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Agriculture

BETTER TOGETHER.

1964-2014 Oudtshoorn Research Farm 50

Scientific Poster Book
Oudtshoorn Research Farm

Scientific Poster Book Oudtshoorn Research Farm

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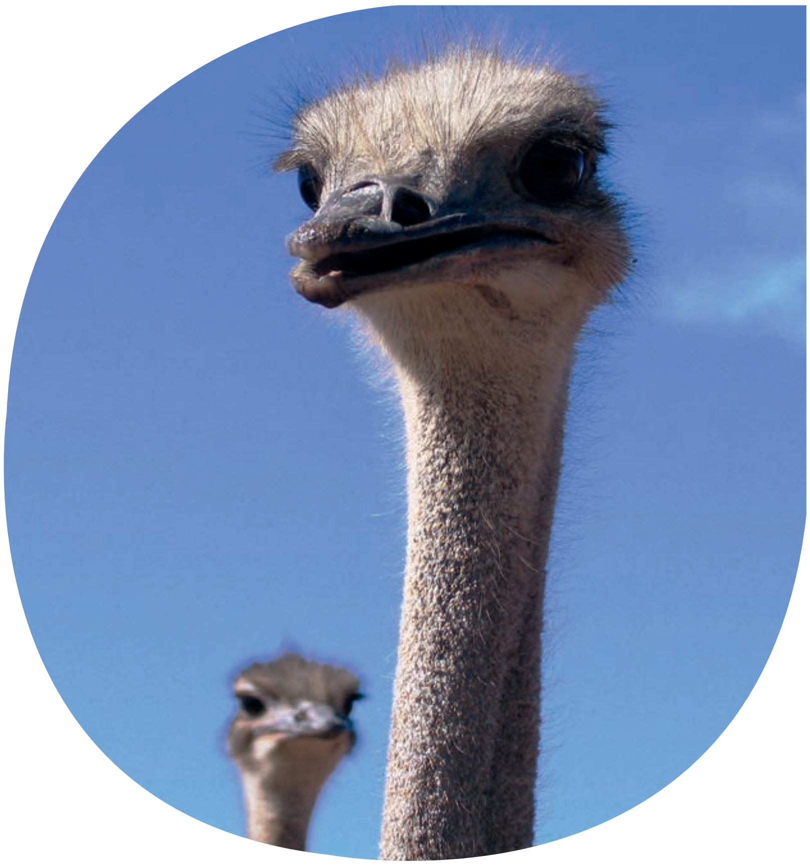

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Foreword

The first and foremost challenge in South Africa is to boost economic growth, increase employment and alleviate poverty – by providing adequate and safe food resources for our people. The sustainability and global competitiveness of our agricultural sector is pivotal in this regard, and is based on the innovative low input and high output farming practices of our commercial and smallholder farmers.

Science and technology are the basis of the knowledge economy and continue to provide the impetus for new production methods and products. This is especially pronounced in the Klein Karoo region, where several challenges – like climate change and avian influenza – are changing the "business as usual" to "business and knowledge un-usual".

In supporting the food needs towards 2030, the smallholder and commercial sector should be supported by innovative and problem-solving research and development initiatives. In order for agricultural producers (commercial and smallholder) to increase their production, two critical factors are to be reckoned with: lower input technology (lower input cost) and higher output (production) technology. The role of research and development is of critical importance in this respect. The world-renowned Oudtshoorn research farm has distinguished itself as the only ostrich research facility of its kind in the world, and has supported farmers in the Klein Karoo for the past 50 years – and will continue to do so in years to come. Our scientific expertise in ostrich feeding, breeding and management has received national and international recognition from peers, and has encouraged us to further excel in these fields.

Comprehensive and problem-focused research programmes and projects by the Oudtshoorn research team will continue to generate cutting-edge solutions. This will ensure that our producers are sustainable and competitive with limited natural resources and the changing environment – and that this will secure the base to increase agricultural production by 10% over the next ten years.

The Department of Agriculture Western Cape is committed to continuing its research support to its farmers and will expand its research farms so that they continue to be the best centres of excellence and on-farm laboratories. We value the role of our partners – especially our farmers – in our determination to increase agricultural production. As our new slogan clearly states, as partners we are "better together" and we thank you for collaborating with and supporting the Oudtshoorn research farm and its team of experts.

Dr. Ilse Trautmann
CHIEF DIRECTOR: RESEARCH AND TECHNOLOGY DEVELOPMENT SERVICES

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1. Genetic parameters for live weight and skin traits in ostriches

A. Meyer[1], S.W.P. Cloete[2], S.J. van Schalkwyk[1] and K.L. Bunter[3]

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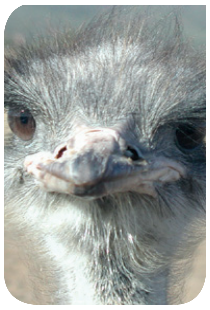
INTRODUCTION

Genetic parameters for leather and production traits in ostriches are virtually non-existent. Leather is an important source of revenue for ostrich farmers and selection strategies should aim to maximize the income from this source by selecting for economically important traits. This study aims to determine genetic parameters and correlations for ostrich leather traits, for use in a future selection strategy.

MATERIALS AND METHODS

Experimental animals: 124 ostriches slaughtered from 1995 to 2000.
Ages: 26 to 553 days of age.
Data recorded: live weight at slaughter, raw skin area and crust skin area.
Complete pedigree records were available. Genetic (co)variances for live weight and various skin traits were estimated. Heritability, as well as genetic and phenotypic correlations, were also computed.



RESULTS

Slaughter age and year significantly (P<0.05) affected all traits recorded, while these were unaffected by gender. Estimates of heritability were 0.32 for slaughter weight, 0.21 for raw skin area and 0.21 for crusted skin area (Table 1). Genetic and phenotypic correlations between slaughter weight and skin area were very high. The genetic correlation between raw and crusted skin area was close to 1, while the phenotypic correlation was correspondingly high.

TRAIT	SLAUGHTER WEIGHT	RAW SKIN AREA	CRUST SKIN AREA
Slaughter weight	0.32±0.08	0.83±0.07	0.88±0.06
Raw skin area	0.77±0.01	0.21±0.06	0.99±0.01
Crust skin area	0.77±0.02	0.92±0.01	0.21±0.08

Table 1. Parameter estimates for live weight and skin traits of slaughter ostriches. Heritability estimates are given on the diagonal, with genetic correlations above, and phenotypic correlations below.

An analysis of skin grading (treated as a binary trait: value 1=first grade; value 0=lower than first grade) was conducted. Estimates of additive variance for grade indicated that there is no genetic variation in skin grading. It was, however, found that slaughter age exerted an important influence on the proportion of first grade skins, which declined as slaughter age increased (P<0.01).

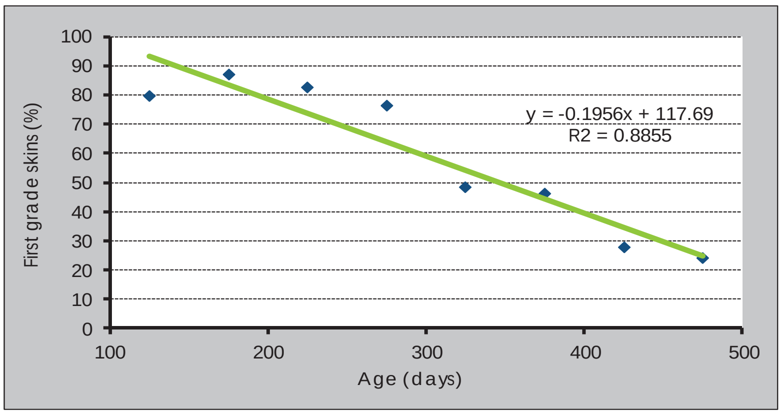


Figure1. The relationship between skin grading and slaughter age.

CONCLUSION

Additive genetic variation exists for live weight, raw and crust skin size. The genetic correlations of skin size with live weight were sufficiently high to allow indirect selection for skin size based on live weight. The genetic improvement of skin area is important, since producers are paid on a per dm² basis. Selection based on live weight will therefore enable producers to obtain the optimal skin size at slaughter. Larger skins would result in greater economic yields, provided that the best grades are attained. No genetic variation was however found for skin grading and can therefore not be improved by genetic selection.

More data and more traits need to be fully investigated to provide guidelines for the formulation of a practical selection strategy that will facilitate genetic progress in the industry.

2. The persistence of ostrich skin lesions to slaughter

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INTRODUCTION

Ostrich leather contributes up to 65% of the total income from slaughter ostriches. Financial gains are directly related to skin grading. Downgrading due to skin damage obtained during normal rearing on ostrich farms results in major financial losses to the ostrich industry.

AIM OF STUDY

To investigate visibility of skin damage at slaughter as affected by lesion size and orientation, type of damage, and age at infliction.

MATERIALS AND METHODS

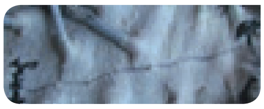
Damage was inflicted to six 1-month-old ostriches by either cutting through the skin with a scalpel blade (n=3), or by superficially scratching with a nail (n=3). Infliction was done in opposite directions on the left and right flank of each animal. The same procedure was repeated at 4, 7, 10 and 13 months of age. Experimental animals were slaughtered at 14 months of age and lesions were assessed on the crust skins. Objective measurements were taken of both the length and surface area of lesions by using a Digimatic Caliper and a Li Cor LI3100 portable area meter, respectively.


Scratch mark on 1-month-old chick


Lesion after slaughter at 14 months


Scratch mark on 10-month-old bird


Lesion after slaughter at 14 months


Scratch mark on 13-month-old bird


Lesion after slaughter at 14 months


Cut wound on 1-month-old chick


Lesion after slaughter at 14 months


Cut wound on 13-month-old bird


Lesion after slaughter at 14 months

RESULTS

Lesion size at time of slaughter was independent of method used to inflict damage at 1 month of age (Figure 1). Lesion size was not influenced by direction of infliction, but decreased with an increase in age at infliction. For scratch marks the response was curvilinear, stabilizing at between 2.04±0.24 and 1.78±0.24 at 7 to 13 months of age, while for cut marks the response was more linear, with means being 4.06±0.23 at 4 months, 3.53±0.24 at 7 months, 2.94±0.23 at 10 months, and 2.70±0.30 at 13 months of age.

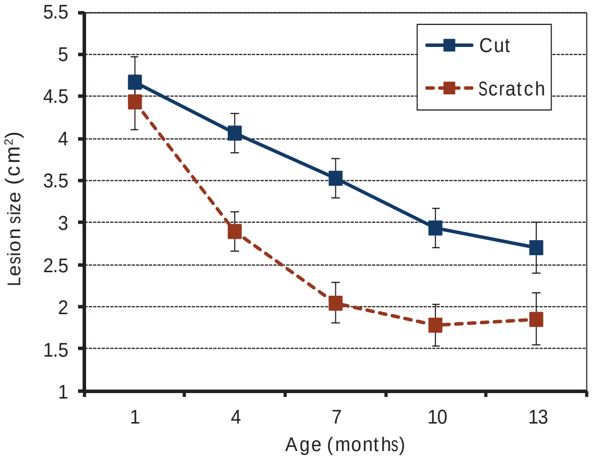


Figure 1. Lesion size on the crust skin according to age at infliction and type of damage.

CONCLUSION

Skin damage at a very young age resulted in larger, more visible lesions than damage inflicted nearer to the time of slaughter. At later ages, cut wounds resulted in larger lesions at slaughter than scratch marks. These results are contrary to the common belief that damage incurred at a young age will disappear by the time of slaughter. Grading of ostrich skins is based on visible skin damage. Both types of damage will result in visible lesions and thus lower skin grading as such. Minimizing ostrich skin damage through preventative farming practices, starting from a young age, is of the utmost importance in order to ensure that the highest skin grades are attained at slaughter.

3. Genetic parameters for ostrich slaughter and skin traits

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INTRODUCTION

The nodulated appearance of ostrich leather is what makes it unique and exotic. The size of the nodulated area of a skin (referred to as the crown area) consequently has important financial implications. Genetic selection for a bigger nodulated area on ostrich skins was thus investigated.

MATERIALS AND METHODS

Pedigree and slaughter data were obtained from the pair-bred South African Black (Struthio camelus domesticus) ostrich breeding flock at the Oudtshoorn Research Farm. Slaughter age, slaughter weight (SW) and raw skin size (RSSZ) were recorded at slaughter. Processed skins were evaluated for the following traits (Figure 1): crown width (CW), crown length (CL), crown shape (CS), neckline length within the crown (NLLC), neckline width at the top of the crown (NLWT), and neckline width in the middle of the crown (NLWM).

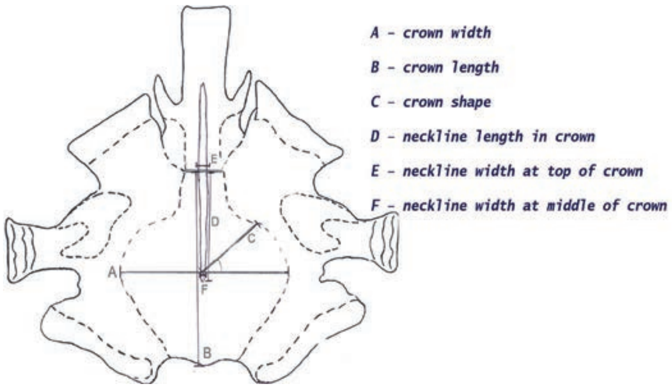

Figure 1. Diagram of an ostrich skin with measurements indicated.

The available skins were progeny of 317 dams mated with 344 sires to form 450 unique combinations. The ASREML programme (Gilmour *et al.* 1999) was used to estimate fixed effects and to derive variance components. Fixed effects were gender and year of hatch, while slaughter age was included as a linear covariate. The random genetic effects of animal and dam were added sequentially to the operational model. Log-Likelihood ratios were used to determine the most suitable random effects model in single-trait analyses. Dam effects failed to improve the log likelihood, and were excluded. The single-trait runs were followed by three multi-trait analyses. The first run was a seven-trait model involving all the traits except SW. The addition of SW led to convergence problems and SW was then analysed with RSSZ, CW, CL and CS, followed by an analysis with RSSZ, NLLC, NLWT and NLWM. SW was then included as a linear covariate in the seven-trait analysis to account for the effect of animal size.

RESULTS

The mean (±s.d.) slaughter age was 322±111 days (range: 119-723 days). Age and date of slaughter were partially confounded in the data, but slaughter age was included in the model to account for such differences. Means (±s.d.) for the traits evaluated were: 80.4±21.7 kg for SW, 119.9±20.7 dm² for RSSZ, 653.3±48.8 mm for CW, 798.4±64.3 mm for CL, 279.0±31.1 mm for CS, 474.8±50.1 mm for NLLC, 35.3 ± 6.7 mm for NLWT and 17.1±4.8 mm for NLWM. Coefficients of variation ranged from 7-30%. Multi-trait estimates of heritability (h^2) corresponded well with single-trait estimates. Multi-trait estimates are reported in Table 1 and genetic and environmental correlations in Table 2.

Most of the traits were affected by slaughter age ($P<0.05$). Regressions amounted to 0.142±0.004 kg/day for SW, 0.178±0.004 dm²/day for RSSZ, 0.272±0.027 mm/day for CW, 0.328±0.036 mm/day for CL, 0.124±0.019 mm/day for CS, 0.147±0.034 mm/day for NLLC, and 0.021±0.005 mm/day for NLWT.

Trait	Multi-trait			Multi-trait with SW as covariate		
	σ^2_a	σ^2_e	h²	σ^2_a	σ^2_e	h²
SW (kg)	47.19	113.71	0.29±0.05	-	-	-
RSSZ (dm²)	31.27	75.72	0.29±0.05	5.95	34.59	0.15±0.04
CW (mm)	475.78	1104.6	0.30±0.06	249.61	685.11	0.27±0.07
CL (mm)	614.22	1911.3	0.24±0.06	156.77	1525.4	0.09±0.04
CS (mm)	112.84	57.6	0.16±0.05	50.84	491.47	0.09±0.04
NLLC (mm)	361.41	1663	0.18±0.05	325.92	1567.11	0.17±0.05
NLWT (mm)	12.18	30.84	0.28±0.06	10.82	29.31	0.27±0.06
NLWM (mm)	2.92	14.54	0.17±0.05	2.91	14.24	0.17±0.05

Table 1. Variance components (σ^2_a – direct additive genetic variance; σ^2_e – environmental variance) and ratios (± s.e.) for ostrich slaughter and skin traits as estimated in multi-trait analysis, with or without slaughter weight (SW) as a linear covariate.

Estimates of h² were low to moderate. When SW was included as a covariate, h² estimates of RSSZ, CL and CS decreased significantly, indicating that the observed genetic variation were partially caused by size differences between ostriches. Crown width, however, remained moderately heritable after SW was considered. Neckline traits were genetically largely independent of the inclusion of SW in the model.

The genetic correlation of SW with RSSZ approached unity (Table 2). Genetic correlations between the slaughter traits (SW and RSSZ) and crown traits were relatively high, but were reduced in magnitude when SW was added as a covariate. The inclusion of SW significantly influenced h² estimates and genetic correlations involving RSSZ and quantitative crown traits, although correlations among neckline traits were not markedly affected. NLLC had a high genetic correlation with NLWM, irrespective of the inclusion of SW as a covariate. Selection for a shorter NLLC would therefore also result in a narrower NLWM, which would both improve the cutting value of an ostrich skin.

