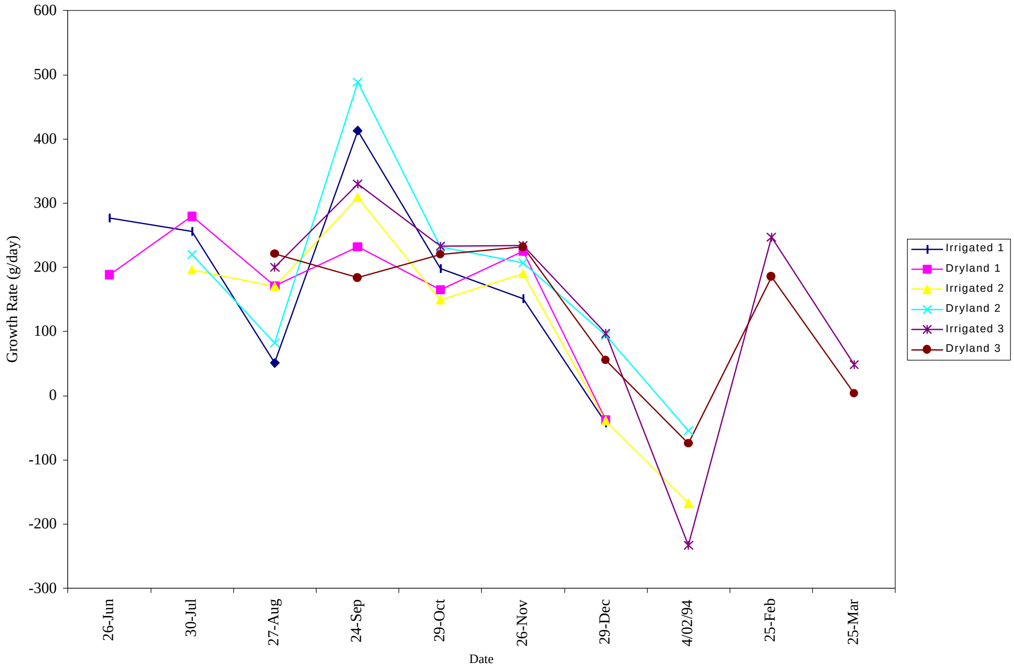


Plate 4.1. Variation in body size amongst birds of approximately the same age.

4.1.5.2. Growth Rate

Growth rate is the most useful measure of performance in this experiment, given that the context is the production of birds for slaughter at 12-14 months of age. The effect of the spring growth flush is evident in the increased growth rates seen in September (Figure 4.8.), however, these were short-lived with the October and November values declining to those seen before the growth increase. The other point to note is the significant decline seen in December and January when the pasture begins to dry off, and increase again in February following another period of increased pasture growth.

Figure 4.8. Mean growth rate (g/head/day) for each treatment group



As for live weight, a multiple analysis of variance with time as a repeated measure was used to examine the effect of pasture type and bird age on growth rate. Again the effect of time was found to be significant ($p<0.001$) with growth rate generally decreasing as the birds get older. There were also significant interactions for pasture type and time ($p<0.001$) and for age and time ($p<0.01$) indicating that the effect of pasture type and age of the bird on its growth rate, varies as the birds age.

A multiple linear regression was performed to examine the effect of nutritive and other factors on bird growth rates. Factors included in the regression were genotype paddock type age, predicted ME, CP and ADF. Genotype and paddock were coded for the analysis while all other factors were numeric. Age ($p<0.01$), genotype ($p<0.05$) and CP ($p<0.01$) were found to significantly effect growth rate. Hybrid birds were found to have a significantly faster growth rate than others. A 1% increase in crude protein increased growth rate by approximately 8.20 g/day while and every day increase in age of the bird decreased the growth rate by approximately 0.01g. There is no clear effect of pasture type as discussed above.

4.2. Experiment 2

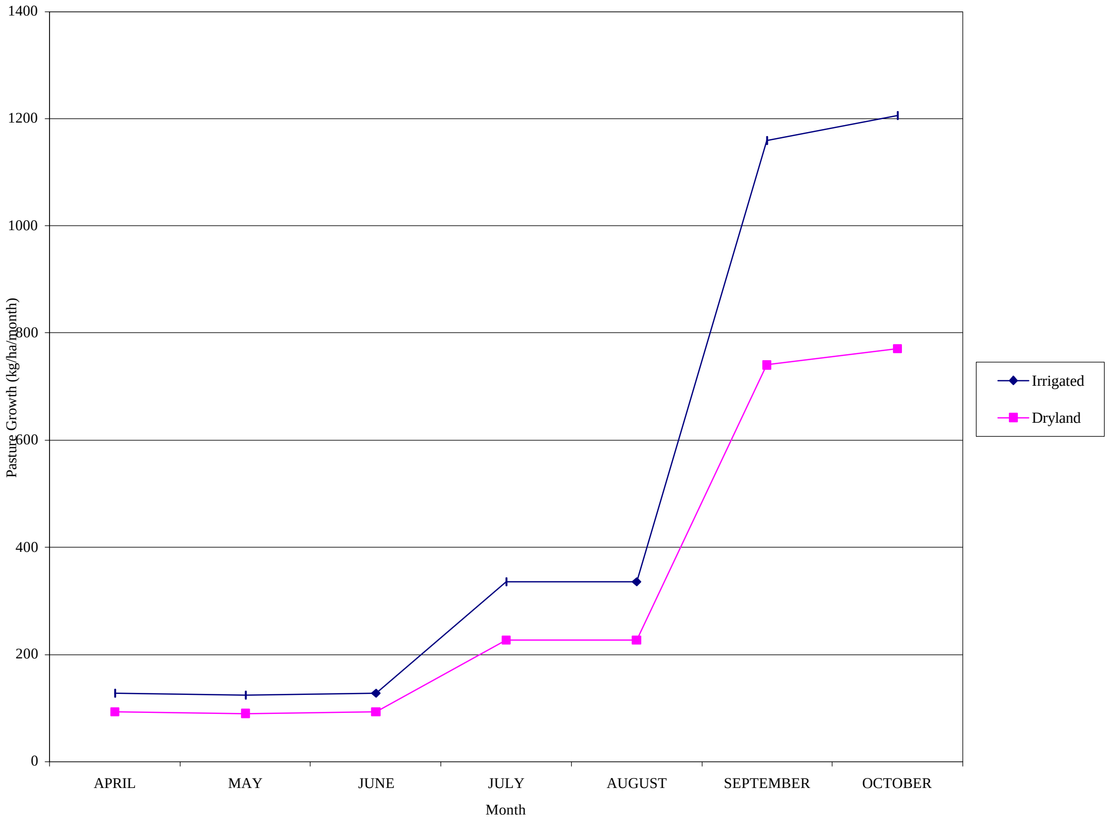
4.2.1. Experimental Problems

Due to a number of experimental problems during experiment 2, the data has not been statistically analysed. Problems centred around the death of a number of birds following the change to 3 three experimental rations. This management change was accompanied by an extended period of poor weather with incessant rain and low temperatures. This combination saw altered grazing patterns, refusal of supplement and the subsequent death of birds. The experiment was then redesigned with 4 treatment groups, however shortly after the re-establishment of the experimental protocol, birds owned by the principal industry partner were withdrawn following an offer being received for their purchase. This saw the cessation of all experimental activity. However, some lessons may be learned from the restricted data set and as a result, data is presented graphically however, in the following session.

4.2.2. Pasture Growth

A similar pattern to that seen in the first experiment is evident in Figure 4.9. Low rates of pasture growth can be seen in winter followed by the increase in pasture growth during spring. Of note, and in contrast to experiment 1, is the difference in productivity between the two pasture types, with the irrigated pasture being superior, this difference increasing as the pastures entered the spring growth phase.

Figure 4.9. Pasture growth during experiment 2



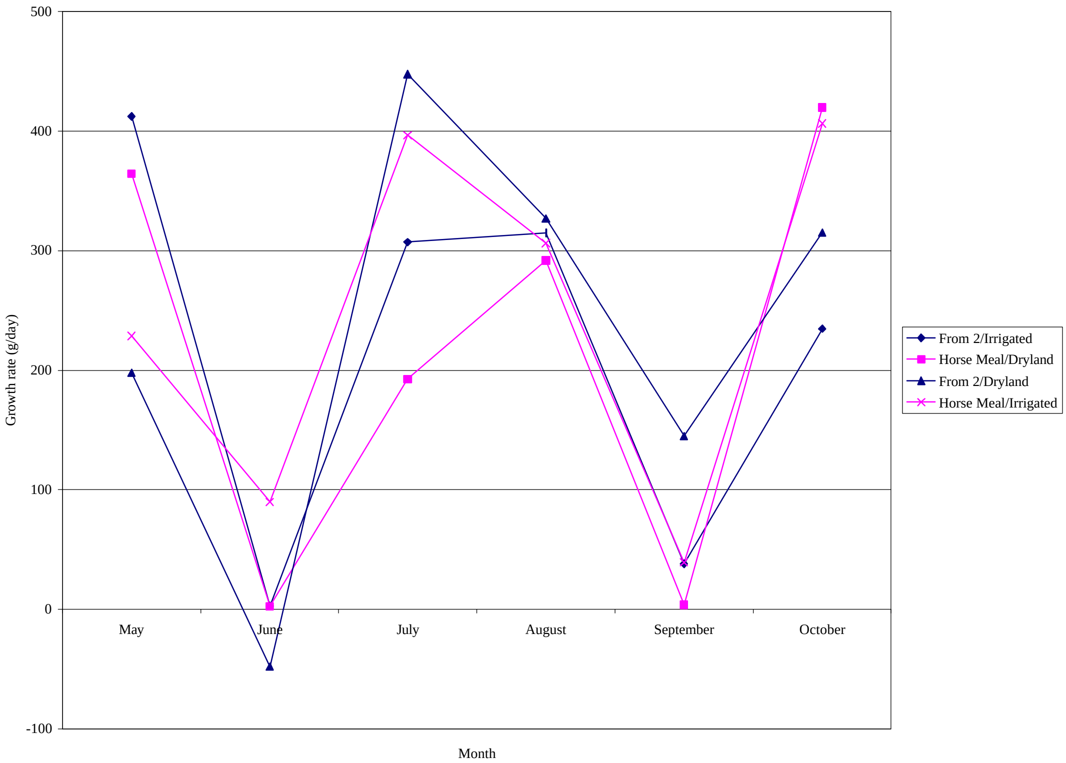
4.2.3. Ostrich growth.

The original purpose of the experiment was to examine the role of different supplements on bird growth in a predominantly grazed environment. While it is difficult to interpret the results due to the experimental problems, the horse mix seemed to be having an effect on both pastures treatment groups from both pasture types (Figure 4.10.). There also appears to be an effect due to the irrigated pasture type as indicated by the heavier ‘Froms Ent’ fed group and the closing of the liveweight difference between the two ‘Horse Meal’ fed groups where the dryland group was approximately 8-9 kg heavier at the start of the experimental period.

Figure 4.10. Ostrich live weight during experiment 2 for different pasture/supplement combinations. (Broken vertical lines indicate differing supplementation periods. Numbers at the top of the figure indicate supplementation rates. Letters indicate different supplements used; A = From's Ent No. 1, B = From's Ent No. 1, No.2 and lucerne pellets, C = From's Ent No. 2 and Horse Mix).