Trait	Correlated trait	Multi-trait without SW		Multi-trait with SW	
		r_e	r_g	r_e	r_g
Slaughter weight (SW)	RSSZ	0.75±0.02	0.90±0.03	-	-
	CW	0.59±0.03	0.66±0.10	-	-
	CL	0.42±0.04	0.94±0.05	-	-
	CS	0.36±0.04	0.76±0.12	-	-
	NLLC	0.25±0.04	0.27±0.17	-	-
	NLWT	0.18±0.05	0.44±0.14	-	-
	NLWM	0.12±0.05	0.17±0.18	-	-
Raw skin size (RSSZ)	CW	0.65±0.03	0.65±0.10	0.36±0.04	0.10±0.19
	CL	0.51±0.04	0.90±0.06	0.30±0.04	0.47±0.22
	CS	0.42±0.04	0.68±0.12	0.21±0.04	0.11±0.25
	NLLC	0.30±0.05	0.27±0.17	0.18±0.04	-0.03±0.21
	NLWT	0.22±0.05	0.36±0.15	0.08±0.05	0.11±0.19
	NLWM	0.13±0.05	0.06±0.19	0.03±0.04	-0.09±0.21
Crown width (CW)	CL	0.44±0.04	0.54±0.13	0.22±0.05	-0.21±0.25
	CS	0.38±0.04	0.57±0.15	0.20±0.05	0.10±0.25
	NLLC	0.25±0.05	0.12±0.19	0.13±0.05	-0.14±0.21
	NLWT	0.21±0.06	0.34±0.16	0.10±0.06	0.12±0.19
	NLWM	0.20±0.05	0.09±0.20	0.14±0.05	0.01±0.21
Crown length (CL)	CS	0.07±0.05	0.69±0.15	-0.12±0.04	0.11±0.34
	NLLC	0.41±0.04	0.22±0.19	0.35±0.04	-0.17±0.29
	NLWT	0.10±0.05	0.31±0.17	0.00±0.05	0.04±0.25
	NLWM	0.14±0.05	-0.02±0.21	0.07±0.04	-0.23±0.27
Crown shape (CS)	NLLC	0.03±0.05	0.31±0.21	-0.07±0.04	0.11±0.28
	NLWT	0.30±0.05	0.30±0.19	0.24±0.05	0.07±0.25
	NLWM	0.06±0.05	0.27±0.22	0.00±0.04	0.28±0.27
Neckline length in crown (NLLC)	NLWT	0.07±0.05	0.22±0.19	0.02±0.05	0.10±0.21
	NLWM	0.20±0.04	0.81±0.13	0.17±0.04	0.83±0.13
Neckline width at top (NLWT)	NLWM	0.13±0.05	0.38±0.18	0.10±0.05	0.35±0.19

Table 2. Estimates of environmental (r_e) and genetic (r_g) correlations (± s.e.) among ostrich slaughter and skin traits from multi-trait models excluding or including slaughter weight as covariate.

CONCLUSIONS

Moderate h² estimates for ostrich slaughter and skin traits, combined with moderate to high levels of phenotypic variation, suggest that these traits will respond to selection. Sustained genetic progress in these traits thus seems feasible, without undue concern about unfavourable correlated responses.

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4. Preliminary results on the effect of genotype on embryonic position in dead-in-shell ostrich eggs

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INTRODUCTION

- Shell-deaths contribute approximately 20% to hatching failure.
- Unexpectedly high levels of embryonic deaths in South African Black (SAB) male x Zimbabwean Blue (ZB) female is cause for concern.
- Best hatching results in absolute terms were achieved in the reciprocal cross.
- AIM: To determine the effect of genotype on embryonic position in dead-in-shell (DIS) eggs.

MATERIALS AND METHODS

- Experimental population used for the study (2006): commercial pair-bred flock at Oudtshoorn Research Farm, South Africa.
- The flock consisted of both pure SAB and pure ZB ostriches, as well as different combinations of the pure strains.
- A total of 769 DIS ostrich eggs were opened.
- The position of the embryo was recorded, with the normal position of the embryo before pipping as reference.
- Chi-square procedures were used to assess the effects of genotype.

Genotype	n	Embryos in the normal position (%)	Embryos in the normal position in respect to body part (%)		
			Head	Beak	Foot
Overall	769	41.6	45.3	41.6	39.6
SAB ♂ x SAB ♀	543	41.4	44.2	40.6	38.8
ZB ♂ x ZB ♀	18	33.3	38.9	38.9	33.3
ZB ♂ x SAB ♀	111	36.9	42.7	38.2	36.0
SAB ♂ x ZB ♀	40	55.0	65.0	60.0	52.5
Back crosses	57	45.6	48.2	45.6	47.4
Chi^2		4.84	7.30	6.75	5.26

Critical Chi^2 (P=0.05) for 4 degrees of freedom = 9.488

RESULTS AND DISCUSSION

- No significant differences between genotypes were found for the proportion of correct embryonic positions in near-term DIS eggs.
- It is impossible to relate higher embryonic losses in the SAB x ZB cross to embryo position in near-term DIS eggs.
- Further research is indicated.

5. Estimating heritability of subjectively assessed ostrich leather quality traits using threshold models

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INTRODUCTION

Several ostrich leather quality traits cannot be assessed objectively. A subjective scoring system was therefore devised to facilitate the assessment of such traits. Genetic parameters for the possibility of genetic improvement of these traits could be estimated. Linear-threshold models were used to properly account for the distribution and categorical nature of the data.

MATERIALS AND METHODS

Data:

•Processed crust skins from birds slaughtered between 1997 and 2007, aged 240 to 480 days (mean ± s.d. = 367±55 days) scored for nodule traits (nodule size and shape), and for the prevalence of hair follicles and pitting damage.

•Live weight at slaughter, slaughter age and crust skin size were available for most birds included.

Well-rounded and prominent nodules

Hair follicles

Pitting damage

Statistical analyses:

•Linear-threshold animal model - THRGIBBS1F90 software

•Fixed effects:

  o Contemporary group (n=21)

  o Gender (male and female)

•Slaughter age (240 to 480 days) - linear covariate

•Random effects:

  o Animal: single random effect

•Traits:

  o Slaughter weight and skin size: normally distributed

  o Subjectively assessed traits: threshold.

RESULTS

	Live weight (LW)	Skin size (SSZ)	Nodule size score (NSZ)	Nodule shape score (NS)	Hair follicle score (HF)	Pitting score (PIT)
σ^2 (a)	75.92	42.29	0.56	0.53	0.48	0.20
σ^2 (e)	97.86	87.02	0.66	1.06	0.50	1.15
Heritability estimates (diagonal, bold), residual (above diagonal) and genetic (below diagonal) correlations						
LW	0.44 ± 0.09	0.64 ± 0.08	0.40 ± 0.10	0.32 ± 0.19	0.12 ± 0.10	-0.22 ± 0.08
SSZ	0.98 ± 0.19	0.32 ± 0.07	0.51 ± 0.10	0.49 ± 0.21	0.16 ± 0.08	-0.19 ± 0.07
NSZ	0.42 ± 0.16	0.49 ± 0.18	0.46 ± 0.12	0.38 ± 0.12	0.26 ± 0.11	-0.26 ± 0.10
NS	0.32 ± 0.19	0.49 ± 0.21	0.78 ± 0.27	0.33 ± 0.12	-0.07 ± 0.16	-0.12 ± 0.07
HF	-0.15 ± 0.16	-0.16 ± 0.08	0.04 ± 0.18	0.23 ± 0.20	0.49 ± 0.13	0.03 ± 0.08
PIT	0.24 ± 0.21	0.25 ± 0.21	0.55 ± 0.32	0.32 ± 0.27	-0.24 ± 0.25	0.15 ± 0.06

CONCLUSIONS

- Sufficient genetic variation exists for nodule traits and hair follicle prevalence to allow for sustained genetic progress.
- In practice, selection decisions will depend on progeny test results, as nodule traits cannot be scored on live birds at present.
- Alternatively, progress in traits like nodule shape and size could be achieved through favourable genetic correlations with live weight and/or skin size, evaluated on an age constant basis.

6. Genetic parameters for feather weights of breeding ostriches

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INTRODUCTION

- Ostrich farming has been a commercial enterprise since 1857 and an important contributor to the agriculture economy in South Africa.
- Ostrich feathers were the main commercial product before World War 1.
- Ostrich feathers are highly prized by the fashion industry.
- The feather industry collapsed during World War 1.
- The industry recovered with meat and skins becoming the main sources of income.
- Research on improving feather quality and quantity was discontinued and no scientific selection was implemented.
- AIM: To estimate environmental and genetic parameters for quantitative ostrich feather traits.

MATERIALS AND METHODS

- Experimental population: commercial pair-bred flock at Oudtshoorn Research Farm, South Africa (2001 - 2006).
- The flock consists of 188 breeding pairs and includes both pure SAB and pure ZB ostriches
- Feathers are harvested, sorted, categorized and weighed every year after an 8-month breeding season.
- Separate categories were combined to obtain the total feather weight for each bird.
- Feather weights are extremely variable.
- Data were transformed to square roots to stabilize variance.
- A six-trait model was fitted, involving all feather categories, using ASREML.

RESULTS

Heritability of total feather weight = 0.30 ± 0.06

Six-trait h^2 (bold), r_G (above diagonal) and r_P (below diagonal) estimates

Traits (g)	Short hard body	Long hard body	White plumes	Floss	Short body floss	Tail
SHB	**0.16 ± 0.04**	0.73 ± 0.12	0.73 ± 0.12	0.73 ± 0.14	0.87 ± 0.10	0.74 ± 0.13
LHB	0.74 ± 0.50	**0.21 ± 0.05**	0.66 ± 0.12	0.54 ± 0.16	0.81 ± 0.11	0.82 ± 0.10
WP	0.11 ± 0.37	0.99 ± 0.62	**0.22 ± 0.05**	0.74 ± 0.14	0.65 ± 0.14	0.90 ± 0.10
Floss	0.19 ± 0.26	-0.04 ± 0.54	-0.15 ± 0.40	**0.16 ± 0.05**	0.54 ± 0.18	0.73 ± 0.14
SBF	0.67 ± 0.18	0.23 ± 0.43	0.35 ± 0.29	0.40 ± 0.23	**0.18 ± 0.05**	0.74 ± 0.14
Tail	0.12 ± 0.25	0.08 ± 0.46	-0.30 ± 0.41	0.03 ± 0.25	0.27 ± 0.21	**0.20 ± 0.05**

FEATHER CATEGORIES

- Short hard body (SHB)
- Long hard body (LHB)
- White plumes (WP)
- Floss
- Short body floss (SBF)
- Tail

DISCUSSION

- Feather quantity is heritable and will respond to direct selection.
- Selection for specific categories of feathers is likely to result in correlated responses in other categories.
- Below-unity genetic correlations suggest that feather weights on different body parts may not always be the same genetic trait.
- Further research is needed to assess the genetics of qualitative ostrich feather traits.

7. Effect of temperature and pH on the motility and viability of ostrich spermatozoa

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INTRODUCTION

Artificial insemination in ostriches has reached the stage of the development of protocols for semen holding and preservation. However, the optimal chemical environment, storage temperature, storage time, and semen dilution rate are species specific and the ostrich may require a specific semen-storage protocol.

OBJECTIVE

To examine the effect of temperature and pH on the velocity and viability of ostrich spermatozoa.

METHODS

- Semen was collected from 4 ostrich males using the dummy female method.
- Each male was replicated 3 times.
- Ejaculates were diluted and incubated for 10 min at 20°C and 40°C, in 4 different buffers which were temperature adjusted at pH values of 6, 7, 8 and 9.
- Average path velocity was recorded using computer-assisted sperm analysis (CASA).
- Sperm viability was assessed using nigrosin-eosin staining, and the proportion of live normal, live abnormal, and dead spermatozoa were determined.

RESULTS

- All pH treatments incubated at 40°C had higher sperm velocity ($p<0.05$) than those at 20°C.
- At 40°C, sperm velocity was higher at pH 8 (mean ±SE = 32.67 ±1.43) compared to pH 6 (26.83 ±1.36).
- Sperm velocity was independent of pH at 20°C ($p>0.05$).
- Viability of spermatozoa did not differ between the two incubation temperatures ($p>0.05$).
- Higher pH values negatively affected the proportion of live normal spermatozoa for both incubation temperatures ($p<0.05$).

Figure 1. Temperature affects sperm velocity.

Figure 2. Temperature and pH do not affect the proportion of abnormal spermatozoa.

Figures 3 and 4. Sperm viability decreases with higher pH values and is not affected by temperature.

Figure 1

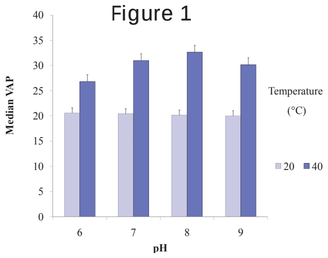


Figure 2

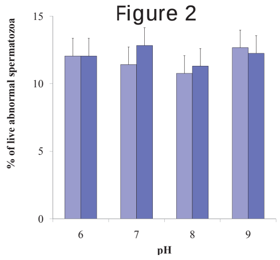


Figure 3

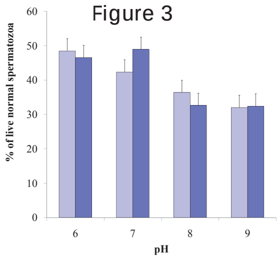
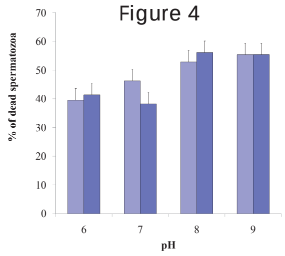


Figure 4



CONCLUSION

A combination of a higher temperature (40°C) and a mid-range pH (~ 8) appear to maximise the velocity of spermatozoa. Temperature does not affect the viability of spermatozoa, but neutral to basic pH values seems to be favoured by ostrich spermatozoa.

The authors acknowledge the Western Cape Animal Production Trust, the Oudtshoorn Research Farm – and especially, Z. Brand, A. Engelbrecht, S. Engelbrecht and C. Mutlow at the Klein Karoo Laboratory.

8. Seasonal variation in semen characteristics and male libido in the ostrich

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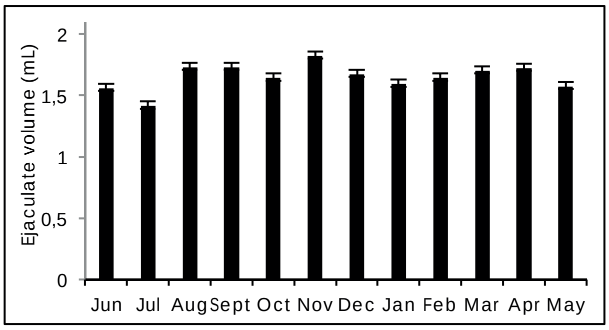
INTRODUCTION

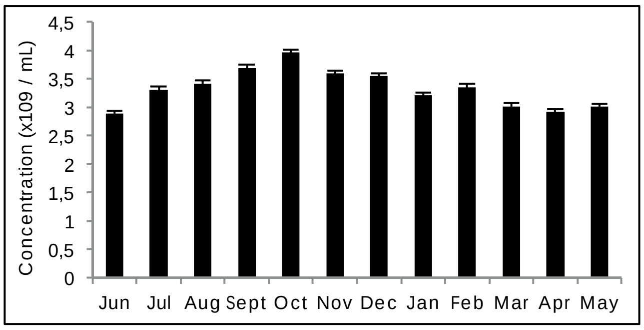
- Reproductive performance of male ostriches is essential to the success of breeding programmes.
- Semen quality and quantity are influenced by seasons in various livestock species.
- Aim: to investigate potential seasonal variation in semen output and libido in **the ostrich.**

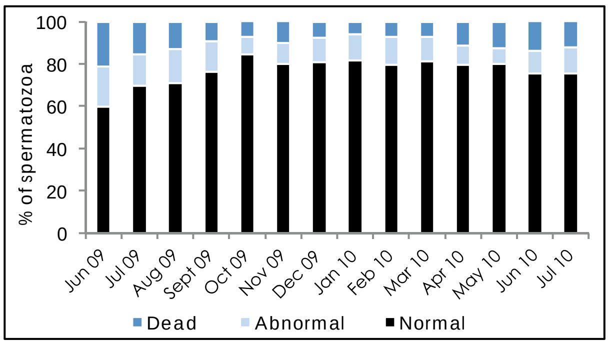
METHODS

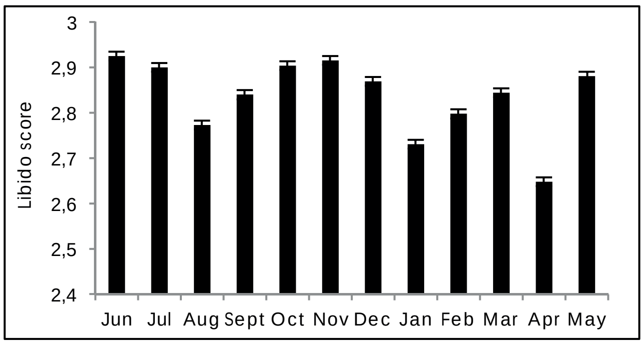
- 7 male ostriches (2-4 years old).
- 1006 ejaculates collected using the dummy female method from June 2009 to June 2011.
- Ejaculate volume, concentration, number of spermatozoa, viability of sperm and male libido were recorded.

RESULTS









CONCLUSIONS

- It is possible to collect semen from ostriches all year round.
- Spring (October to November): higher numbers and better quality spermatozoa were collected with maximum male libido.
- Cognisance of seasonality may help maximize the number of females inseminated successfully.

The authors acknowledge the National Research Foundation of South Africa, the Western Cape Agricultural Research Trust, and workers and technicians at the Oudtshoorn Research Farm.

9. Genetic parameters for slaughter and meat traits in ostriches

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BACKGROUND AND STUDY OBJECTIVE

Knowledge of genetic parameters essential for establishing a breeding programme for improvement of ostrich carcass composition and yield. Objective: Estimate genetic parameters for ostrich carcass and meat traits.

MATERIALS AND METHODS

Data:

- Slaughter and meat data from birds slaughtered between 1997 and 2011, aged 210 - 540 days (mean ± s.d. = 373 ± 76 days).
- Only data from South African Black ostriches (*Struthio camelus domesticus*) used for analyses.
- Right pelvic limbs removed and dissected, 10 major muscles weighed.

Statistical analyses:

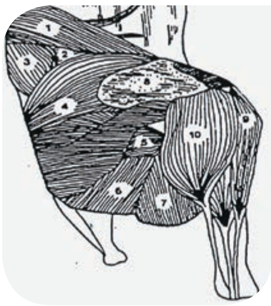
- Animal model - ASREML software
- Fixed effects
  - Contemporary group for live weight
  - Slaughter group for slaughter traits
  - Gender
- Age fitted as linear covariate for all traits
- Random effects
  - Animal: direct genetic effects
  - Maternal permanent environmental effects
- Traits
  - Live weight analysed with carcass traits and groups of muscle weight traits in multi-trait analyses.

RESULTS

- Abdominal and subcutaneous fat weights highly variable, CV % > 50%.
- Most traits dependent on age: yield increases with age.
- Gender influenced fat weights: males have less fat.

(Co)variance components, ratios and correlations:

- Maternal permanent environmental variance insignificant in multi-trait analysis.
- Moderate to high heritability estimates for muscle traits, ranging from 0.14 to 0.43.
- Positive genetic correlations between live weight and muscle weights, ranging from 0.59 to 0.82.