The growth rate date Figure 4.11. is extremely difficult to interpret and reflects the difficulties of the experiment and the changing treatments to which the birds were exposed. Again, there may be increased growth rates amongst those groups fed the horse meal.

Figure 4.11. Ostrich growth rates during Experiment 2 for different pasture/supplement combinations.



4.3. Grazing Behaviour

Grazing behaviour was assessed in terms of the number of birds within the population undertaking various activities throughout the period analysed. Data is presented in Table 4.8 for each of a number of activities. A general linear models procedure was used to assess the significance of the main effects, period and day. The analysis showed there to be significant effects for the proportion of birds grazing for both period and day, and a significant effect of day, but not period, for the proportion of birds eating supplement. This comes about due to the general increase in the proportion of birds grazing over time throughout days 3 and 4, when supplement was provided, although this patten was not seen on day 1, when supplement was also provided. It was also seen on day 2, when supplement was not provided, although the increase was not as marked. A significant effect of day was also found for the proportion of birds pluming. No other effects were significant.

Table 4.8. Mean proportion of birds (%) undertaking various activities on different days at differing times of the day. Analysis is for main effects of day (D) and period (P). (*=p<0.001, **=p<0.01, *=p<0.05).**

Day	Period	Grazing	Supp feeding	Sitting	Walking	Running	Drinking	Pluming	Standing and other
Day 1	8-10	NA							
	10-2	0	41.3	40	4.4	5.5	1.3	0	6.9
	2-5	0	94.7	0	3.9	0	0	0.8	1.0
Day 2	8-10	69.7	0	12.2	13.6	4.2	0	0	0.3
	10-2	76.6	0	11.6	6.0	2.1	0.6	0	2.1
	2-5	91.9	0	0	6.5	0	0	0	1.2
Day 3	8-10	2.5	50.0	41.1	5.8	0	3.6	0	0
	10-2	31.8	11.0	26.2	5.6	0	2.8	0	22.9
	2-5	79.1	0	1.3	1.3	2.8	0.2	0	15.7
Day 4	8-10	17.5	60.6	8.3	8.9	0.3	2.2	1.7	0
	10-2	56.2	27.4	3.5	9.9	2.1	0	1.8	0
	2-5	79.4	13.9	1.2	4.3	0	0	1.2	0
Average		45.9	27.2	13.2	6.4	1.5	1.0	0.5	4.6

	Grazing		Supp feeding		Sitting		Walking		Running		Drinking		Pluming		Standing and other	
Effect	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P
Significance	**	*	*	-	-	-	-	-	-	-	-	-	**	-	-	-

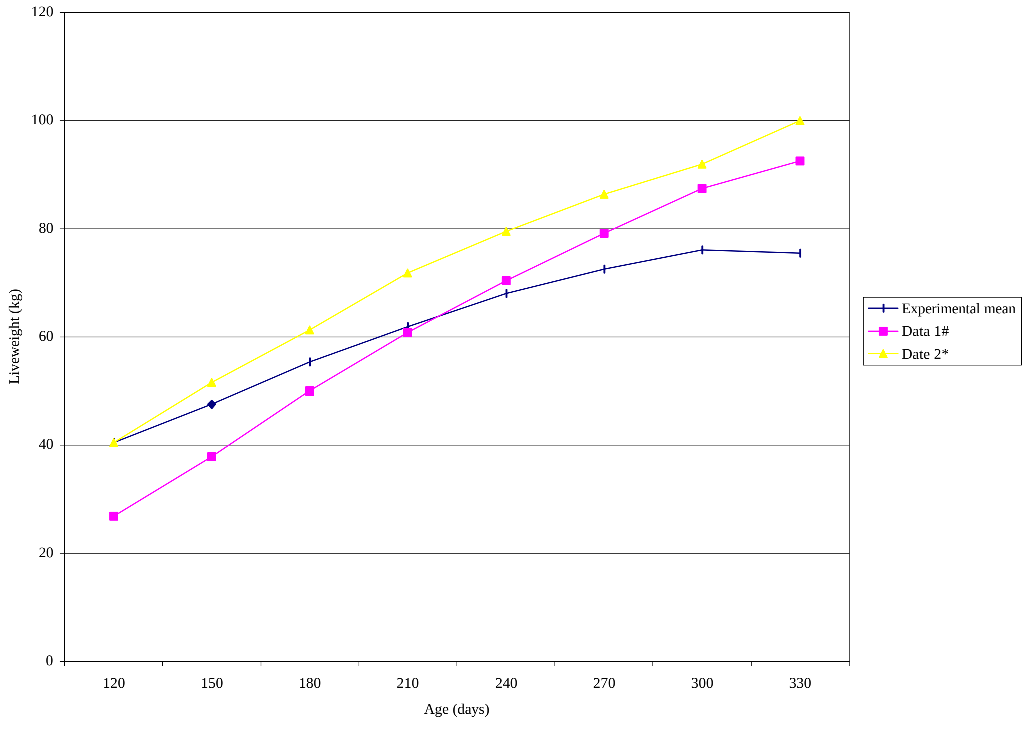
5. DISCUSSION OF RESULTS

5.1. Ostrich liveweight and growth

Useful indicators for ostrich growth in grazing systems can be gained from the results, despite the problems with experiment 2.

It is interesting to consider the results against the limited data available in the literature. The striking difference is the slower growth rates at later ages, leading to lighter liveweights at 12 to 14 months of age, the typical age range for the slaughter of young stock. Figure 4.12. compares literature data with those from the current experiment, however it should be noted that the data from the literature is drawn from experiments in intensive management systems, where birds were fed prepared rations. As a result the inherent variability of the grazing environment, in terms of both nutritional quality and quantity, is removed in these experiments.

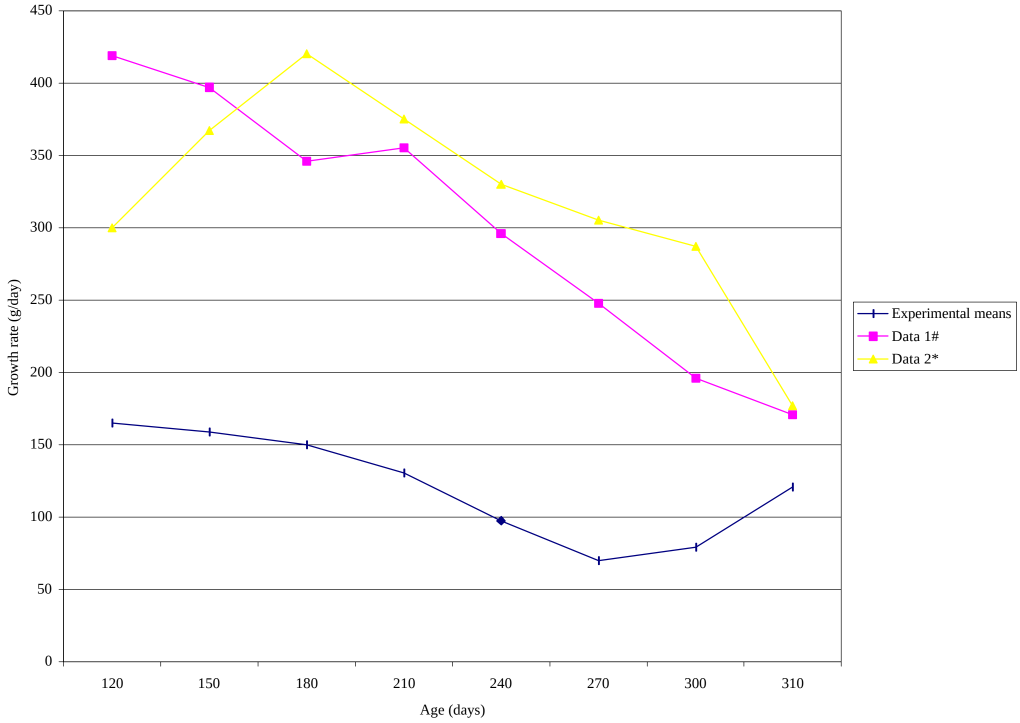
Figure 4.12. Comparison of experimental results (experiment 1) with those from the literature (#mean of Smith et al., (1995) and Cilliers and Hayes (1996), *Degan et al. (1991)). N.B. All data sets from this experiment have been avaraged and standardised based on age, assuming entry into the experiment at 120 days.



Young ostrich (<120 days) in experiment 1 had equal or superior growth to those in the literature. This suggests that the growth potential of the birds was similar, but that the grazing environment did not support growth rates similar to those seen under intensive management systems.

When growth rate is considered (Figure 4.13.) an overall trend of declining growth rate with age is seen in all data sets however the significantly slower growth rate in the pasture fed group is evident at all ages. What is also clear is the influence of pasture conditions on growth, with an increase in growth rate at later ages, which coincided with improvements in both pasture quality and quantity.

Figure 4.13. Comparison of experimental results with those from the literature (*Degan et al. (1991) and #mean of Smith et al., (1995) and Cilliers and Hayes (1996)).



The drivers of production in the grazing system, need to be understood. Regression analysis indicated that the significant factors influencing growth rate were age, genotype and crude protein. The effect of age, as previously discussed, was negative, with growth rate declining as the bird's age (Figure 4.13.). Cross-bred birds had superior growth rates to the pure-bred genotypes suggesting that hybrid vigour may be able to be utilised in ostrich management systems as in other beef and sheep-meat systems to increase growth rate. Further investigation of its potential would appear warranted.

Given the importance of crude protein in determining ostrich growth, it is interesting to note that peak growth rate coincides with the peak in pasture production, even though crude protein level is falling slightly at this point when compared to the green pick that was available during winter. However, at this point, given the increased pasture production, total protein availability would be increased.

There is little information available in the literature as to the role of protein in determining ostrich growth rate. However Gandini (1986) reported that ostrich diets with crude protein levels below 16% would cause decreased growth and feed conversion efficiency. Again, this needs to be considered in light of the intensive conditions under which the experiments were conducted, and translating to a recommendation regarding protein levels in a dynamic pasture system is difficult. However, some comments can be made.

The supplement in experiment 1was provided at either 0.5 or 1.0 kg/head/day. Supplement crude protein level was 21%, which translates to crude protein supply of either 105 or 210 g/kg feed consumed. Pasture protein levels were between 8 and 16% for the irrigated pasture and 8 and 12% for the dryland pasture, when comparing mid-winter with early summer. Given that during winter, birds were supplemented at 1.0 kg/head/day, the protein supplied in the supplement coupled to that available in pasture meets this requirement of 16%. However in summer protein deficiency may be a problem, and is coupled to higher levels of fibre in the diet and hence reduced overall digestibility. As a result careful consideration must be given to grazing management to ensure clover composition in the pasture, and hence protein levels, are maintained. In this experiment, clover composition declined considerably during summer. Possibly, integration with other species such as sheep may be a useful grazing management tool, either in mixed or rotational grazing systems, to help manipulate and manage pasture composition.