(Co)variance components and ratios for genetic parameters for and among ostrich slaughter traits

Trait	Live weight	Carcass weight	Pelvic limb weight	Abdominal fat weight	Subcutaneous fat weight
Additive genetic correlations (h^2 in bold)					
Live weight	0.34 ± 0.06	0.94 ± 0.03	0.90 ± 0.04	0.56 ± 0.16	0.92 ± 0.07
Carcass weight		0.27 ± 0.06	0.99 ± 0.01	0.47 ± 0.18	0.73 ± 0.12
Pelvic limb weight			0.32 ± 0.06	0.41 ± 0.19	0.67 ± 0.13
Abdominal fat weight				0.22 ± 0.08	0.63 ± 0.18
Subcutaneous fat weight					0.21 ± 0.06
Residual correlations (σ^2_e in bold)					
Live weight	81	0.71 ± 0.02	0.75 ± 0.02	0.62 ± 0.05	0.52 ± 0.04
Carcass weight		21.6	0.93 ± 0.01	0.62 ± 0.05	0.38 ± 0.05
Pelvic limb weight			2.68	0.54 ± 0.06	0.34 ± 0.05
Abdominal fat weight				1.5	0.48 ± 0.05
Subcutaneous fat weight					1.3
Phenotypic correlations (σ^2_p in bold)					
Live weight	123	0.78 ± 0.01	0.80 ± 0.01	0.60 ± 0.03	0.62 ± 0.02
Carcass weight		29.7	0.94 ± 0.00	0.58 ± 0.03	0.46 ± 0.03
Pelvic limb weight			3.9	0.50 ± 0.03	0.42 ± 0.03
Abdominal fat weight				1.9	0.63 ± 0.03
Subcutaneous fat weight					1.7

CONCLUSION

- Derived heritability estimates indicate that genetic improvement in ostrich carcass and meat traits is achievable.
- Estimated genetic relationships mostly favourable, barring those involving fat depots because fat is considered a waste product. Exploiting fat as valuable oil needs consideration (as for the emu).

10. Improving farmed ostrich welfare through developing good human-bird interactions

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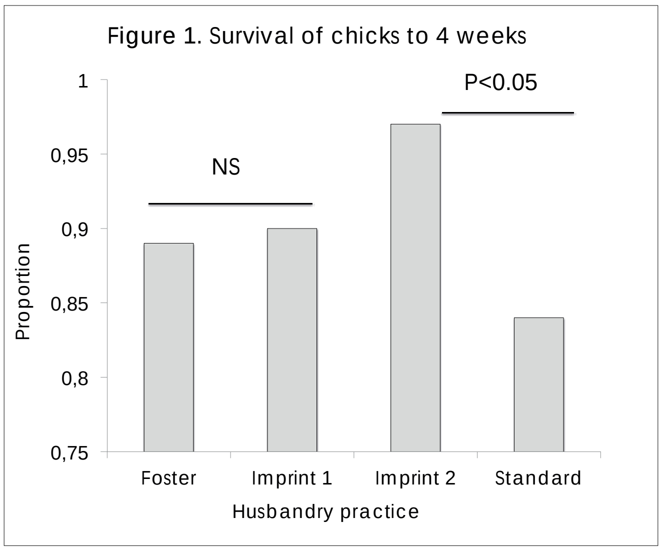
THE PROBLEM

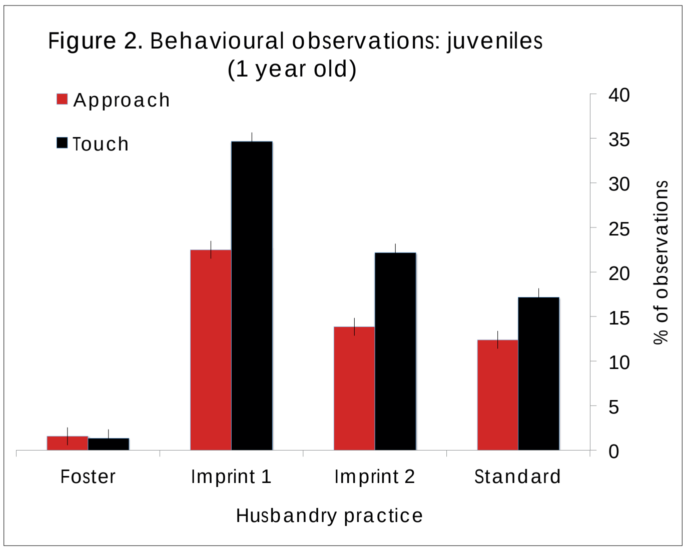
- Welfare of farmed ostriches is still compromised by:
  - o Poor egg hatchability
  - o Low chick survival
- Husbandry practice is yet to be optimized in this species
- Aim of the study: To investigate the effect of different husbandry practices on chick survival and juvenile response to human presence at yearling age.

METHODS

- 4 practices: standard, 2 extensive human care treatments (Imprint 1 and 2), foster parent care
- Recorded chick survival to 4 weeks
- Behaviour observed in juveniles:
  - o 3 times a week / 3 months
  - o 2 observers
  - o behaviour recorded toward observer:
    - ➢ approaching / keeping a distance
    - ➢ allowing to be touched
    - ➢ sexual or aggressive behaviour.

RESULTS





⊙ Only one individual observed kicking on two occasions / no sexual display recorded

CONCLUSIONS

- Extensive human care is beneficial for early chick survival.
- More docile behaviour is expressed by chicks that experienced extensive human presence soon after hatching.
- Further studies are required to investigate the full implications of extensive human care on sexual/ aggressive behaviour when birds reach sexual maturity.

11. Artificial insemination of ostriches: the effect of dilution rate on the duration of the fertile period and rate of sperm loss

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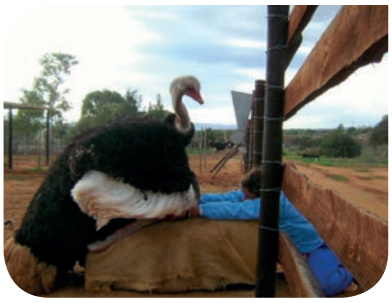
THE PROBLEM

Neat avian semen needs to be diluted prior to artificial insemination (AI) to:

- maximize the efficiency of sperm usage
- maintain optimum fertility on a maximum number of females
- Aim of the study: To investigate the effect of dilution rate on the duration of fertile period and the rate of sperm loss.



METHODS

Experiment 1	Experiment 2
10 females	14 females
3-4 males	2-3 males
Pooled ejaculates diluted 1:2 with EK	Pooled ejaculates diluted 1:4 with EK

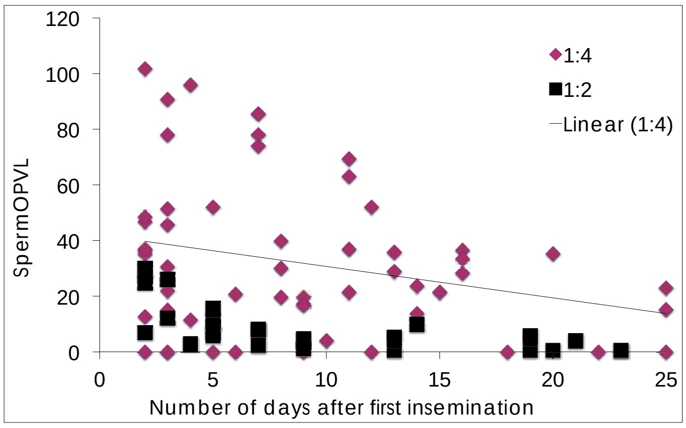
AI dose
3 billion sperm

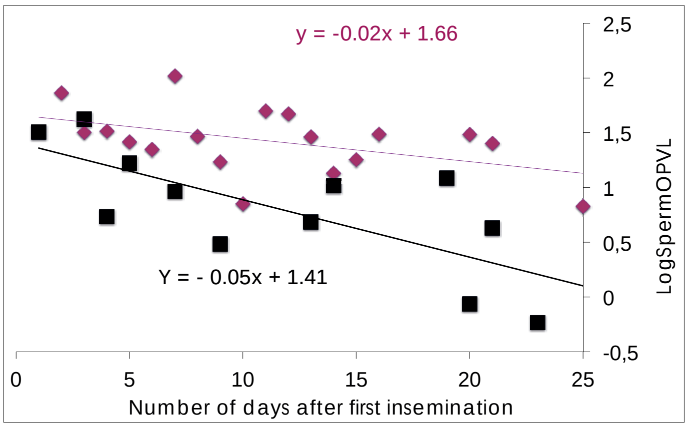
5 AI doses on consecutive mornings

Egg break out for 3 weeks after last insemination

Estimation of fertilization status and number of sperm trapped in perivitelline membrane ($Sperm_{OPVL}$)

RESULTS





- No difference in the duration of the fertile period between 2 dilution rates: ◆12 days, ■9 days (P > 0.05).
- $Sperm_{OPVL}$ was detected for up to ◆20 days,■ 18 days (P>0.05).
- Mean number of LogSpermOPVL higher for 1:4 than 1:2 dilution ($F_{1,68}$=19.68, P<0.001).
- Rate of sperm loss lower in 1:4 than 1:2 dilution ($F_{1,68}$=7.39, P=0.008).

CONCLUSIONS

- Fertile eggs are produced for >1 week after first artificial insemination.
- Fertile period observed is shorter than that reported under natural conditions.
- EK diluent is developed for other poultry, and is possibly not optimal for ostriches.
- Further studies are required to determine optimum diluent characteristics, dilution rate for short- and long-term storage, as well as optimal AI dose to maximize fertile period.

12. Changes in the air cell volume of artificially incubated ostrich eggs

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INTRODUCTION

- Egg candling is commonly used on commercial ostrich farms during artificial incubation to determine fertility and to monitor progress of the developing embryo.
- **AIM: To report on aspects of water loss in artificially incubated ostrich eggs, by assessing changes in air cell volume and factors influencing it during the incubation period.**

MATERIALS AND METHODS

- A total of 2160 incubated ostrich eggs were candled and photographed.
- Images were digitized using the software package AnalySIS® (Soft Imaging System, 1999), to determine the percentage of the egg volume occupied by the air cell at different stages of incubation.
- Volume occupied by the air cell (measured in pixels as determined with AnalySIS®) was expressed as a percentage of the volume occupied by the entire egg.

RESULTS

- Air cell volume: fresh eggs - 2.46%.
- Air cell volume for incubated fertile eggs: 15 days - 9.31%; 22 days - 11.2%; 29 days - 13.8%; 36 days - 15.18%; 41 days - 24.4%.
- Air cell volume in infertile eggs was significantly ($P<0.05$) higher at 19.3% on day 29 of incubation than in dead-in-shell eggs (14.3%) or eggs that hatched (13.8%).
- Air cell volume at 41 days of incubation was significantly ($P < 0.05$) higher in eggs that hatched normally than in dead-in-shell eggs (28.3% and 21.7%, respectively).
- Air cell volume was consistently higher during mid-incubation in eggs that exhibited high rates of water loss when compared to hatched eggs.

Figure 1. Images of the ostrich egg used to derive the percentage of the candled eggs occupied by the air cell from 3 to 42 days of incubation.

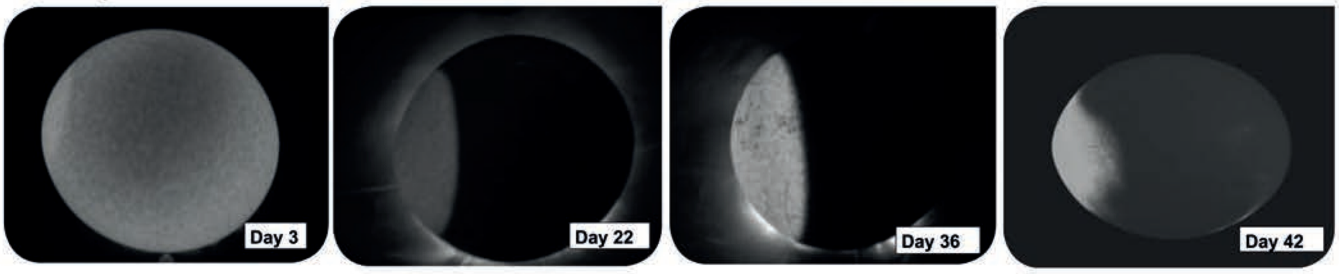


Figure 2. The percentage of the egg volume (± S.E.) occupied by the air cell in hatched (Hatch), infertile (Infertile) and dead-in-shell (DIS) ostrich eggs during the 41-day incubation period.

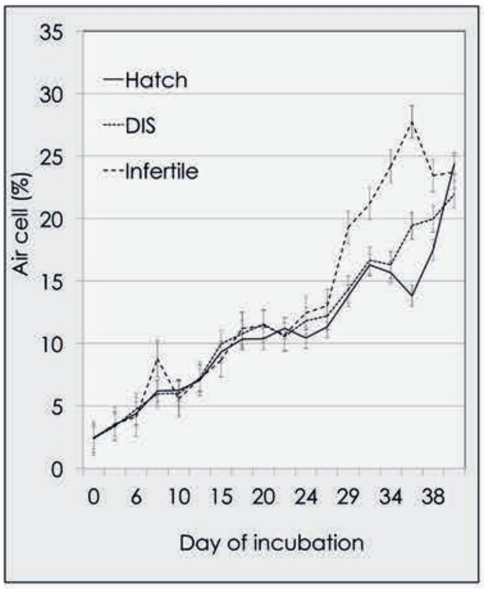
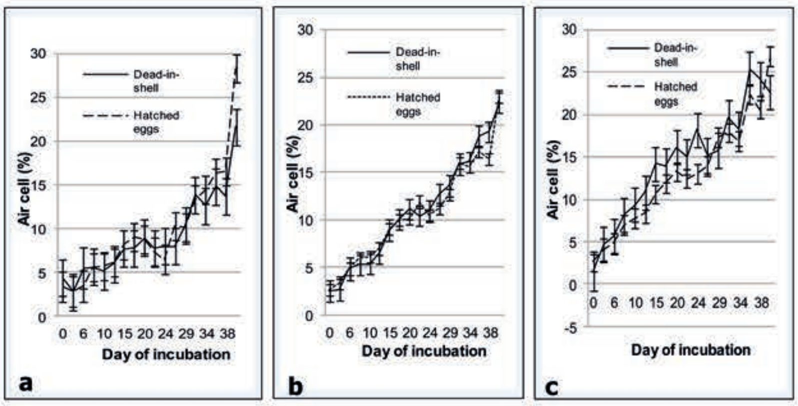


Figure 3a, b, c. The percentage of the egg volume occupied by the air cell in dead-in-shell and hatched ostrich eggs during the 41 day incubation period for eggs with low (a), medium (b) and high (c) levels of water loss.



CONCLUSION

Although some subtle differences were detected between hatched and DIS chicks during this study, these differences were too small for the techniques to find application in the broader industry.

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13. Embryonic development and relative changes in the composition of ostrich eggs during incubation

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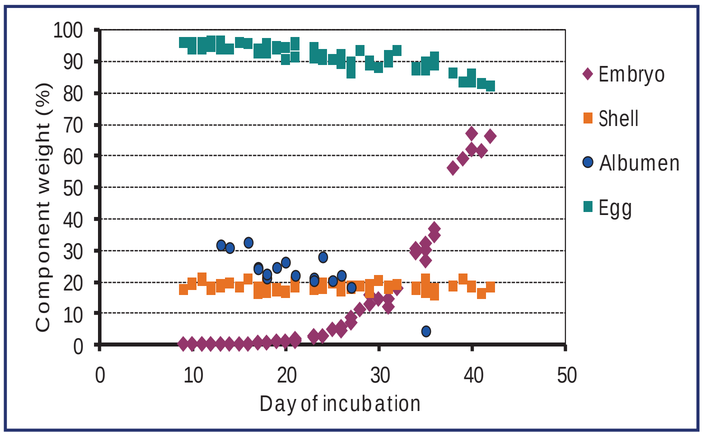
INTRODUCTION

- Hatching success of ostrich eggs is poor compared to that of commercial poultry – only around 50%.
- Knowledge of age and degree of development of embryo at time of death is an important tool for identifying incubation problems that result in low hatchability.
- The content of the eggs was closely studied to enable us to give a detailed description of the development of the embryo during incubation.

RESULTS

- Shell weight remained constant at ± 18% of initial egg weight.
- Embryo mass increased exponentially during incubation.
- Most embryonic growth takes place in the last week of incubation – from 26 to 79% of initial egg weight.
- Albumin weight declines from ± 50% of initial egg weight at a rate of 1.4% per day of incubation.
- Weight of egg membranes was constant at ± 1% of initial egg weight.



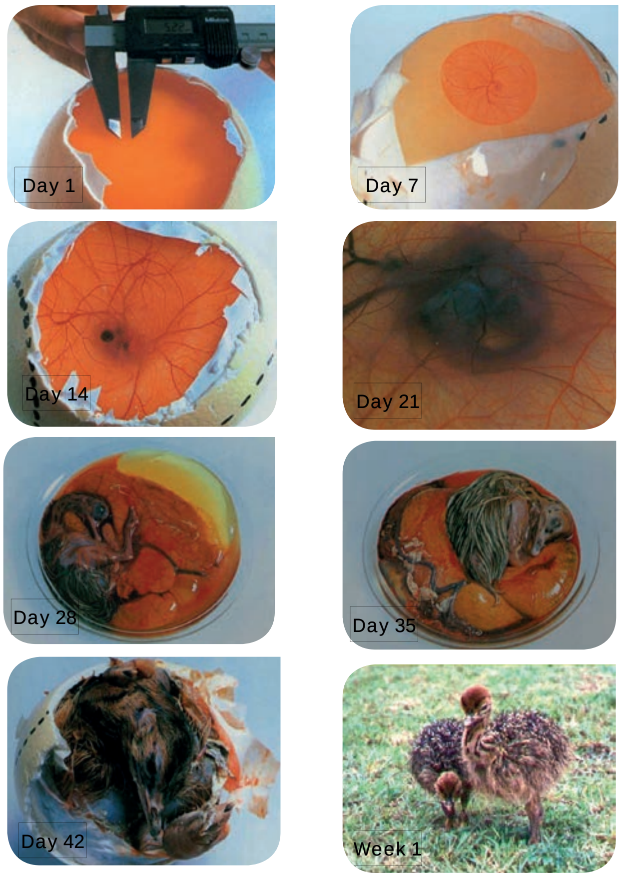
MATERIALS AND METHODS

- Eighty-four ostrich eggs were weighed daily to determine water loss.
- The eggs were opened to weigh components.
- Stages of development were recorded.

DISCUSSION

- Using weight changes that occur during incubation, as well as development stages, a more accurate mortality age of the embryo can be established.
- This is an important tool for identifying incubation problems that result in low hatchability.