Clearly timing of hatching will be important if the birds are to enter a grazing system for finishing. Birds in later hatching groups may see their growth rates decline at an earlier age, than groups hatched earlier, as they are forced to deal with poorer quality summer pastures at a younger age. If they are then to be held until pasture quality improves again, there is the potential for the gain to be lost in terms of the ability of the bird to utilise the feed. For example, in the period from 10 to 12 months of age, Degan et al., (1991) found feed conversion efficiency to drop from 9.62:1 (kg feed/kg liveweight gain) to 17.10:1. Early hatching dates would therefore seem to be the most effective in ensuring young birds can take advantage of the spring pasture flush and of the high protein levels available in the winter pasture.

While it is difficult to interpret the results from experiment 2, they do suggest that the role of protein is not clear. The superior growth rate seen for birds supplemented with horse meal is not a simple protein effect with the protein level of the ration being approximately 10%, lower than the other supplement offered. Observations by the researchers suggest the palatability of the horse meal was perhaps the highest of all the supplements used throughout the program, with birds being extremely aggressive in their efforts to access the supplement. Palatability, or acceptability to the animal may therefore play a role in determining animal performance, and this should be further investigated.

5.2. Comparative feeding costs

If the industry is to develop viably and ostrich meat to gain more widespread acceptance as a mainstream red-meat alternative, wholesale prices must decrease from the levels being suggested in the early life of the industry. To some extent this has already occurred. Given this new reality, production systems for slaughter stock must be cost-effective and utilise low-cost feeding systems. While some of the discussion above has indicated short-comings in the grazing system, there are opportunities for further development in this area, but cost will be the determining factor.

It is useful to consider some indicative feeding costs between intensive and supplemented extensive management systems. Supplements used in this experiment cost $0.60 per kg. In an intensive management system based on the intake values presented by Degan et al. (1991), Smith et al. (1995) and Cilliers and Hayes (1996), ration cost per day ranges between $0.54 and $0.69 at 4 months to $1.44 at 14 months. Pasture compares favourably, with the Tasmanian DPIF (1998a,b), giving pasture establishment and annual maintenance costs as $237.72 and $50.12 per hectare respectively, for low rainfall pastures similar to the dryland pasture in this experiment. For high rainfall pastures, similar to the irrigated pasture reported here, costs are reported as $103.61 and $362.04 per hectare for pasture establishment and annual maintenance respectively. Given the pasture in experiment 2 was more representative of that seen in typical grazing systems as it had been established for a year, its pasture production data provides an interesting comparison.

Total productivity over the 7 month period from April to October was 3414 kg/ha for the irrigated pasture and 2241 kg/ha for the dryland pasture. If it is assumed that birds would graze pasture for 10 months and these values are typical 7 month production figures, then total feed cost for the irrigated pasture is in the order of 2.1 c/kg and 1.6 c/kg for the dryland pasture. Even given the low levels of dry matter which may be present in the pasture during winter, the feed cost is reduced to at least 10% of an intensive system. Where supplement is used, fed at 1 kg/head/day for three months and 0.5 kg/head/day for 7 months each bird will receive in the order of 200 kg of supplement. In an intensive system, again based on the intake figures provided by Smith et al. (1995) and Cilliers and Hayes (1996), each bird receives in the order of 600kg. Even when the cost of pasture is taken into account in the supplemented system, it is clearly far more cost-effective.

5.3. Pasture as a high quality feed resource for ostrich

Macro- and micro-nutrient requirements need to be considered when assessing the suitability of pasture as a feed source for ostrich. As mentioned earlier, there is still little data available although Kreibich and Sommer (1995) and Smith *et al*. (1995) provide some indication. What information is available is often given in terms of what is currently provided in commercially prepared rations, rather than what is required, highlighting that little objective data isavailable. However, if this is used as a guide, requirements for phosphorus would appear to be met in clover dominant pastures although values for grass species are unclear. Calcium may be more difficult, although clover has twice as much calcium as that typically found in grass species. As a result, a mixed sward may meet requirements, but a grass dominant sward, a situation typical of Australian grazing systems, will not. Again, clover content in the pasture appears to be important. Levels of iron, manganese and molybdenum would appear to be sufficient in mixed swards with good clover content, however, levels of copper appear to be marginal and zinc is likely to be insufficient. It should be noted that even at the lowest level of supplementation used in experiment 1 (0.5 kg/head/day) the supplements used would have amply met the birds' requirements, when added to the nutrients provided in the pasture.

For all of these trace elements, the level in grass species is not clear from the literature. Vitamin levels of pasture are also unclear.

5.4. Grazing behaviour

The simple grazing behaviour experiment performed as part of the overall program has provided some useful information with respect to the activity of birds and their interaction with supplement. It is clear that the birds utilise the supplement quickly, with the proportion of birds feeding on supplement declining as the day progressed, while conversely, the proportion grazing increased. For other behaviours, occurrence seems to be at random both within and between days, with no patterns apparent.

Implications in terms of supplement provision will depend on the nature and role of the supplement being provided. If the supplement is to provide a combination of nutrients where a steady ‘trickle’ is required by the animal, the sporadic but typical supplementation practices of grazing systems may not be suitable. If an energy or protein supplement is being provided however, they may be appropriate. Vitamin, macro- and micro-nutrient supplements may be better provided through addition to the water source. Lick blocks do not appear to be useful given the nature of the animal and the authors are unaware of work looking at the use of slow release device in ostrich.

It should be noted that attempts were made to conduct a small pasture selection trial as part of the overall experimental program. Various pasture species were grown to differing levels of maturity to be offered to birds, their selection responses then being recorded and analysed. Unfortunately, the experimental flock was withdrawn before the experiment could be conducted. Later attempts with another small group were unsuccessful, the birds being unfamiliar with both the research staff and the environment.

Given the apparent importance of pasture composition however, an assessment of pasture preference and palatability would appear warranted. An understanding of whether birds actively select for clover or grass and the severity of this preference will be important for the development of effective grazing management systems which ensure both maximum bird growth and the maintenance of pasture composition.

5.5. General Comments

Another useful aspect of the project was the experience gained in the practical management of ostrich in an extensive grazing environment. Some points worthy of note are listed below:

- After becoming acquainted with yards and handling facilities, birds become much more easy to handle. Birds do not move through gates as easily as sheep and cattle and have a tendency to stay ‘where they are’ rather than me through an open gate.
- Birds should not be rushed during handling. They are startled easily and their ability to take flight quickly means the group can become widely dispersed in a short period of time. Slow, gentle handling is far more effective.
- Once in yards, hooding ensures safe handling for both birds and farmer. Large weighing platforms should be used with birds being walked on to the platform by the operator.
- Birds pace fence lines. Fences should be free of protrusions such as strainer posts if possible, to avoid birds becoming entangled if startled.

Plate 5.1. Areas of bare ground either side of the fence line due to pacing of birds. Large areas of pasture can be lost through this behaviour.

- Fencing materials should be chosen carefully to help limit the ability of birds to become entangled. Damage to hides due to wire or posts will see downgrading of skin quality and a significant loss of overall value of the individual bird. Supplements and watering points may be better placed centrally within grazing areas to encourage birds away from fences and gates.

6. IMPLICATIONS

The work presented in this report has a number of significant implications for the ostrich industry and especially individual enterprises which may wish to focus on the cost-effective production of young slaughter stock. These are summarised below against each of the project objectives.

Evaluate the growth rate of juvenile ostrich in a supplemented grazing environment.

Develop some understanding of the potential of Australian pastures to support ostrich growth and the way in which changes in pasture quality and quantity impact on growth.

The growth of ostrich will not be as rapid in a grazing system but will be far more cost-effective. High-quality Australian pastures, where clover content in the sward is managed and maintained, will meet most of the nutrient requirements of young growing ostrich. Supplements should focus on the supply of macro- and micro-nutrients (especially calcium, copper and zinc) rather than acting as either protein and/or energy supplements. As a result they may be better supplied in a form which encourages frequent uptake by the animal eg. in water.

The decline in pasture quality presents problems for the final stages of bird growth through to the desired age of 14 months. The cost of maintaining birds through the summer, when growth rate slows considerably may not be warranted. As a result, early hatching dates are critical to ensure effective and rapid bird growth. Birds hatched late will not reach suitable weights for slaughter prior to the decline in pasture quality in late spring/early summer.

The critical factor influencing growth at this time appears to be protein content of the pasture. Another factor is the variability within the population for growth rate. While part of this will be an environmental effect, there may also be a considerable genetic component. This issue of genetic variability needs to be assessed and clear selection strategies must be put into place to ensure that only high quality stock is used as a breeding resource in the future.

Evaluate management and other practical issues relating to the growth of juvenile ostrich in a grazing environment.

Develop some general management guidelines for the extensive production of ostrich.

It is important to realise that the species is effectively ‘semi-wild’. There are a number of potential problems that those used to dealing with domesticated livestock species may face. Ostrich move through yards and gates differently to sheep and cattle. They must be moved slowly and with care. Birds should be hooded prior to conducting management practices involving bird handling. This is critical for the safety of both the primary producer and the animal.

Ostrich have a sudden and dramatic flight response and hence a slightly slower movement through the paddock and yards may save considerable time compared to the birds splitting up over the paddock area. Once startled they will move over long distances very rapidly, making re-mustering of the group difficult.

Paddocks and yards must be kept clear of sharp corners and protrusions. Hide value can be considerably reduced by birds catching legs or body on pieces of wire, strainer posts etc.

Many factors contributing to bird mortality are not understood and higher death rates than might be expected in other livestock species are considered normal.

Evaluate the efficacy of different commercial rations as supplements for use in a grazing management system.

Develop an understanding of the behaviour of ostrich in a grazed environment and the implications for this on management.

As discussed above, the role of supplements needs to be clearly defined. They are probably not best used as protein or energy sources as careful management of both pasture and husbandry can achieve improved growth rates at little or no cost. However, they do have a role with respect to the supply of macro- and micro-nutrients for which pasture is deficient. This is likely to be especially important in breeding hens, where the requirements for nutrients such as calcium will be considerably higher.

Issues such as palatability need to be further evaluated. Results from experiment 2 suggest there may have been some effect of supplement on bird growth, however in this case, this would not have been due to the ration’s protein level as bird growth was higher on the supplement with a lower protein content.

Ostrich utilise the supplement provided in a grazing environment very quickly, and hence methods of supplementation need to be devised whereby, the supplementary nutrients can be delivered more evenly over time.

7. RECOMMENDATIONS

Future industry development will depend to a considerable degree on the ability of ostrich meat to compete cost-effectively with other, both traditional and non-traditional red-meats. This in-turn will depend upon the ability of the industry to produce the product cost-effectively. As a result, the further development of grazing management knowledge with respect to ostrich production, is critical.

To support this, the following issues deserve further investigation:

- The role of protein and energy in determining ostrich growth
- Macro- and micro-nutrient requirements for ostrich and the way in which they vary with age and physiological state.
- Influence of, and factors determining palatability in young ostrich.
- Within and between pasture species preference in young ostrich.
- Establishment of the most-effective mode for delivery of supplements to young, growing ostrich.
- Genetic variability for growth and effective methods for identifying superior individuals with respect to this characteristic, at an early age.
- The role of grazing with other species in mixed or rotational grazing systems to help manipulate and manage pasture composition and quality.