DEVELOPMENTAL STAGES OF THE OSTRICH EMBRYO



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14. Developing an artificial insemination programme in ostriches: egg production of single versus pair-mated females

Z. Brand[1,2] , M. Bonato[1], I.A. Malecki[3], P.K. Rybnik[3], C.K. Cornwallis[4] and S.W.P. Cloete[1,2]

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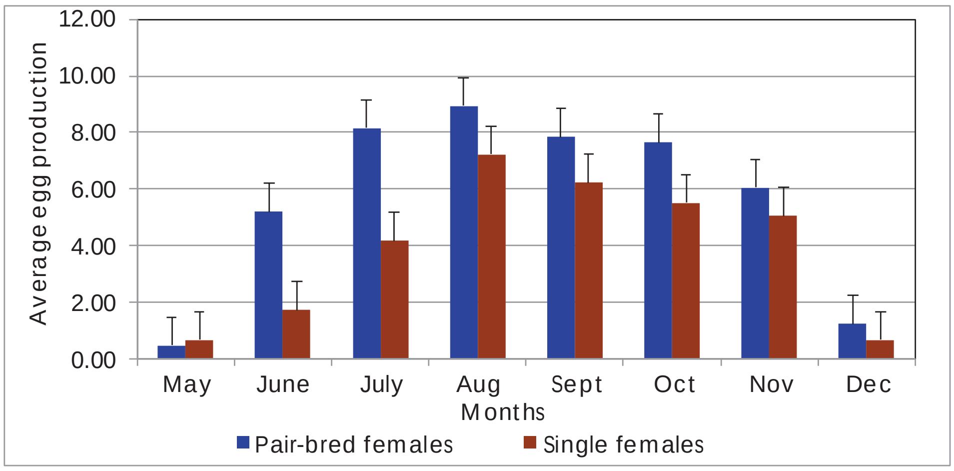
INTRODUCTION

- Artificial insemination (AI) is a general practice in most commercial livestock farming systems.
- This procedure is not practiced in ostrich farming.
- It is generally accepted that ostrich females do not produce eggs in the absence of males.
- Females that produce and maintain egg production in the absence of males is crucial to developing an AI programme.
- AIM: To determine if single females produce eggs when not paired with males.

MATERIALS AND METHODS

- Experimental population at Oudtshoorn Experimental Farm consisted of:
- Two to four-year-old pair-bred females, including pure South African Black (SAB) females (n=55) and crosses between Zimbabwean Blue males (ZB) with SAB females (n=25).
- Two to four-year–old docile females without prior experience with males, including pure SAB females (n=16) and crosses between ZB with SAB females (n=2), kept in the absence of male ostriches.
- The single females were kept in individual pens throughout the breeding season.
- Eggs from both groups of females were collected daily and production was recorded from May to December 2009.
- A mixed model analysis was performed with egg production as the response variable, female treatment, age and breed entered as fixed factors and ID number as a random factor.

Figure1. Egg production (mean ± se) of females with and without males.



RESULTS

- The average egg production per month was 3.90 ± 0.91 for single females and 5.69 ± 1.14 for pair-bred females.
- The total egg production per female for pair-bred females was significantly higher than that of single females ($F_{1,7}$=4.82, P=0.03).
- During the first three months the single females produced significantly fewer eggs ($F_{1,1}$=5.05, P=0.003). Egg production between the groups did not differ significantly for the rest of the breeding season.
- Both groups of females had a similar production pattern peaking in August.
- Three and four-year-old females produced significantly more eggs than two-year-old females ($F_{1,2}$=4.92, P=0.01).
- Overall genotype (SAB vs. SABxZB) had no effect on egg production (P>0.05).

DISCUSSION

- Pair-bred females produced significantly more eggs than single females.
- Male presence is not essential, but it does enhance egg production.
- Male presence resulted in more eggs being produced at the beginning of the breeding season.
- The stimulation of egg production early in the season needs to be investigated for single females.
- The age of females needs to be considered in order not to discriminate against two-year-old single females.

15. Embryonic development and weight changes in ostrich egg components during incubation

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INTRODUCTION

- Artificial incubation of ostrich eggs is poorly understood when compared to poultry.
- The low hatching success of the artificially incubated eggs is considered as a limitation.
- It is important to know the age and degree of development of embryos at time of death to identify incubation problems.
- AIM: To describe the development of the ostrich embryo and changes in weight of the egg components from day 8 to 42 of incubation.

MATERIALS AND METHODS

- Experimental population: commercial pair-bred flock at Oudtshoorn Research Farm.
- 84 eggs were weighed and incubated at 36°C and 24% RH.
- Two eggs were weighed daily to determine water loss and then opened.
- Embryo and albumin weight and stage of development were recorded.
- 12–24 randomly chosen eggs were candled and photographed.
- 486 images were digitized and percentage of egg volume occupied by the air cell was determined using AnalySIS software.

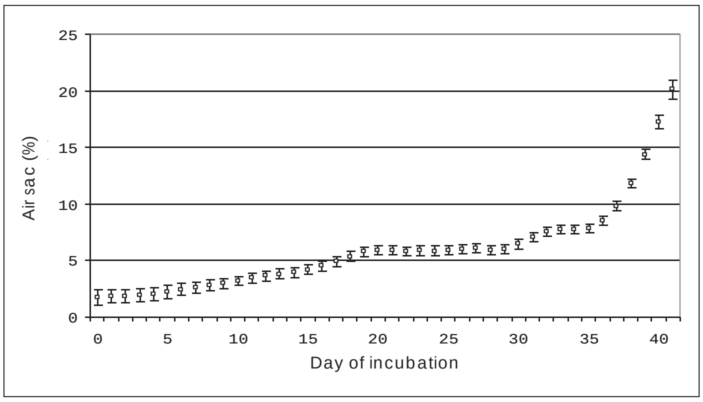
Table 1. Development stages of ostrich embryos.

Day 8	Limbs clearly discernible, eyes became visible (n=1)
Day 10	Growth in length of the limbs observed; embryo weight= 0.68 g (n=3)
Day 12	Beak clearly discernible; embryo weight=1.91g (n=2)
Day 14	Blood vessel network and amniotic sack enclosing the embryo covered upper surface of the yolk. All body organs present; mean weight=2.59 g or 0.174% of initial egg weight (n=1)
Day 18	Feather buds seen; embryo weight=6.96 g (n=3)
Day 20	Rudimentary feathers discerned. Embryo weight=14.14 g (n=2)
Day 21	Embryo weight=17.9±2.2 g or 1.29±0.24% of initial egg weight (n=3)
Day 24	Plumules present. The beak began to harden; embryo weight=36.27 g (n=2)
Day 28	Embryo turned with its spine parallel to the long axis of the egg; embryo weight=142 g or 10.8% of initial egg weight (n=1)
Day 35	Embryo bent its neck to right over right foot, with its beak pointing towards air cell, to attain correct pipping position; embryo weight=382±19 g or 27.3±2.4% of initial egg weight (n=3)
Day 38	All albumin was completely incorporated and remaining yolk began to be absorbed into the body cavity through the navel; embryo weight=774.77 g (n=1)
Day 40	All yolk was absorbed into body cavity; embryo weight=923±41 g or 64.5±3.5% of initial egg weight (n=2)
Day 42	Hatching; embryo weight=870.77 g (n=1)

RESULTS

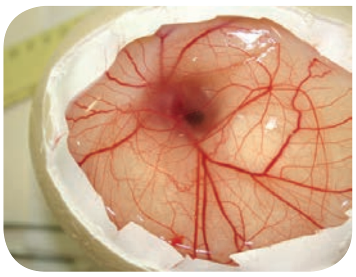
- 65 eggs (77.4%) showed evidence of embryonic development.
- The developmental stages of the embryos are shown in Table 1.
- Evaporative water loss occurred at 0.31% per day and totaled 13% of initial egg mass over the incubation period.
- Shell weight (±18%) and shell membrane (±1%) remained constant.
- Embryo weight increased exponentially up to 79% of initial egg weight during incubation.
- Albumin weight decreased linearly from ±50% of initial egg weight at a rate of 1.4% per day and was completely incorporated by day 35 of incubation.
- The percentage of the egg occupied by the air sac changed from 1.76% for fresh eggs to 20.1% at 42 days.

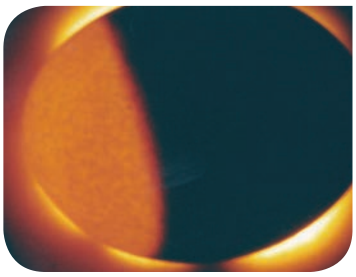
Figure 1. The percentage of the egg volume occupied by the air sac in ostrich eggs during the 42-day incubation period (modeled by a cubic spline).



DISCUSSION

- The pattern allows a more accurate estimate of the time of death of embryos and may help to identify particularly sensitive periods.
- Further research is needed to elucidate factors associated with embryonic mortalities and to refine accurate determination of the various malpositions of ostrich embryos.





16. The relationship of body measurements with egg and chick production in ostriches (*Struthio camelus* var. *domesticus*)

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INTRODUCTION

About 80% of the national ostrich breeding population is maintained in flocks that vary in size from 50-100 birds per flock. The communal nesting system of ostriches complicates the identification of poor or non-producing females, which impacts negatively on the cost-effectiveness of any commercial ostrich enterprise. Identification of such females will increase the profit margin of commercial ostrich systems by culling poor or non-producing individuals.

MATERIALS AND METHODS

Data were collected from a pair-mated breeding flock for which individual breeding records were available. A total of 2800 records for egg and chick production respectively, and 4500 records for live weight, were recorded. Body measurements recorded included chest circumference and tail circumference, both at the beginning and end of breeding seasons (Measurements 3 and 4; Figure 1). Reproduction data recorded included egg and chick production.

Figure 1. Diagram to indicate the location of measurements recorded in this study (3=tail circumference, 4=chest circumference).

RESULTS

Table 1. Significant correlations (bold and shaded) of body measurements with egg production.

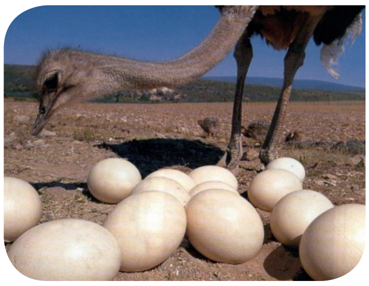
Parameter	Live weight		Chest circumference		Tail circumference	
	Beginning of season	End of season	Beginning of season	End of season	Beginning of season	End of season
r_{PE}	-0.31 ± 0.16	-0.26 ± 0.16	-0.36 ± 0.16	-0.33 ± 0.16	-0.13 ± 0.25	0.15 ± 0.20
r_P	0.05 ± 0.03	-0.09 ± 0.03	0.01 ± 0.03	-0.11 ± 0.03	0.10 ± 0.02	-0.05 ± 0.02
h^2	0.31 ± 0.04	0.27 ± 0.04	0.18 ± 0.04	0.17 ± 0.04	0.16 ± 0.03	0.17 ± 0.03

Table 2. Significant correlations (bold and shaded) of body measurements with chick production.

Parameter	Live weight		Chest circumference		Tail circumference	
	Beginning of season	End of season	Beginning of season	End of season	Beginning of season	End of season
r_{PE}	-0.15 ± 0.13	-0.20 ± 0.13	-0.17 ± 0.13	-0.22 ± 0.13	-0.07 ± 0.20	-0.12 ± 0.16
r_P	0.02 ± 0.03	-0.13 ± 0.03	0.00 ± 0.03	-0.11 ± 0.03	0.06 ± 0.02	-0.06 ± 0.02
h^2	0.31 ± 0.04	0.27 ± 0.04	0.18 ± 0.04	0.17 ± 0.04	0.16 ± 0.03	0.17 ± 0.03

CONCLUSIONS

Selecting females for egg and chick production based on body measurements offers limited potential for genetic progress in commercial breeding flocks. The observed correlations will more likely be a reflection of the nutritional status of females (i.e. underfed or overfed), as more productive females will invest more energy into egg production rather than deposit it as fat reserves around the tail.



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17. The impact of slaughter age on the profitability of an intensive slaughter ostrich production system

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INTRODUCTION

The objective of this study was to quantify the margin above specified costs of ostriches slaughtered at the age of 8.5, 10.5, 12.5, 14.5 and 16.5 months with regards to the three main end products (skin, meat and feathers), based on the production standards used in an intensive production unit.

MATERIALS AND METHODS

175 South African Black ostriches (*Struthio camelus domesticus*) were randomly distributed into 10 groups of between 16 to 20 birds per group at the age of 4 months (n=81) and 6 months (n=94) respectively. Birds were slaughtered at the age of 8.5, 10.5, 12.5, 14.5 and 16.5 months respectively, and all experimental data were collected. Data were analysed according to the analysis of variances. Industry figures and norms were used as proxy for other production inputs and costs. A gross margin analysis was performed per bird to assess the effect of different slaughter ages on financial viability of each production system.

RESULTS AND DISCUSSION

In this case study, the margin above cost per bird was the highest for birds slaughtered at the age of 10.5 months. Gross income tended to increase with increased slaughter age, however, direct costs, notably feed cost, affected the margins. The margin above cost showed a steady decline as birds are slaughtered at higher ages. Slaughter at 16.5 months revealed a negative margin.

Figure 1. Margin Above Specified Costs per bird for ostriches slaughtered at the age of 8.5 to 16.5 months .

Figure 2. The proportion of skin: meat income from birds slaughtered at the age of 8.5 to 16.5 months.

CONCLUSION

It is important to keep in mind that this was a case study and financial viability calculations are relevant and valid for data obtained in this study only. Financial viability is case-specific and may vary between producers, depending on their individual management practices, production systems, cost structures, and particularly feed cost and mortality rates. Results of this study may be of significant value when managerial decisions are made by ostrich producers.

18. Effect of artificially flavoured mash on the intake of ostrich chicks

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INTRODUCTION

Local studies have indicated that ostrich chicks may die from starvation after the yolk sac has been absorbed and when they refuse to eat.

This considered, the aim of this study was to look at different ways to improve the palatability of feed for newly hatched ostrich chicks.

MATERIALS AND METHODS

Some 96 day-old ostrich chicks – 8 groups of 12 each – were raised in an environmentally controlled housing system. Each group received the same ration (pre-starter mash), which was artificially flavoured using four different flavours (bitter, sweet, salt and sour). Untreated mash was used as a control. Food and water were provided *ad libitum* – from day one. Feed consumption for each flavour was recorded for a period of four weeks. Data collected were analysed according to analysis of variance.

RESULTS AND DISCUSSION

Table 1. Distribution (%) of taste preferences as determined by feed intake at an early age (1-8 days).

Taste	Week 1	Week 2	Week 3	Week 4	Period
Control	16.67^a	15.33^a	17.31^a	17.83^a	17.08^a
Bitter	19.89^a	13.86^a	15.17^a	15.70^a	15.68^a
Sweet	19.61^a	17.25^a	18.39^a	16.99^a	17.86^a
Salt	28.82^b	40.20^b	30.66^b	35.12^b	34.01^b
Sour	15.01^a	13.36^a	18.46^a	14.36^a	15.38^a
Std dev	2.55	2.94	2.8	2.65	1.35
P	0.01	0.0	0.0037	0.0	0.0

Percentage intake from differently flavoured feeds over the period was: 34.0% (salty), 17.9% (sweet), 17.1% (control), 15.7% (bitter), and 15.4 (sour). For each week the intake for salty feed was significantly higher than that of the other flavourants.

CONCLUSION

The study showed that ostrich chicks with no previous exposure to feed have a preference for salty feed. Further studies are currently being done to determine the exact salt levels the chicks prefer – as well as the effect of higher salt intake on production and health.

19. Effect of artificially coloured mash on the intake of ostrich chicks

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INTRODUCTION

Local studies have indicated that ostrich chicks may die from starvation after the yolk sac has been absorbed and if they refuse to eat.

The aim of this study was to look at different ways to improve the attractiveness of feed for newly hatched ostrich chicks.

MATERIALS AND METHODS

Ninety six day-old ostrich chicks, 8 groups of 12 each, were raised in an environmentally controlled housing system. Each group received the same ration (pre-starter mash) – coloured with four different artificial colours (blue, red, green and yellow). Untreated mash was used as a control. Food and water were provided *ad libitum* as from day one. Feed consumption for each colour was recorded for a period of four weeks. Data collected were analysed according to analysis for variance.

RESULTS AND DISCUSSION

Table 1. Distribution (%) of colour preferences as determined by feed intake at an early age (1-28 days).

Colour	Week 1	Week 2	Week 3	Week 4	Period
Control	27.79^{b}	28.12^{b}	28.91^{b}	28.64^{c}	27.81^{c}
Blue	12.46^{a}	17.00^{a}	21.15^{b}	22.32^{b,c}	19.46^{a,b}
Yellow	18.72^{a,b}	23.41^{a,b}	21.18^{b}	22.49^{b,c}	21.56^{b,c}
Green	14.94^{a}	12.55^{a}	8.39^{a}	10.48^{a}	11.95^{a}
Red	26.10^{b}	18.93^{a,b}	20.36^{b}	16.08^{a,b}	19.22^{a,b}
Std. dev.	3.66	3.86	3.54	3.66	2.79
P	0.02	0.07	0.01	0.02	0.01

Percentage intake from differently coloured feeds over the period was: 27,8% (control), 21,6% (yellow), 19,5% (blue), 19,2% (red) and 12% (green).

CONCLUSION

The study indicates that ostrich chicks with no previous exposure to feed have no preference for feed coloured artificially with either green, blue, yellow or red.

20. Effect of supplementary feeding on the production of grazing ostriches

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INTRODUCTION

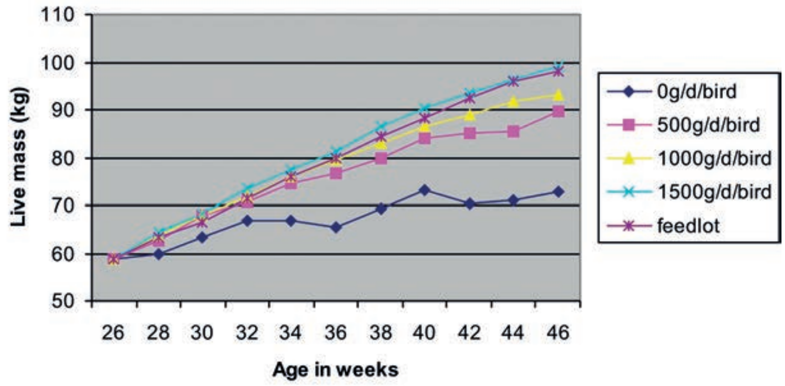
The experiment was conducted to study the effect of different levels of supplementary feed on the production of ostriches grazing irrigated lucerne pastures.

MATERIALS AND METHODS

Some 250 ostriches – at six months of age – were randomly allocated to five groups of 50 ostriches each. One group (zero grazing) received a complete finisher diet while the other four groups grazed irrigated lucerne pastures in a two-week rotational system at a stocking density of 14.7 birds/ha – and received supplementary feed at 0 g/bird/day, 500 g/bird/day, 1 000 g/bird/day, and 1 500 g/bird/day respectively.