8. COMMUNICATIONS STRATEGY

Given the currently depressed state of the industry, effective communication strategies are difficult to determine. However, there are signs the state of the industry may be improving with the rural press recently reporting that agreements had been reached in South Australia to supply ostrich meat to supermarkets.

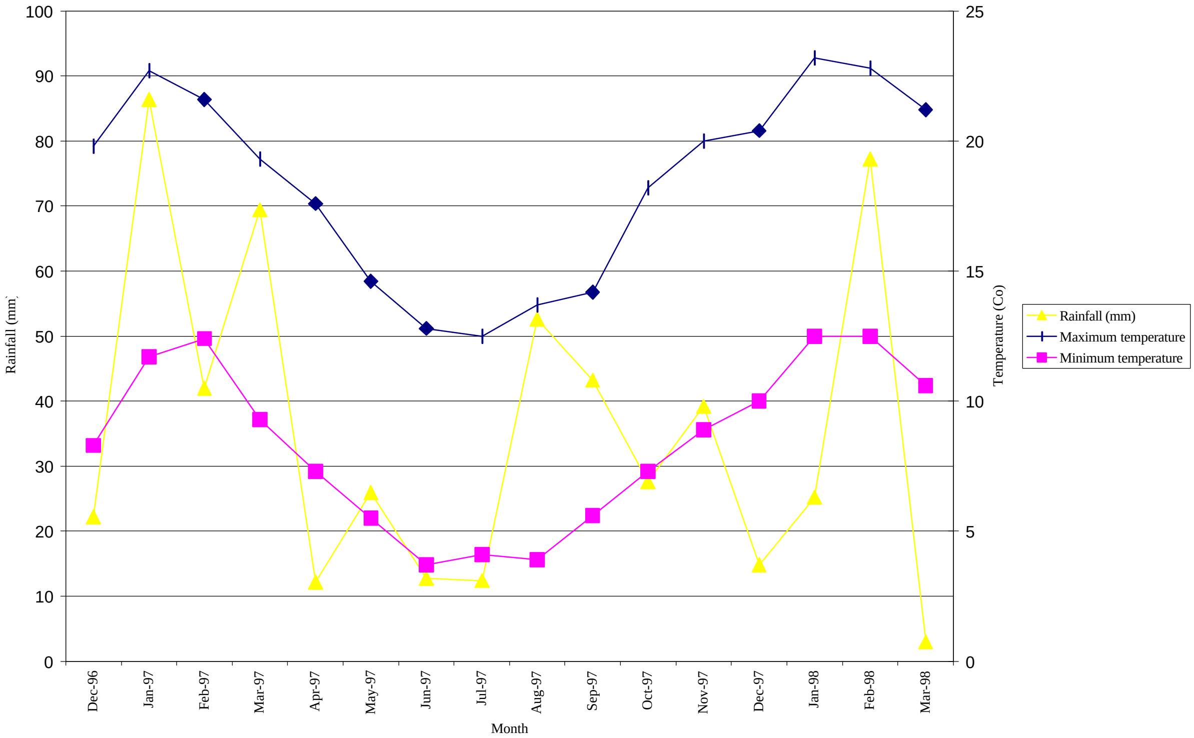
An effective delivery mechanism may be to utilise the ‘Prograze’ grazing education packages currently being conducted in many states both through state Departments of Agriculture and private providers. A module could be developed for ostrich production in a grazing environment.

Attracting new people to the industry will be difficult given the very public demise over the last 12-18 months. However, efforts must be made to ensure future development does not occur along a high-value path, but rather as an alternative extensive industry. This should only follow improvements in the relevant potential markets. Such efforts will ensure future producers bring an existing skill base to the industry, a commitment to primary production and a knowledge of the difficulties and vagaries of livestock markets.

APPENDICES

Appendix 1. Weather Data

Figure A1.1. Temperature and rainfall data for experiment 1.



Appendix 2. Species composition in pastures.

Figure A2.1. Comparison of irrigated and dryland pastures for changes in grass composition.

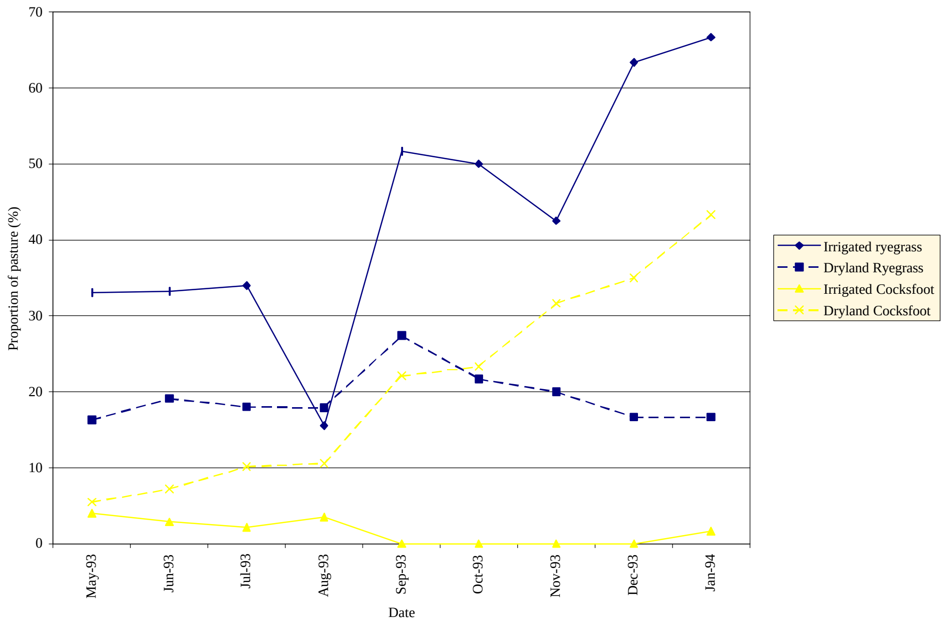


Figure A2.3. Comparison of irrigated and dryland pastures for changes in clover composition. N.B. The irrigated pasture was sown with white clover, while the dryland pasture was sown with sub-clover.

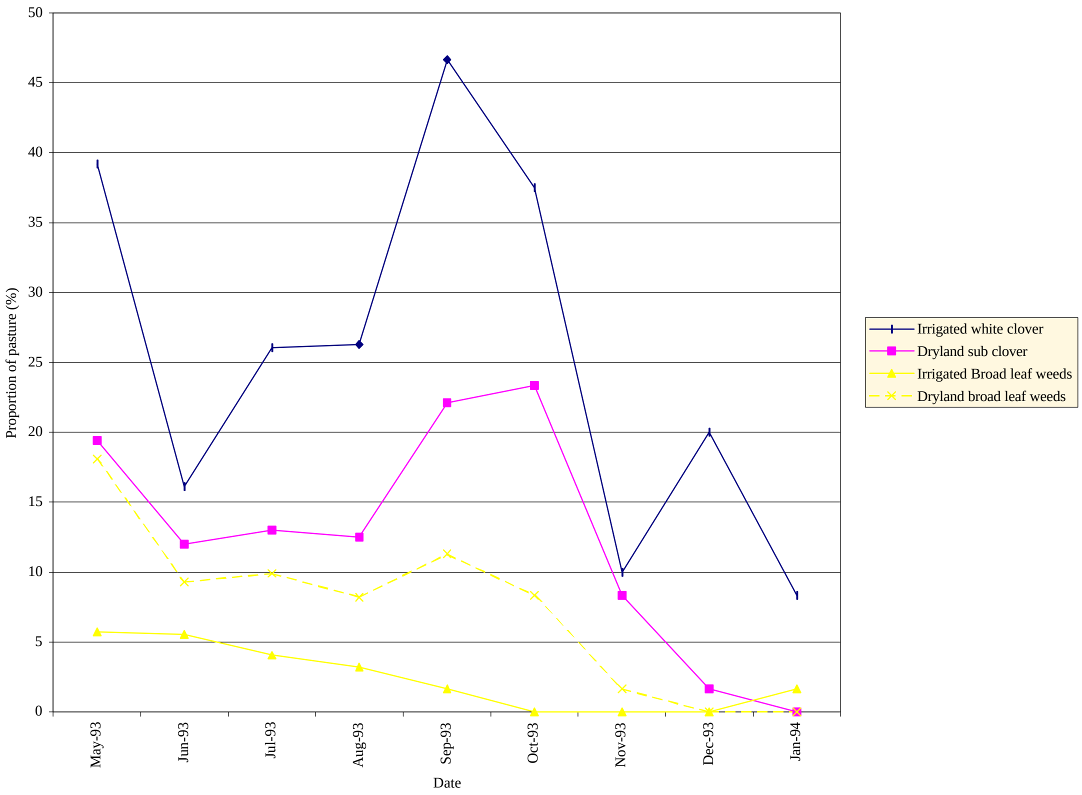
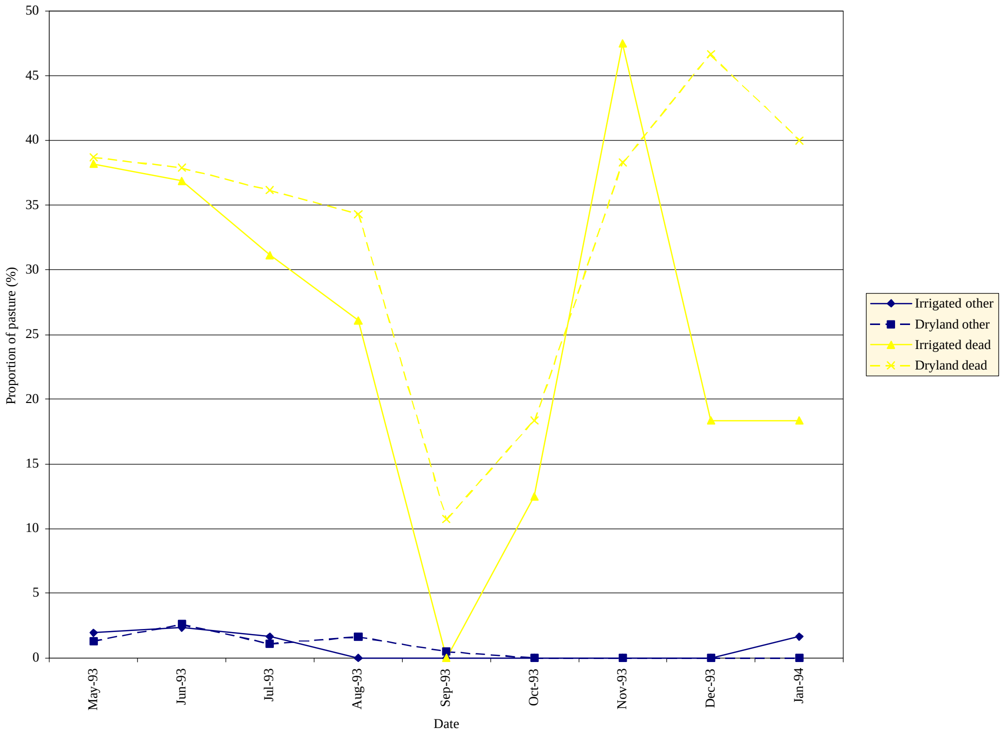


Figure A2.3. Comparison of irrigated and dryland pastures for changes in the composition of other species.



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