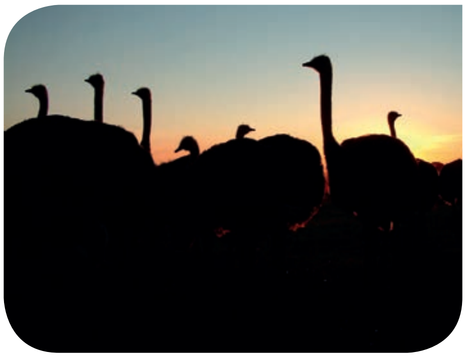
RESULTS

Figure 1.The average body weight of ostriches in the five treatment groups.



CONCLUSION

It is clear that the birds grow according to the amount of feed used to supplement the pasture. This indicates that lucerne pastures *per se* cannot fulfil the nutritional needs of birds grazing the pasture at these stocking densities. An economic evaluation is needed to evaluate the financial advantage of the three different supplementary feeding levels.



21. Effect of supplementary feeding of grazing ostriches on the yield and composition of irrigated lucerne pastures

B.B. Aucamp[1], T.S. Brand[1&2] and J.M. van Heerden[3]

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[3]ARC, PO Box 3320, Matieland 7602, South Africa

INTRODUCTION

This experiment was conducted to determine the effect of grazing ostriches receiving supplementary feed at different levels – on the yield and composition of irrigated lucerne pastures.

MATERIALS AND METHODS

Some 250 ostriches at six months of age were randomly allocated to four groups of 50 ostriches each while grazing irrigated lucerne pasture in a two-week rotational system, at a stocking density of 14.7 birds/ha. Birds received supplementary feed at 0 g/bird/day, 500 g/bird/day, 1 000 g/bird/day and 1 500 g/bird/day. The available pasture dry matter was determined with exclosure cages. The material was subsequently manually fractionated into different fractions.

RESULTS

The effect of supplementary feeding on the production of grazing ostriches was:

Figure 1. Total plant material and lucerne, clover and broadleaf weeds (utilisable plant material), as well as grass and dry material available (not utilisable) for each supplementary level (exclosure cages).

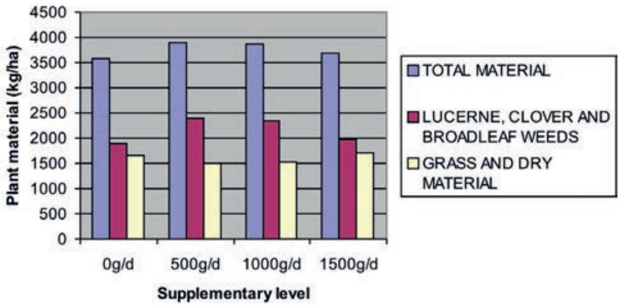
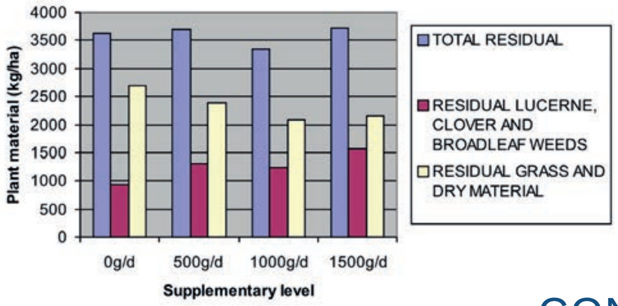


Figure 2. Total plant material and lucerne, clover and broadleaf weeds, as well as grass and dry material residues after grazing.



CONCLUSION

The level of residual lucerne, broadleaved weed and clover (the utilisable part of the total grazing material) after grazing seems to indicate an increase in the substitution level of the pasture by the feed in the 1 500 g/bird/day group. Overgrazing in the case of the zero-feed grazing group also occurred, which was either due to the length of the grazing period or a too-high stocking density.

22. Impact of slaughter age on the profitability of an intensive slaughter ostrich production system

C. Bhiya[1&2], J.W. Jordaan[1], T.S. Brand[2&3], B.B. Aucamp[2] and A.C.M. Kruger[2]

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INTRODUCTION

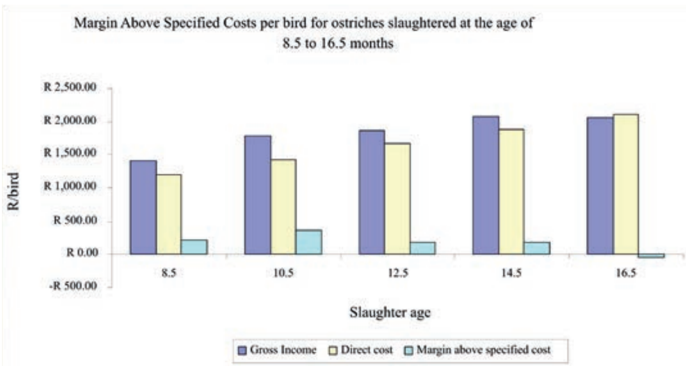
The objective of this study was to quantify the margin above specified costs of ostriches – slaughtered at 8.5, 10.5, 12.5, 14.5 and 16.5 months – with regard to the three main end products (skin, meat and feathers). This is based on the production standards used in an intensive production unit.

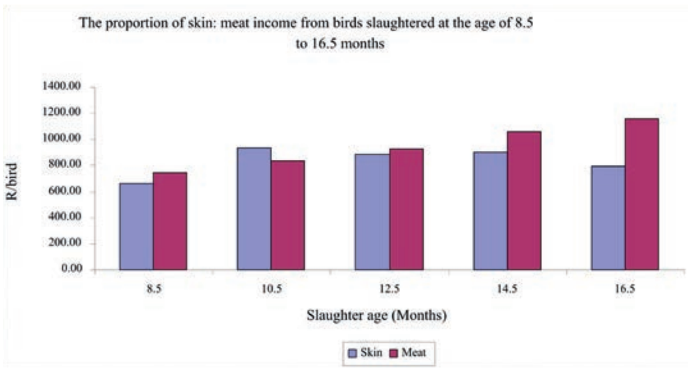
MATERIALS AND METHODS

Some 175 South African Black ostriches were randomly distributed into 10 groups of between 16 to 20 birds, at the age of 4 months (n=81) and 6 months (n=94) respectively. Birds were slaughtered at the age of 8.5, 10.5, 12.5, 14.5 and 16.5 months respectively, and all experimental data were collected. Data were analysed according to the analysis of variances. Industry figures and norms were used as proxy for other production inputs and costs. A gross margin analysis was performed per bird to assess the effect of different slaughter ages on the financial viability of each production system.

RESULTS AND DISCUSSION

In this case study, the margin above cost per bird was highest for birds slaughtered at the age of 10.5 months. Gross income tends to increase with the increased slaughter age; however, direct cost – notably feed cost – affected the margins. The margin above cost showed a steady decline as birds were slaughtered at higher ages. Slaughtering at 16.5 months revealed a negative margin.





CONCLUSION

It is important to consider that this was a case study and financial viability calculations are relevant and valid for the data obtained. Financial viability is case-specific and may vary between producers depending on their individual management practices, production systems, cost structures, and particularly feed cost and mortality rates. The results of this study may be of significant value when ostrich producers need to make management decisions.

23. Estimation of the abdominal fat thickness of live ostriches using the ultrasound technique

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[5]Department of Animal Science: Ankara University, Ankara, Turkey

OBJECTIVES

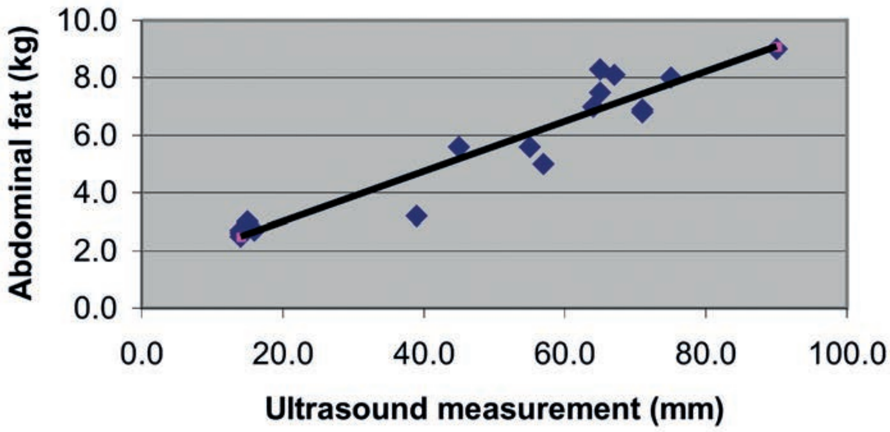
The objective of the study was to determine the relationship between the abdominal fat weight of slaughter birds and the fat thickness measurement in live birds – using the ultrasound scanning technique.

METHOD

The subcutaneous fat thickness of 60 live ostriches – ca 52 weeks of age and fed diets differing in energy concentration – was measured ultrasonically (Scanoprobe 2, Scanco Inc., Ithaca, USA). The birds were subsequently slaughtered and the abdominal fat of each bird was collected and weighed. Measurements were compared by regression analysis.

RESULTS

Figure 1. Relationship between the ultrasound measurement and abdominal fat weight in ostriches.



The data revealed that the abdominal fat weight in ostriches may be predicted by the linear equation 1.28 + 0.087 x ultrasound measurement (R^2 = 0.91).

CONCLUSIONS

Ultrasound is a reliable technique to predict the abdominal fat weight in ostriches. This can be developed as a scientific technique to determine their nutritional status.

24. Effect of supplementary feeding to lucerne pasture on the production of grazing ostriches (*Struthio camelus*)

M. Strydom[1,2], T.S. Brand[1,2], B.B. Aucamp[1] and J.M. van Heerden[3]

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INTRODUCTION

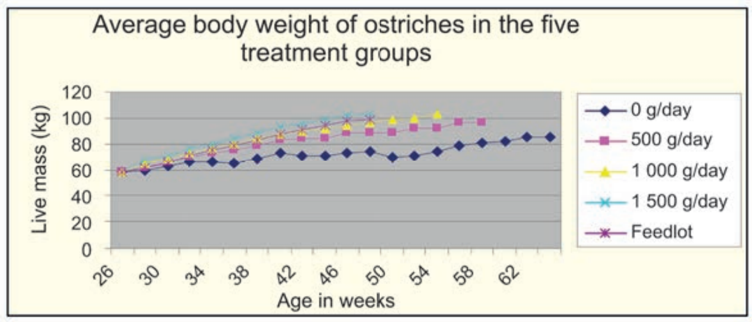
The successful growth of slaughter ostriches is dependent on adequate nutrition. Purchased feed is the greatest cost involved in the production of ostriches. It is therefore necessary to make use of farm-grown feeds and pasture as far as possible. For economic production, the objective of this study was to find the correct balance of supplementary feed in relation to lucerne pasture – in order to produce to maximum economic advantage.

MATERIALS AND METHODS

Some 250 ostriches (six months of age) were randomly allocated to five groups of 50 ostriches each and were grazed on lucerne pasture in a 2-week rotational system. One group of ostriches received a complete finisher diet with zero grazing, and the other four groups grazed on irrigated lucerne pastures in addition to a supplementary feeding mixture (0 g/bird/day, 500 g/bird/day, 1 000 g/bird/day and 1 500 g/bird/day respectively) that was formulated according to their nutritional requirements.

RESULTS AND DISCUSSION

The birds receiving 1 500 g supplementary feed/day and those receiving a complete finisher diet grew significantly faster ($p \leq 0.05$) than birds consuming supplementary feed of 1 000 g, 500 g or 0 g/bird/day.



It is clear that the birds grow according to the amount of feed used to supplement the lucerne pasture. The ostriches on the lucerne pasture which received no supplementary feed did not manage to accomplish slaughter weight and this indicates that lucerne pasture *per se* is unable to fulfil the nutritional needs of birds at a stocking density of 15 birds/ha.

CONCLUSION

It was concluded that the incorporation of lucerne pasture in the diets of growing and finishing ostriches will reduce feeding costs. A feeding level of 500 g/bird/day gave the best economic results as a supplementary feeding level to irrigated lucerne pastures under these experimental conditions.

25. Colour preferences of ostrich (*Struthio camelus*) chicks

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INTRODUCTION

Behaviour studies on ostrich chicks may be helpful to provide information on the requirements of ostriches in commercial systems. Studies on the food preferences of ostrich chicks may also be helpful to prevent the current high mortality rates. Previous studies on the preference of ostrich chicks – that had free choice to feed on different colours – varied. This study was conducted to provide further information on the colour preference of ostrich chicks.

MATERIALS AND METHODS

Colour preference trials were conducted on five groups of 10, month old ostrich chicks. Plastic strips of different colours were hung on a line 1 metre above the ground. Colours tested were: blue, yellow, gold, green, red, silver, black and white. Different groups of 10 ostrich chicks each were observed for 15 minutes. The number of pecks towards a colour were counted. This procedure was repeated over 7 days. Data were collected and analyzed using analysis of variance.

RESULTS AND DISCUSSION

Table 1. Pecks (%) directed at different colours.

Colour	Pecks per 15-minute period (%) (Mean ± SE)
Blue	3.4 ± 2.2^{a}
Yellow	17.6 ± 2.2^{c}
Gold	5.0 ± 2.2^{a}
Green	31.9 ± 2.2^{d}
Red	5.0 ± 2.2^{a}
Silver	14.8 ± 2.2^{bc}
Black	9.4 ± 2.2^{ab}
White	13.0 ± 2.2^{bc}

^{a,b,c,d} denote significant differences ($P \leq 0.05$)

CONCLUSION

The study indicates that ostrich chicks have a preference for green coloured objects. This contradicts a previous study where ostrich chicks did not show the same preference when coloured feed was provided. Further studies are currently being undertaken.

26. Effect of direct artificial light of high intensity on feed bowls – on feed intake, growth and behaviour of newly hatched ostrich (*Struthio camelus*) chicks

M. Janse van Vuuren[1,3], T.S. Brand[1,2] and B.B. Aucamp[1]

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INTRODUCTION

Behaviour studies on ostrich chicks may help provide information on how to stimulate their feed intake and growth. This may help to prevent the current high mortality rates of ostriches raised under commercial systems.

This study was conducted to provide information on the effect of artificial light on feed bowls – on the feed intake, growth and behaviour of ostrich chicks.

MATERIALS AND METHODS

Some 110 ostrich chicks were divided randomly into 10 groups of 11 chicks per group. Artificial light of high intensity (1 500 lux) was focused on the feed bowls of five of the groups, while the other five groups had no additional lighting on their food except for that provided by the housing system. Ostrich chicks and food were weighed weekly from hatching up to 30 days of age. The number of pecks directed at food bowls was counted for two-minute periods for 70 periods. Data were collected and analysed using analysis of variance.

RESULTS AND DISCUSSION

Table 1. Influence of additional lighting on food bowls – on feed intake, growth rate and behaviour of ostrich chicks.

Treatment	Feed intake (g) (mean ± SE)	Growth (g) (mean ± SE)	Pecks directed at food bowls (%) (mean ± SE)
Control	132.5 ± 12.0^{a}	82.6 ± 6.8^{a}	37.6 ± 6.99^{a}
Light	175.8 ± 12.0^{b}	104.2 ± 6.8^{b}	86.98 ± 6.99^{b}

^{a,b}denote significant differences ($P \leq 0.05$)

CONCLUSION

The study results suggest that the additional provision of high intensity lighting on food bowls stimulates feed intake and growth in ostrich chicks. Behavioural data support this by further indicating more pecking activity directed at feed under extra lighting of high intensity.

27. Effect of application of 24 h artificial light on feed intake, growth and behaviour of ostrich chicks

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INTRODUCTION

The aim of the study was to determine whether the application of additional light influences dry matter intake, growth, feed conversion rates and behaviour – of growing (1-28 day-old) ostrich chicks. A time-activity budget was recorded over a 24-hour period for both (24 hours of daylight and normal day/night cycles) light regimes.

RESULTS AND DISCUSSION

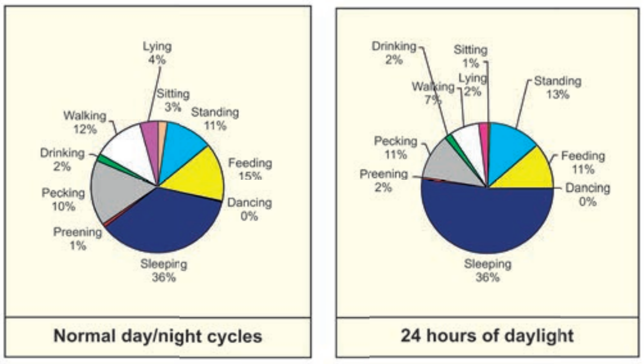
Table 1. Growth data for ostrich chicks (age 1-28 days) under two different light regimes.

Application	End-weight (g)	ADG (g/bird/day)	DMI (g/bird/day)	FCR (kg feed/kg gain)
24 hours light/day	3.13[a]	62.80[a]	153.71[a]	2.54[a]
Normal day/night	3.17[a]	66.80[a]	165.79[a]	3.03[a]
Std dev	0.16	7.24	9.89	0.44
P-value	0.86	0.66	0.40	0.44

[a]Denote significant ($P<0.05$) differences between the main effects.

No significant differences ($P>0.05$) in feed intake, growth rate or feed conversion ratio were observed between the two different light regimes.

Figure 1. Time-activity budget of ostrich chicks (7 days of age) subjected to two different light regimes.



Chicks subjected to normal day/night cycles spent more time sleeping (52%) than those subjected to 24 hours of daylight (36%). Chicks subjected to 24 hours of daylight spent more time eating (14.7%) than those subjected to normal day/night cycles (11.43%).

28. Effect of feed processing and restriction of water availability on the intake and growth of ostrich chicks

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INTRODUCTION

This study was performed to determine the effect of feed processing (i.e. meal, crumbles or extruded feed) on the feed utilisation and performance of young ostrich chicks. The simultaneous effect of water restriction on their performance was also tested.

MATERIALS AND METHODS

Ostrich chicks were raised in an environmentally controlled housing environment. A pre-starter ration was provided *ad libitum* and presented either as a meal, crumble, or as an extruded diet. Half of the pens received water *ad libitum*, while the other half only received water for an hour in the morning and an hour in the afternoon. Live weight and dry matter intake were recorded weekly for 10 weeks. The data were analysed using multifactor analysis of variance (ANOVA).

RESULTS AND DISCUSSION

No significant interaction ($P>0.5$) between feed processing and water availability was detected and the effect of the different factors was presented separately.

Table 1. Influence of feed processing on the intake and production performance of ostrich chicks from 6 to 15 weeks of age.

Treatment	Starting weight (kg)	End weight (kg)	ADG (g)	DMI (g/bird/day)	FCR (kg feed/kg gain)
Extruded	3.9^{a}	22.7^{a}	331.5^{a}	673.4^{a}	2.9^{a}
Crumbles	4.0^{a}	29.4^{ab}	344.9^{a}	713.8^{a}	2.4^{a}
Meal	4.0^{a}	37.0^{b}	424.6^{b}	878.5^{b}	2.3^{a}
Mean	4.0	29.7	367.0	755.3	2.5
Std dev	0.1	7.3	23.2	46.7	0.4
P-value	0.12	0.07	0.01	0.01	0.66

^{a,b}Denote significant differences ($P<0.05$) between the main effects.

Dry matter intake over the period was the highest for chicks fed meal – with this followed by those eating crumbles and those who were fed on a extruded diet. Birds consuming the meal diet accordingly grew faster than those consuming the crumbled or extruded diets.

Table 2. Influence of water restriction on the feed intake and growth rate of ostrich chicks from 6 to 15 weeks of age.

Application	ADG (g)	DMI (g/bird/day)	FCR (kg feed/kg gain)
Water (restricted)	377.6^{a}	642.8^{a}	2.4^{a}
Water (*ad libitum*)	356.4^{a}	767.7^{a}	2.6^{a}
Mean	367.0	755.3	2.5
Std dev	18.3	36.8	0.3
P-value	0.89	0.56	0.3

^{a}Denote significant differences ($P<0.05$) between the main effects.

No significant differences in feed intake, growth rate or the feed conversion ratio of birds subjected to *ad lib* water provision and water restriction, were observed.

29. Effect of different dietary salt levels on the feed intake and growth rate of ostrich chicks

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INTRODUCTION

The aim of this study was to determine the optimum dietary salt level preferred by ostrich chicks and the effect of dietary salt level on the feed intake, growth rate, and feed conversion ratio of ostrich chicks.

MATERIALS AND METHODS

Ostrich chicks, at 7 weeks of age, were raised in an environmentally controlled housing system. Salt was mixed into portions of a starter ration – to provide 4 different levels of salt in the basal diet (0.4%, 1.4%, 2.4%, and 3.4%). Dry matter intake and live weight of birds were determined once a week for an experimental period of five weeks.

RESULTS AND DISCUSSION

Table 1. Salt preference (%), as determined by feed intake of ostrich chicks (8-12 weeks of age) in a free-choice situation.

Salt content as percentage of basal diet	Dry matter intake (%)
0.4	16.6[a]
1.4	36.4[c]
2.4	25.2[b]
3.4	21.8[ab]
Std dev	12.9
P-value	0.01

[a,b,c]Denote significant differences ($P<0.05$) between the main effects.

Intake was the highest for the diet containing 1.4% salt – followed by the diets containing 2.4 % salt, 3.4 % salt and 0.4 % salt respectively.

Table 2. Effect of dietary salt inclusion on production performance of ostrich chicks (7-12 weeks of age) – as tested in a growth study.

Dietary salt content (%)	Starting weight (kg)	End weight (g)	DMI (g/bird/day)	ADG (g/bird/day)	FCR (kg feed/kg gain)
0.4	6.87	8.55 [1,2]	399.5[a]	220.4[a]	2.5[a]
1.4	7.12	9.28 [1,2]	467.9[a]	312.4[b]	1.5[b]
2.4	7.56	9.51 [2]	464.3[a]	266.0[ab]	1.9[ab]
3.4	6.73	8.39 [1]	433.1[a]	256.7[ab]	1.7[ab]
Mean	7.09	8.93	441.2	263.9	1.9
Std dev	0.27	0.34	24.9	21.7	0.3
P-value	0.16	0.09	0.20	0.05	0.21

[a,b]Denote significant differences ($P<0.05$) between the main effects.
[1,2]Denote significant tendencies ($P<0.10$) between the main effects.

Production data from the experiments with different salt inclusion levels revealed a tendency ($P = 0.09$) for a higher end-weight for birds consuming a diet with 1.4% salt – compared to birds consuming a diet with 0.4% salt. Growth rate was the best for the birds receiving a diet with 1.4% salt inclusion, followed by 2.4% salt inclusion, 3.4% salt inclusion, and 0.4% salt inclusion respectively. Feed conversion ratio (FCR) was the best for chicks receiving the 1.4% salt inclusion, followed by the treatments with 3.4%, 2.4% and 0.4% salt included.

It was concluded that birds may prefer diets containing higher salt concentration than is traditionally provided.

30. Effect of supplementary feeding of grazing ostriches (*Struthio camelus*) on the yield of irrigated lucerne pasture

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INTRODUCTION

Lucerne pasture can make a substantial contribution to the nutrient requirements of ostriches – provided it is supplemented with a concentrate suitable for the pasture type and growth stage of the bird. The most important factor in grazing management of lucerne pasture is the stocking rate, and the objective of many grazing systems must be to get the optimum balance between number of animals and pasture production. This study was conducted to determine the effect of grazing ostriches receiving supplementary feed at different levels – on the yield of irrigated lucerne pastures and calculated intake of birds.

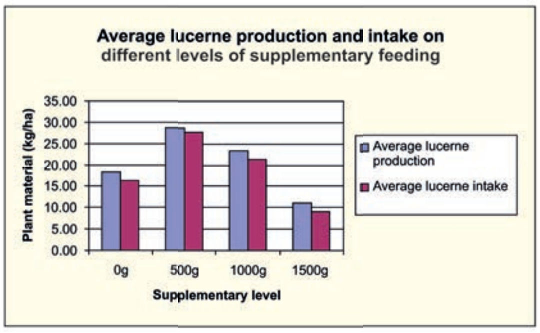
MATERIALS AND METHODS

Some 250 ostriches (± six months of age) were randomly allocated to five groups of 50 ostriches each. Four of these groups grazed irrigated lucerne pastures with supplementary feed supplied at 1 500 g/bird/day, 1 000 g/bird/day, 500 g/bird/day and 0 g/bird/day, and the fifth group was put in a feedlot and received a complete finisher diet (zero grazing). The lucerne pasture was grazed in a rotational system at a stocking rate of 15 birds/ha. Pasture samples were collected and manually divided into lucerne, grass, broadleaf weed, clover, and dry or dead material.

RESULTS AND DISCUSSION

Collected pasture samples were composed mainly of lucerne, with only negligible quantities of clover, grass, broadleaf weeds and dry or dead material. The ostriches mainly consumed lucerne.

Figure 1. Mean lucerne kg/ha/day for the camps, and mean lucerne intakes (kg/bird/day) of the ostriches.



CONCLUSION

The data indicate that as the level of supplementary feed increases, so the ostriches consume less lucerne pasture – which affected pasture yield. The level of residual lucerne dry matter after grazing was significantly higher ($p \leq 0.05$) in the camps grazed by the 1 500 g group compared to the camps of the 0 g group. This indicates either a high level of substitution of feed in the 1 500 g group or an overgrazing in the case of the zero feed grazing group. The results are important for determining the optimum supplementary feeding levels for grazing ostriches.

31. Effects of transport on blood chemistry and physiological stress indicators in ostriches

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INTRODUCTION

Ostriches (*Struthio camelus*) experience many stressors during transport, such as handling, loading and unloading, confinement and partial immobilization, motion, vibration, noise and changes in environmental conditions[1]. The stressors incurred during transport, and the possible injuries as a result of stress, lead to poor meat quality and this translates into huge economic losses. It is thus imperative to find ways of decreasing the negative effects of such stressful events, especially when birds are exposed to these stressors shortly before slaughter.

Despite the fact that ostriches are known to be highly nervous birds[2], their stress hormone response to transportation has not yet been assessed.

Aims:

- Assess transport-related stress in ostriches by both conventional assessment and the corticosterone response
- Assess metabolic stress incurred as a result of transport
- Investigate the ability of transported birds to recover from transport-related stress overnight, prior to slaughter.

MATERIALS AND METHODS

- Ethical approval for the study was obtained from the Stellenbosch University Sub-committee B Animal Research Ethics committee (reference # 2009B03003).
- Sixteen ostriches (average weight 94±12 kg) were randomly divided into 2 groups (n=8 each), and subjected to either 60 or 600 km road transport.
- Blood samples were taken at baseline (8 am), immediately post-transport (2 pm), and after overnight recovery (8 am).
- Analysis:
  - EDTA-blood was analysed for full blood and differential white cell counts (Celldyne 3700 with VetPack software, Abbott Diagnostics).
  - SST-clotted blood was analysed for serum total protein, albumin, globulin, aspartate aminotransferase (s-AST) and creatine kinase (s-CK) concentration by standardized methods (PathCare), and for serum corticosterone concentration using rodent EIA kits, as described for use in Rheas[3] (IDS cat # AC-14F1, AEC Amersham).
- Data were analysed using Statistica v.8 (StatSoft Software). Analyses included ANOVA with repeated measures and Bonferroni *post hoc* tests. Data are presented as means and standard deviations. A p-value of P<0.05 was accepted as statistically significant.

RESULTS and DISCUSSION

Hydration status of ostriches was not significantly different over time or between groups (Table 1). Values were all within the expected ranges for ostriches.

This is the first study to report on corticosterone values in ostriches. Corticosterone concentrations increased significantly from baseline after 60 km, but not after 600 km (Figure 1). This increase was maintained until the next day. However, it is possible that this response was the result of an acute stress response prior to transport, and not a response to transport-related psychological stress. This is supported by the fact that heterophil:lymphocyte ratio (a parameter routinely used to reflect transport-related stress in birds) was similar for all time points and groups. (Figure 2).

Table 1. Concentrations of serum proteins measured over time.

Parameter	Baseline	Post-transport	Recovery
60 km group:			
Total protein (g/ℓ)	38 ± 7	38 ± 5	40 ± 5
Albumin (g/ℓ)	21 ± 3	21 ± 2	22 ± 2
Globulin (g/ℓ)	17 ± 4	17 ± 3	18 ± 4
600 km group:			
Total protein (g/ℓ)	41 ± 10	40 ± 6	44 ± 8
Albumin (g/ℓ)	22 ± 4	22 ± 2	23 ± 3
Globulin (g/ℓ)	19 ± 6	18 ± 4	20 ± 6

Serum aspartate aminotransferase (s-AST) concentration ranges at baseline were similar to those previously reported for ostriches[4]. s-AST values only increased in the group transported 60 km, and only significantly so during the overnight recovery period (Figure 3). The significance of this is not clear, but may suggest exposure of this group only to an additional metabolic stressor not related to the transport itself, which also supports the interpretation of the corticosterone results above. No significant difference in absolute values was observed between groups, probably due to high variability in the 600 km group.

Creatine kinase concentrations in both groups were significantly affected by transport (Figure 4), although distance travelled did not affect the magnitude of increase by time of sacrifice. The suggested muscle damage was probably the result of postural instability during transport.

Figure 1

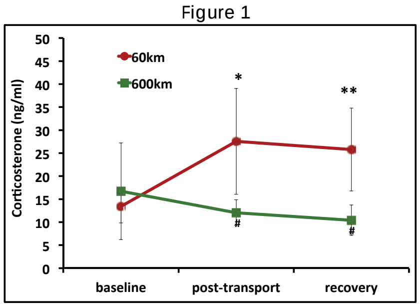
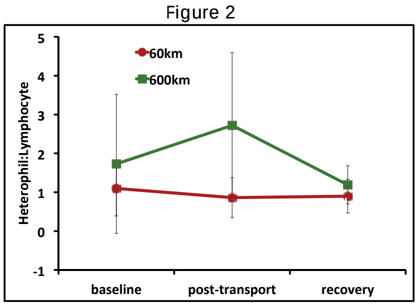


Figure 2



*, **: Values significantly different from baseline, P<0.005 and P<0.01 respectively
#: Significant difference between groups, P<0.005

Figure 3

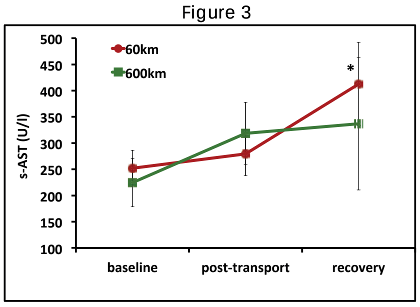
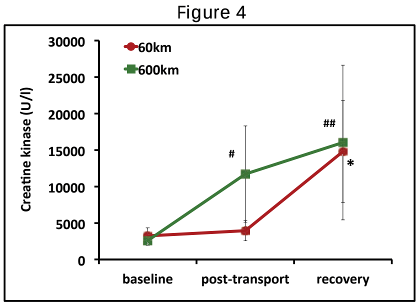


Figure 4



*: Value significantly different from baseline (P<0.005) and post-transport (P<0.05)
#, ##: Values significantly different from baseline, P<0.05 and P<0.001 respectively

CONCLUSION

We conclude that in South Africa, transport stress in adult ostriches:

- Is not directly related to the extent of psychological stress incurred
- Is rather the result of metabolic stress
- Is a condition from which these birds cannot sufficiently recover in the time allowed prior to slaughter.

We recommend that further studies are conducted to investigate the efficacy of nutritional, rather than anxiolytic, intervention to either prevent metabolic stress or to enhance recovery.

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32. Effect of cotton oilcake meal inclusion on ostrich meat's chemical composition

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INTRODUCTION

Although ostriches were originally domesticated for the harvesting of their feathers, and which was followed by high prices being paid for their skins, currently they are farmed to produce a healthy red meat. The successful rearing of ostriches requires high standards of nutrition and because nutrition accounts for nearly 75% of total ostrich production costs, more information in this area is required. The protein source represents a large part of these costs, and therefore the evaluation of alternatives at lower prices is essential. Cottonseed oilcake meal (CSOCM) – a textile industry by-product – offers an alternative to the commonly used, but more expensive soybean oilcake meal. This study aimed to establish whether and to what extent the gradual replacement of soybean oilcake meal (SBOCM) with CSOCM could affect ostrich meat quality.

MATERIALS AND METHODS

A total of 105 ostriches were used to study the effect of the inclusion of cottonseed oilcake on meat (fan fillet) chemical composition of ostriches aged from 6 to 13 months. Diets were formulated to allow for the gradual replacement of soybean oilcake meal with cottonseed oilcake meal (0% CSOCM/Control, 3% CSOCM, 6% CSOCM, 9% CSOCM and 12% CSOCM). Thawed and homogenised fan fillet samples were analysed according to the AOAC (2002) methods – to determine moisture, ash, protein, and total lipid and cholesterol content.

RESULTS AND DISCUSSION

Results presented in Table 1 show that dietary protein source did not influence the dry matter, protein, lipid, ash or cholesterol content of ostrich fan fillet meat. The free Gossypol content of the control diet (0% CSOCM), 3% CSOCM and 6% CSOCM was not detected (detection limit of 20 ppm) – and for the 9% CSOCM and 12% CSOCM diets the Gossypol content was 20 ppm. Despite growth and production results, it can be concluded that CSOCM will not affect the quality of ostrich meat negatively when included up to 12% of ostrich diets.

Figure 1. Gradual replacement of SBOCM with CSOCM.

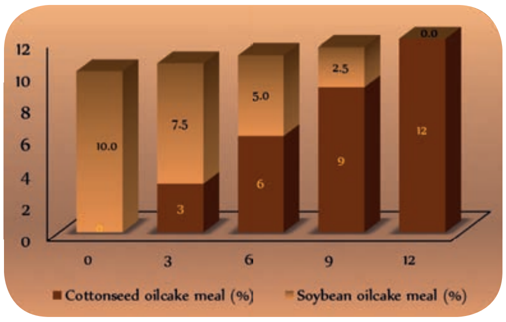

Table 1. Proximate composition and cholesterol content of fan fillet meat from ostriches receiving increasing dietary levels of CSOCM.

	Experimental Diets					
	Control	CSOCM 3%	CSOCM 6%	CSOCM 9%	CSOCM 12%	*P*-Value
Samples, No.	16	18	17	21	19	
Dry matter, %	24.9	25.2	24.9	24.7	25.2	ns
Protein, %	21.1	21.3	21.4	20.9	21.3	ns
Lipids, %	3.09	3.30	2.88	2.94	3.23	ns
Ash, %	1.05	1.08	1.14	1.04	1.03	ns
Cholesterol, mg/100 g	62.3	63.8	62.3	63.7	64.2	ns

CONCLUSION

Chemical analysis revealed that the Gossypol content of the experimental diets was very low, and therefore no adverse effects due to Gossypol poisoning were noticed. Considering the overall results, CSOCM seems to be a viable and less expensive alternative to soybean oilcake meal as a protein source in ostrich nutrition – and can be included up to 12% in ostrich diets. As a precaution, the Gossypol content of the CSOCM should be determined before its inclusion in ostrich diets.

33. The effect of dietary bulk density on the feed intake of ostrich chicks (*Struthio camelus* var. *domesticus*)

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INTRODUCTION

High feeding costs may be overcome by predicting nutritional requirements more accurately. The current mathematical optimization model (Prof Tertius Brand, Prof Robert Gous) was used to determine nutrient requirements of the ostriches. The trial aimed to optimize the model in terms of intake simulation. Wheat straw was used in commercial ostrich diets for the pre-starter, starter and grower phases. Wheat straw was not used but may be included at low levels in rations for the finisher and maintenance phases.

MATERIALS AND METHODS

Experiment location: Kromme Rhee Experimental Farm. 5 separate trials (Pre-Starter, Starter, Grower, Finisher, Maintenance) were done. Diets were diluted with wheat straw and the feed intake compared. Wheat straw was milled (8 mm sieve), mixed with the formulated diet, and pelleted. Feed and water were available *ad lib.* The feed intake was determined for each pen by weighing back the feed left in troughs every week. Data were analysed by ANOVAS with the GLM procedure of SAS version 9.2.

Table 1. Experimental design

	Dilution levels in %	Number of birds	Number of pens	Birds per pen	Repetitions
Pre-Starter (Fig 1)	0, 10, 20	120	6	20	2
Starter (Fig 2)	0, 10, 20	120	6	20	2
Grower (Fig 3)	0, 15, 30, 45, 60	150	10	15	2
Finisher (Fig 4)	0, 15, 30, 45, 60	150	10	15	2
Maintenance (Fig 5)	0, 20, 40, 60, 80	100	10	10	2

RESULTS AND DISCUSSION

The expected outcome of this research was for the feed intake to increase as the bulk increased due to the lower level of energy. The intake will increase until it is limited by gut capacity. This result is perfectly demonstrated in the grower and finisher phases. It would also be demonstrated in the starter phase if the level of fibre were included at higher levels.

Table 2. Least squares means (±SE) and significance for average daily feed intake per ostrich for each of the phases for the different treatments.

Treatment	Pre-Starter	Starter	Grower	Finisher	Maintenance
0%	0.3192 ± 0.01618^{a}	0.5161± 0.07322^{a}	1.4625 ± 0.09372^{a}	1.9932 ± 0.06616^{a}	2.7208 ± 0.1368^{a}
10%	0.2535 ± 0.01618^{b}	0.6616 ± 0.07322^{a}			
15%			1.6679 ± 0.09372^{a}	2.1754 ± 0.05828^{b}	
20%	0.1527 ± 0.01618^{c}	0.6725 ± 0.07322^{a}			2.1186 ± 0.1368^{b}
30%			1.6269 ± 0.09372^{a}	2.092 ± 0.05486^{ab}	
40%					2.1446 ± 0.1368^{b}
45%			0.8947 ± 0.09372^{b}	1.6578 ± 0.05567^{c}	
60%			0.8479 ± 0.09372^{b}	1.2091 ± 0.08825^{d}	1.0852 ± 0.1368^{c}
80%					0.8424 ± 0.1368^{c}

CONCLUSION

The results of this study show that the ability of the digestive tract of the ostrich to digest and tolerate high levels of fibrous material in its diet improves with growth. Ostrich intake parameters with regards to bulk capacity were determined in this study. These bulk capacity and intake regulation limits in the ostrich will facilitate least cost modelling and, ultimately, this will be used in the mathematical optimization model for feed intake predictions, for feeds containing different levels of fibre.

Figure 1. Feed intake for different dilution levels : Pre- Starter

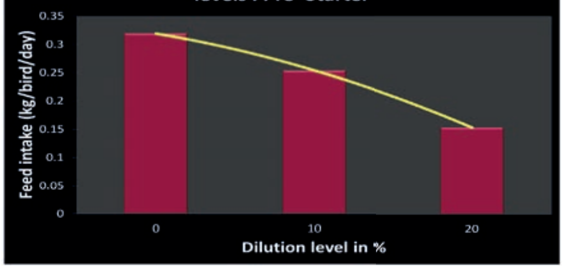


Figure 2. Feed intake for different dilution levels : Starter

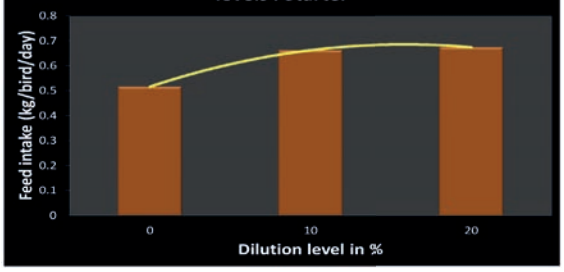


Figure 3. Feed intake for different dilution levels : Grower

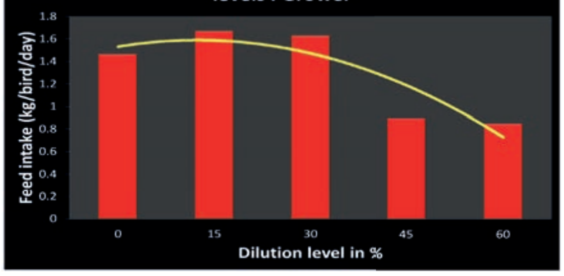


Figure 4. Feed intake for different dilution levels : Finisher

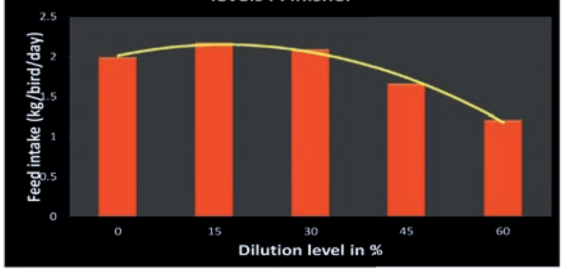
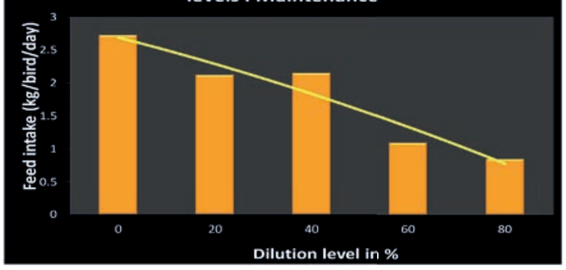


Figure 5. Feed intake for different dilution levels : Maintenance



34. Effect of an increasing dietary energy level on the feed intake and production of breeding ostriches

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INTRODUCTION

Poultry are able to control their feed intake at different dietary energy levels, but to what extent this ability influences breeding ostriches is currently unknown. This experiment was conducted to determine the effect of increasing dietary energy on feed intake and different production parameters of breeding ostriches.

MATERIALS AND METHODS

Ninety pairs of breeding ostriches were divided into six groups of 15 pairs each. Six diets with increased metabolisable energy content (8.0, 8.7, 9.4, 10.1, 10.8 and 11.5 MJ ME/kg feed), but equal in other nutrients, were provided *ad lib* to the birds during the 8-month breeding season (May–December). Production data were analyzed by one-way analysis of variance and by regression analysis.

RESULTS

Average feed intake (kg/bird/day) among the different experimental diets was not statistically different ($P>0.05$). An average feed intake value of 3.7±0.2 kg per bird, per day was recorded. The increase in live mass of the female ($y=2.46x-20.9; R2=0.05; P<0.05$) and male ($y=3.37x-24.4; R2=0.16; P<0.05$) birds due to dietary energy level, indicated that they both over-consumed energy in the diets with the higher energy values. No significant differences ($P>0.05$) were observed for other production parameters measured.

Dietary energy level (MJ ME/kg feed)	8	8.7	9.4	10.1	10.8	11.5	
Dietary crude protein (%)	12	12	12	12	12	12	
Dietary lysine levels (%)	0.58	0.58	0.58	0.58	0.58	0.58	
Dietary sulphur amino acids (%)	0.42	0.42	0.43	0.43	0.43	0.44	[1]SE
Average feed intake (kg/bird/day)	3.70^{a}	3.80^{a}	3.70^{a}	3.90^{a}	3.70^{a}	3.60^{a}	0.2
Average ME-intake (MJ/day)	29.6^{a}	33.0^{a}	34.4^{ab}	39.8^{bc}	39.7^{bc}	42.1^{c}	1.5
Egg production (eggs/female/season)	47.2^{a}	43.9^{a}	48.3^{a}	57.1^{a}	33.6^{a}	43.6^{a}	5.8
Chick production (chicks/female/season)	20.0^{a}	18.3^{a}	18.5^{a}	32.6^{a}	16.5^{a}	21.6^{a}	4.5
Dead-in-shell eggs (eggs/female/season)	7.20^{a}	7.70^{a}	7.20^{a}	11.1^{a}	5.10^{a}	6.90^{a}	1.8
Infertile eggs (eggs/female/season)	13.7^{a}	13.9^{a}	16.7^{a}	7.70^{a}	7.80^{a}	9.70^{a}	3.6
Egg weight (g)	1488.1^{a}	1384.0^{a}	1367.1^{a}	1395.5^{a}	1374.1^{a}	1425.9^{a}	31.1
Males' mass change (kg)	5.30^{ab}	2.80^{a}	5.10^{a}	10.8^{ab}	11.3^{ab}	15.6^{b}	2.4
Females' mass change (kg)	-2.10^{a}	1.60^{a}	3.20^{a}	4.90^{a}	0.90^{a}	10.0^{a}	3.4

^{a},^{b},:means in rows with different superscripts differ significantly ($P<0.05$)
[1]SE=standard error

CONCLUSION

Breeding ostriches used in this study did not regulate their feed intake according to dietary energy level when consuming diets with relatively high energy values. In all cases dietary energy intake exceeded minimum energy requirements (22 MJ ME/day). The results from this study are important for the determination of the maximum feed intake of breeding ostriches and modeling of the required concentration of other accompanying essential dietary nutrients.

35. Preliminary results on the relationship between the essential aminoacid and crude protein content of lucerne hay

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INTRODUCTION

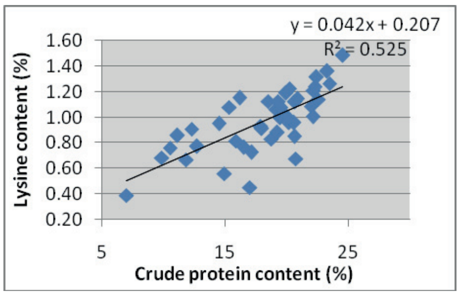
Feed formulation of the rations of monogastric animals should be based on the provision of essential amino-acids and not crude protein, since the nutrient requirements of such animals are based on the amino acids necessary for growth, production etc. and not on crude protein *per se*. Lucerne hay is an important feed ingredient of monogastric animals, especially ostriches. However, considerable variation exists in crude protein and amino acid content of lucerne. To analyze any feed for the crude protein content is quick and affordable, whereas amino acid analysis is time-consuming, laborious and expensive. A preliminary study was therefore performed to determine the relationship between the crude protein and amino acid content of lucerne hay.

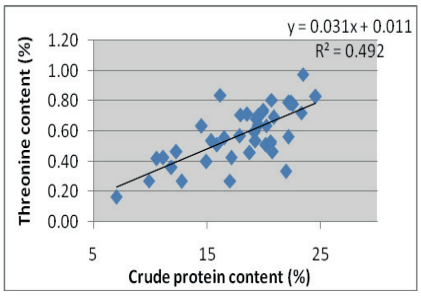
MATERIALS AND METHODS

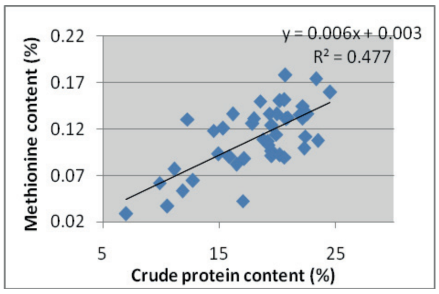
Forty-three lucerne hay samples were randomly collected in the Western Cape region and subjected to crude protein analysis, using a Leco FP428 analyzer according to the Dumas method, and amino acid analysis using a HPLC. Linear regression models were fitted between amino acid and crude protein content.

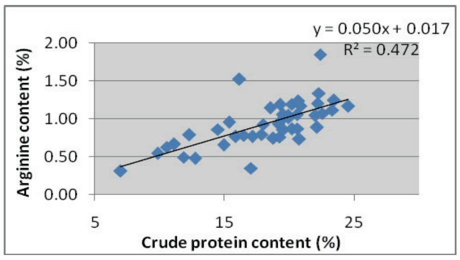
RESULTS

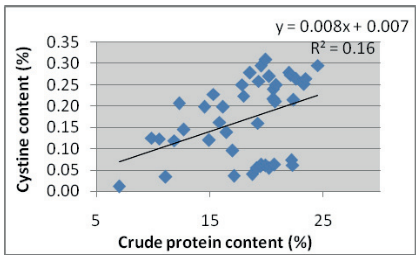
Statistical analysis revealed a linear relationship between lysine, methionine, threonine, cystine, arginine as well as total amino-acid content and the crude protein content of the collected lucerne hay samples.

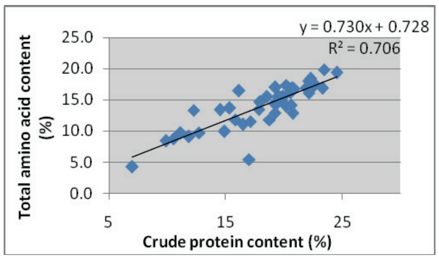












CONCLUSION

Preliminary results indicated that it would be possible to predict the amino acid composition of lucerne hay from the crude protein content thereof. The analysis of more samples is however necessary to be able to apply the results in practice.

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36. Composition of egg yolk absorbed by fasted ostrich (*Struthio camelus* L.) chicks from 1 to 7 days post-hatching, and for chicks from 1 to 16 days post-hatching, on a pre-starter broiler diet

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INTRODUCTION

Since the early part of the 20th Century, many studies have investigated the effect of feeding and starvation on yolk utilisation and the development of the digestive tract and enzyme activity in poultry. It was concluded that yolk utilisation was more efficient in chicks that received feed and water after hatching, and that starvation has a negative effect on the development of the digestive tract and digestive enzymes. This study was done to establish if yolk utilisation in ostrich chicks was similar to that reported in chickens.

MATERIALS AND METHODS

The first trial involved 35 ostrich chicks (1-7 days of age), which were provided with clean drinking water, but no food. Five chicks were slaughtered each day for 7 consecutive days – starting from the day of hatching (Day 1). The second trial involved 49 chicks (2-16 days of age) receiving a pre-starter diet. Of these, 6 were slaughtered every second day (starting at 2 days of age), over a period of 16 days. The chicks in both trials were obtained from the same source and were kept under similar conditions. The chicks were euthanised with CO_2 in a closed container. The yolk sacs were immediately removed from the carcasses, weighed, and pH values were determined. Yolk samples were freeze-dried and analysed for dry matter (DM), crude protein (CP) content, and fat content according to AOAC (1995). Yolk samples from the first trial (the fasted chicks) were further analysed for amino acids, fatty acids and glucose composition. As the same tendencies were observed for crude protein and fat values in both trials, the analyses for amino acids, fatty acids and glucose composition were not repeated for the second trial – due to financial constraints – and were assumed to be similar.

RESULTS AND DISCUSSION

Fasted ostrich chicks absorbed the yolk content at a rate of 28.9 g/day, compared to 22.3 g/day over the first 8 days in the fed chicks. Over the 16-day period, the fed chicks absorbed an average of 16.3 g of yolk per day. The absorption of yolk was much slower than reported for other poultry – which could be expected as the production cycle of the ostrich is much longer than in other poultry. Yolk weight and total CP decreased faster over the first 7 days in the fasted ostrich chicks compared to the fed ostrich chicks, which suggests that the decrease in yolk weight could be attributed to the preferential absorption of protein from the yolk. Fat content decreased faster over the first 8 days from the yolk of the fed ostrich chicks than in the fasted chicks. This may indicate that external feed has a positive influence on the absorption of fat from the yolk content. These results were in direct contrast to results obtained for fed and fasted chicks and poults in previous studies, where lipids were utilised faster than protein from the yolk.

It seemed that little glucose or lipids were utilised from the yolk as an energy source for the fasted ostrich chick. The fasted ostrich chick would therefore be obligated to use yolk protein as an energy source – which could also contribute to the weight loss observed over the 7-day trial period, as less protein was then available for growth. Glucose is used to provide energy for the hatching activities of chicks and it has been reported that glycolysis would be preferred above fatty acid oxidation as oxygen is limited during hatching. It is a possibility that ostrich chicks – during the post-hatch period – preferably obtain energy from synthesised glucose from certain amino acids (glucogenic) in protein, rather than fat. However, this would not favour sustainable early growth and stronger chicks. The results of this trial indicate that the ostrich chick has a greater ability to absorb mono-unsaturated fatty acids (MUFAs) – especially oleic acid (18:1n9c). The inclusion of oleic acid in pre-starter ostrich chick diets should be considered in future studies, as energy from fatty acids may be a better source of energy for sustainable early growth than glucose derived from protein. Previous studies suggest that poults can selectively withdraw fatty acids from the yolk.

CONCLUSION

In both the trials protein was assimilated from the yolk sacs, while it appeared that fat was absorbed at a much slower rate in the fed group. It would be interesting to see whether this apparent ability to withdraw certain fatty acids from the yolk of fasting chicks is repeated when feeding other exogenous feed (i.e. than in fed chicks), over the first weeks post-hatching. Even though this study indicated that yolk absorption is faster in fasted than fed ostrich chicks, the authors concur that ostrich chicks should be fed immediately post-hatch. Further studies should be performed with pre-starter diets that include added amino acids – especially histidine and valine – as well as MUFAs during the first few weeks post-hatching. This is because a preference for these nutrients from the yolk content was indicated in this trial.

Table 1. Mean hatching and slaughter weights (± SE) of fasted ostrich chicks, as well as the yolk weight and pH of the yolk, for 7 consecutive days after hatching.

Slaughter age (days)	Hatching weight (g)	Slaughter weight (g)	Yolk weight (g)	DM (%)	Yolk pH
1	833 ± 102^{a}	833 ± 102^{a}	230 ± 104^{ab}	48.4 ± 6.23^{a}	7.34 ± 0.22^{a}
2	884 ± 81.6^{a}	838 ± 91.9^{a}	249 ± 74.9^{a}	45.3 ± 5.60^{ab}	7.18 ± 0.35^{ab}
3	836 ± 99.6^{a}	739 ± 148^{ab}	206 ± 39.9^{ab}	45.9 ± 2.48^{ab}	7.00 ± 0.28^{bc}
4	835 ± 101^{a}	782 ± 79.4^{a}	164 ± 76.5^{bc}	44.0 ± 2.95^{ab}	6.98 ± 0.18^{bc}
5	836 ± 84.4^{a}	749 ± 83.2^{ab}	109 ± 51.8^{cd}	36.6 ± 4.98^{c}	6.81 ± 0.80^{c}
6	768 ± 86.6^{a}	657 ± 67.1^{b}	78.0 ± 12.0^{d}	48.0 ± 2.41^{a}	6.46 ± 0.30^{d}
7	824 ± 57.3^{a}	661 ± 46.0^{b}	102 ± 7.3^{cd}	41.1 ± 8.22^{bc}	6.69 ± 0.30^{cd}
LSD	116	119	78.8	2.05	2.05

[a,b,c]Column means with different superscripts differ significantly at $P<0.05$, n=5.

Table 2. Mean hatching and slaughter weights (± SE) of fed ostrich chicks, as well as the yolk weight and pH for 16 days post-hatching.

Slaughter age (days)	Hatching weight (g)	Slaughter weight (g)	Yolk weight (g)	DM weight (g)	Yolk pH
2	870 ± 132^{a}	772 ± 118^{d}	229 ± 61.1^{a}	51.7 ± 0.16^{a}	7.28 ± 0.16^{ab}
4	858 ± 65.0^{a}	787 ± 38.3^{d}	160 ± 29.6^{b}	51.5 ± 0.33^{a}	7.03 ± 0.17^{bc}
6	925 ± 129^{a}	853 ± 123^{d}	135 ± 42.4^{b}	51.4 ± 0.29^{a}	6.81 ± 0.16^{c}
*8	827 ± 129^{a}	801 ± 167^{d}	75.2 ± 36.7^{c}	51.3 ± 0.54^{a}	7.01 ± 0.19^{bc}
10	767 ± 136^{a}	902 ± 107^{cd}	68.6 ± 36.0^{c}	51.6 ± 0.28^{a}	7.49 ± 0.40^{a}
12	881 ± 44.2^{a}	1040 ± 170^{bc}	51.6 ± 20.1^{cd}	51.7 ± 0.28^{a}	7.04 ± 0.21^{bc}
14	829 ± 89.0^{a}	1192 ± 273^{ab}	18.4 ± 28.5^{de}	-	7.40 ± 0.25^{a}
16	831 ± 116^{a}	1342 ± 145^{a}	4.56 ± 4.0^{e}	-	-
LSD	127	181	41.4	1.02	0.30

[a,b,c]Column means with different superscripts differ significantly at $P<0.05$, n=6, *n=7.

Table 3. Crude protein and fat content (% of total yolk content) (± SE) of fasted ostrich chicks from 1 to 7 days post-hatching.

Slaughter age (days)	n	Crude protein (%)	Crude protein (g)	n	Fat (%)	Fat (g)
1	5	44.3 ± 1.98^{a}	134 ± 23.4^{a}	5	41.2 ± 2.49^{c}	125 ± 29.1^{a}
2	5	43.8 ± 1.76^{ab}	93.0 ± 23.1^{b}	5	42.4 ± 2.01^{c}	90.1 ± 23.0^{b}
3	5	41.0 ± 3.81^{ab}	73.7 ± 26.1^{b}	5	43.6 ± 4.67^{bc}	76.5 ± 17.2^{bc}
4	5	40.1 ± 2.82^{b}	69.8 ± 37.9^{bc}	5	43.5 ± 6.04^{c}	70.1 ± 22.7^{bc}
5	5	36.0 ± 1.88^{c}	39.0 ± 17.7^{cd}	5	50.1 ± 1.90^{a}	55.1 ± 26.5^{c}
6	4	35.4 ± 1.66^{c}	34.3 ± 3.10^{d}	5	52.8 ± 2.38^{a}	49.7 ± 6.02^{c}
7	4	32.5 ± 4.62^{c}	30.8 ± 11.8^{d}	3	48.9 ± 6.58^{ab}	48.2 ± 4.31^{c}
LSD		3.77	31.3		5.32	28.9

[a,b,c]Column means with different superscripts differ significantly at $P<0.05$.

Table 4. Crude protein and fat content (% of total yolk content) (± SE) of fed ostrich chicks for 16 days post-hatching.

Slaughter age (days)	n	Crude protein (%)	Crude protein (g)	n	Fat (%)	Fat (g)
2	6	44.8 ± 3.77^{a}	103 ± 31.5^{a}	6	40.9 ± 5.27^{d}	93.3 ± 25.5^{a}
4	6	39.3 ± 6.78^{ab}	63.9 ± 18.0^{b}	6	46.3 ± 6.67^{cd}	73.7 ± 14.2^{ab}
6	6	39.7 ± 3.14^{ab}	53.7 ± 17.4^{b}	6	46.5 ± 3.74^{cd}	63.1 ± 21.8^{b}
8	6	37.1 ± 6.43^{ab}	28.3 ± 17.8^{c}	5	48.5 ± 7.70^{bcd}	30.4 ± 23.3^{c}
10	5	32.0 ± 4.52^{bc}	22.1 ± 13.8^{c}	4	51.7 ± 1.23^{bc}	30.2 ± 24.3^{c}
12	6	31.9 ± 4.85^{bc}	16.8 ± 8.04^{cd}	6	55.9 ± 6.56^{ab}	28.4 ± 9.85^{c}
14	1	-	1.25 ± 3.05^{d}	1	-	2.65 ± 6.49^{d}
16		-	-		-	-
LSD		7.96	41.4		9.22	21.0

[a,b,c]Column means with different superscripts differ significantly at $P<0.05$.

Table 5. Amino acid composition (% of total yolk protein content) – that showed significant differences – of yolk from fasted ostrich chicks from 1 to 7 days post-hatching.

Amino acid n	1 5	3 4	5 4	7 3	LSD
Glycine	5.64^{ab}	5.63^{b}	5.78^{a}	5.75^{ab}	0.15
Histidine	1.84^{a}	1.78^{ab}	1.68^{c}	1.71^{bc}	0.08
Methionine	2.90^{ab}	2.97^{a}	2.89^{b}	2.95^{ab}	0.08
Serine	12.0^{ab}	12.1^{a}	11.8^{b}	12.0^{ab}	0.29
Threonine	6.49^{bc}	6.46^{c}	6.69^{a}	6.62^{ab}	0.16
Valine	6.09^{a}	5.81^{b}	5.85^{b}	6.00^{a}	0.11

[a,b,c]Column means with different superscripts differ significantly at $P<0.05$.

Table 6. Fatty acid composition (% of total yolk fat content) – that showed significant differences – of yolk from fasted ostrich chicks from 1 to 7 days post-hatching.

Fatty acids n	C:D	1 5	3 4	5 4	7 2	LSD
Palmitic acid	16:0	32.8^{b}	33.3^{b}	35.2^{b}	58.6^{a}	3.53
Stearic acid	18:0	9.82^{b}	9.87^{b}	10.4^{b}	18.5^{a}	3.56
SFA [1)]		42.9^{b}	43.6^{b}	46.2^{b}	78.0^{a}	6.09
Palmitoleic acid	16:1	7.43^{ab}	8.47^{ab}	6.39^{b}	8.98$^{a'}$	2.46
Oleic acid	18:1n9c	34.1^{a}	33.3^{a}	36.8^{a}	0.07^{b}	5.99
MUFA [2)]		42.2^{a}	42.4^{a}	43.9^{a}	10.8^{b}	6.73
Linoleic acid	18:2n6c	6.02^{a}	5.86^{a}	1.99^{a}	0.09$^{a'}$	9.67
a-Linolenic acid	18:3n3	3.05^{a}	2.25^{ab}	2.78^{a}	1.14^{b}	1.59
Eicosatrienoic acid (ETE)	20:3n3	3.24^{a}	3.79^{a}	3.18^{a}	0.22^{b}	1.15
Docosahexaenoic acid	22:6n3	1.15^{ab}	1.02^{b}	1.06^{b}	1.63$^{a'}$	0.50
PUFA [3)]		14.9^{a}	14.0^{a}	9.92^{a}	10.3$^{a'}$	8.54
UFA [4)]		57.1^{a}	56.4^{a}	53.8^{a}	22.1^{b}	6.09
SFA:UFA		0.76^{a}	0.78^{a}	0.87^{a}	3.65^{b}	0.54

[a,b,c]Row means with different superscripts differ significantly at $P<0.05$.
[1]Saturated fatty acids, [2]Mono-unsaturated fatty acids, [3]Poly-unsaturated fatty acids, [4]Unsaturated fatty acids.

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37. Growth response curves for ostrich chicks fed diets with three different dietary protein and amino acid aevels (*Struthio camelus* var. *domesticus*)

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INTRODUCTION

In an attempt to decrease costs, several studies are being done on ostrich nutrition, as it comprises the largest part of the total costs in an intensive ostrich production system. This study was done to evaluate the growth response of ostrich chicks that were fed diets containing three different levels of protein and amino acids - by using linear and nonlinear models. The aim of this study is to apply different nonlinear and polynomial functions in order to describe the growth of ostriches and to compare different models to find a best-fit model for the data.

MATERIALS AND METHODS

In this trial 180 birds were divided into 18 groups, with 6 groups per treatment, and 10 birds per group. Birds either received a control diet (dietary crude protein and amino acid values predicted by the ostrich nutrition optimisation model) or diets 20% above and 20% below in terms of crude protein and essential amino acid content. Birds were weighed weekly. Complete growth data up until 287 days of age were analysed. Seven different growth models (Table 1) were applied to the data. Linear models (Table 1) with a polynomial structure from third up to fifth order of fit were applied to the growth data.

RESULTS AND DISCUSSION

Nonlinear models: Comparing the models using the AIC (Akaike's Information Criterion), certain models fitted the data better for different treatments (Table 2 and Figure 1). However, the aim of the study was to identify one model for all the data, and thus linear polynomial models were fitted to the data.

Linear polynomial models: The polynomial of the third order had the best fit to the data for the high, medium and low treatments (Table 3). The least square means (LS means) of the polynomial of the third order are depicted in Figure 2. The model that fits the data best is the polynomial of the third order.

Table 1. Growth functions considered for the modelling of ostrich growth data

Model	Equation	No. of parameters	Referrence
Gompertz	$W = a.\exp(-\exp(-b(t-c^*)))$	3	(Thornley & France, 2007)
Brody	$W = a \times (1 - b \times e^{(-c \times t)})$	3	(Fitzhugh, 1967)
Von Bertalanffy	$W = [(\frac{a}{b} - \frac{a}{b - W_0^{\frac{1}{3}}}) \times e^{\frac{1}{3} \times b \times t}]^3$	3	(Thornley & France, 2007)
Logistic	$W = \frac{a}{(1 + b \times e^{(-c \times t)})}$	3	(Fekedulegn *et al.*,1999)
Bridges	$W = W_0 + a \times (1 - e^{(-m \times t^p)})$	4	(Wellock *et al*., 2004)
Janoschek	$W = a - (a - W_0) \times e^{(-c \times t^m)}$	4	(Wellock *et al*., 2004)
Polinomials	$W = d_0 + \sum_{i=1}^{r} d_i \times t^i$	3-5	(Hadeler, 1974)

[1]W = BW; W_0= initial BW in kg; a = mature BW in kg; t = age in days; b, c, m and p= parameter specific for the function; r = second to fourth order of fit; d0 = intercept; di = regression coefficients.

Table 2 Values of Akaike's Information Criterion (AIC) for nonlinear models for the different treatments

Model	Treatment H	M	L
Nonlinear			
Gompertz	7290.9	8197.9	8384.7
Richards	7225.7	**8177.2**	8370.4
Logistic	7479.9	8270.3	8461.6
Von Bertalanffy	7240.6	8181.2	**8354.0**
Brody	7361.2	8233.3	8454.1
Bridges	**7222.6**	8183.8	8361.7
Janoschek	**7222.6**	8182.9	8358.8

[1]The lowest values for AIC are printed in boldface in each column.

Table 3 Values of Akaike's information criterion (AIC) for linear polynomial models for the different treatments

Model	Treatment H	M	L
Linear polynomial			
Polynomial, third order	**7309.5**	**8223.2**	**8394.8**
Polynomial, fourth order	7329.8	8258.2	8430.4
Polynomial, fifth order	7358.8	8288.1	8460.6

[1]The lowest values for AIC are printed in boldface in each column.

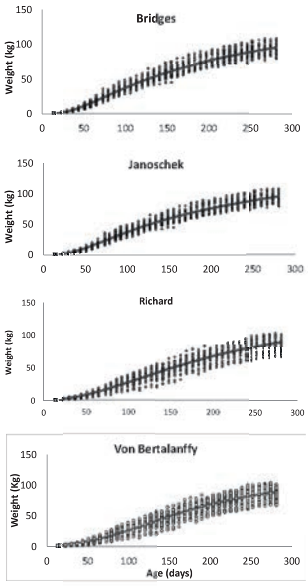

Figure 1. Growth curves for the ostriches as predicted by the Bridges and Janchek (H and Richards (M) and Von Bertalanffy (L) functions.

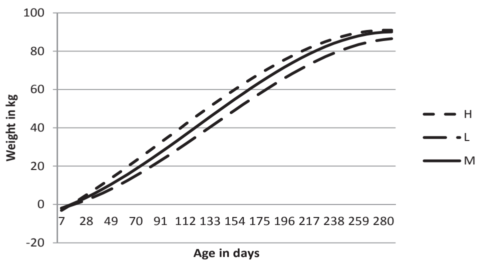

Figure 1 LS means for the polynomial of the third order for different treatments.

CONCLUSION

Concerning the different models, linear polynomial models had a better fit to the data, and of the linear polynomial models the polynomial of the third degree had the best fit to the data. The results of this study may help with future modelling work and the development of optimisation (simulation) models for ostriches.

38. Effects of lairage period and feed availability on the meat quality of ostriches

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BACKGROUND

- Transport and lairage losses responsibility allocation.
- Effects of time spent in lairage on meat quality.
- Effects of time spent in lairage on live and carcass weights.

PROCEDURE

1. A trial group of 92 birds was randomly divided into 4 groups.
2. Group 0 hr; Group 24 hr; Group 48 hr ; and Group 48 hr *ad lib*.
3. Birds were weighed each morning.
4. Birds were sleugtered.
5. Fan fillets of right drum were taken for processing.
6. Standard meat quality test, including shelf life test, was performed.

Group	L_ave LSMEAN	a_ave LSMEAN	b_ave LSMEAN	Chroma_ave LSMEAN	hue_ave LSMEAN	Shearforce_ave LSMEAN	pH LSMEAN	DripLoss_per LSMEAN	Cook_Loss_per LSMEAN
0 hr	$33.02^{a}\pm0.39$	$21.22^{a}\pm0.37$	$12.27^{a}\pm0.26$	$29.98^{a}\pm0.24$	$24.52^{a}\pm0.47$	$48.16^{a}\pm1.86$	$5.97^{a}\pm0.03$	$0.52^{ab}\pm0.07$	$37.28^{a}\pm0.35$
24 hr	$33.51^{a}\pm0.37$	$20.76^{a}\pm0.36$	$12.16^{a}\pm0.25$	$30.29^{a}\pm0.23$	$23.82^{a}\pm0.46$	$41.18^{a}\pm1.8$	$6.07^{a}\pm0.03$	$0.73^{b}\pm0.07$	$36.42^{a}\pm0.34$
48 hr	$33.39^{a}\pm0.54$	$20.48^{a}\pm0.52$	$12.15^{a}\pm0.36$	$30.66^{a}\pm0.33$	$23.82^{a}\pm0.66$	$42.46^{a}\pm2.59$	$6.04^{a}\pm0.04$	$0.39^{a}\pm0.09$	$34.23^{b}\pm0.49$
48 hr *ad lib*	$32.71^{a}\pm0.52$	$20.84^{a}\pm0.5$	$12.29^{a}\pm0.35$	$30.47^{a}\pm0.32$	$24.21^{a}\pm0.64$	$47.33^{a}\pm2.51$	$6.01^{a}\pm0.04$	$0.37^{a}\pm0.09$	$34.09^{b}\pm07$

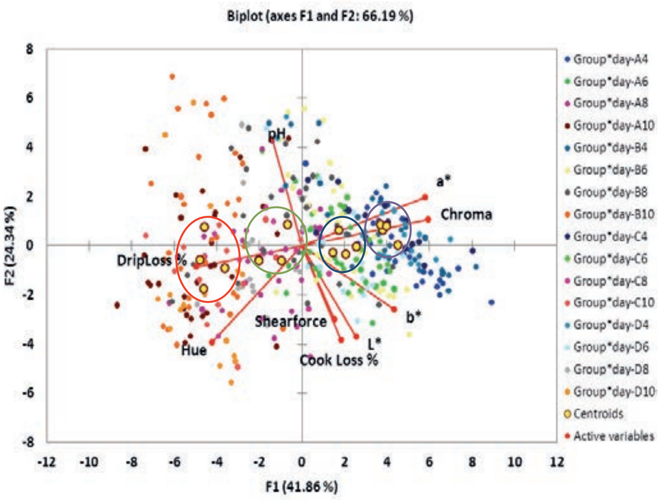
[a,b] LSM with different letter differs at P<0.05

Group	0 hr	24 hr	48 hr	48 hr *ad lib*
Dead carcass weight	$100.49^{a}\pm3.72$	$97.85^{a}\pm3.68$	$95.33^{a}\pm4.21$	$100.98^{a}\pm3.02$
Carcass weight	$49.21^{a}\pm1.67$	$47.47^{a}\pm1.65$	$45.85^{a}\pm1.89$	$48.5^{a}\pm1.36$
Dressing percentage as function of dead weight	$0.491^{a}\pm0.009$	$0.486^{a}\pm0.009$	$0.484^{a}\pm0.010$	$0.481^{a}\pm0.007$
Dressing percentage as function of loading weight	48.952 ± 0.48^{a}	47.71 ± 0.47^{a}	46.61 ± 0.67^{b}	47.22 ± 0.65^{a}
Time point 1	4.04 ± 0.3^{a}	0.58 ± 0.29^{b}	0.74 ± 0.42^{b}	1.63 ± 0.42^{b}
Time point 4	-	-	1.56 ± 1.56^{a}	-1.15 ± 2.45^{b}

[a,b] LSM with different letter differs at P<0.05

CONCLUSION AND DISCUSSION

- Percentage weight loss (cumulative) significantly different with >24 hr in lairage.
- Feeding animals in lairage effected dressing percentage and reduced weight loss.
- Results show that there is no significant difference between groups when looking at quality parameters.
- Current guidelines might have to be re-evaluated with regard to feed availability in lairage.
- Lairage time >24 hr increases weight losses.



39. Effect of cottonseed oilcake as a protein source on production of breeding ostriches

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INTRODUCTION

There is definite evidence that the international and local market has a growing demand for the production of ostrich products. Local farmers need to increase the production of ostriches, but still need to keep the production costs as low as possible. With the increasing production of ostrich chicks, the nutrition of the breeding stock needs to remain optimal. An increase in the prices of the raw materials - especially of protein sources - prevents the production of an economical product with a profitable positive margin. The possible use of cottonseed oilcake, instead of soyabean oilcake - as a cheaper protein option - was examined to determine the quantity and quality that can be used without any negative effects on the production of ostrich chicks. The natural toxin Gossypol occurs in cotton plants and negatively affects male reproduction, and also increases loss of appetite and weight loss in other species.

MATERIALS AND METHODS

Ninety six breeding pairs of South African Black ostrich were divided into two groups to determine the effects of the two different protein sources - cottonseed oilcake and soyabean oilcake - during the breeding season. Cottonseed oilcake and soyabean oilcake were included at respectively 2 x and y percentage of the diets, which were formulated to be iso-nutritious. All data relating to the breeding ostrich production were monitored, and included live mass change of the breeder birds, egg production, and chick production.

RESULTS AND DISCUSSION

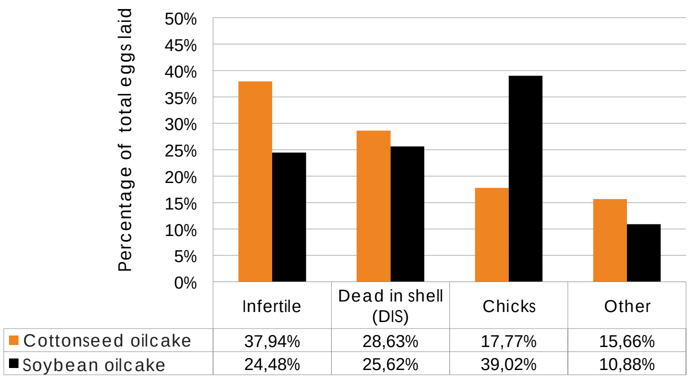
The inclusion of cottonseed oilcake meal in diets had no significant effect on the total number of eggs produced (47.9±3.6 vs 50.3±3.7) or the number of infertile eggs (31.5±3.9 vs 39.3±4.0), while there was a tendency ($p=0.06$) for an increase in the number of dead-in-shell chicks (20.2±2.4 vs 26.8±2.5). The inclusion of cottonseed oilcake meal in diets of breeding birds, however led to a 21.3% decrease in chick production (8.9 vs 18.7 chicks/hen/breeding season). The percentage Gossypol in the cottonseed oilcake was determined to be 10-20 ppm.

Table 1. Least square means (±SE) and significance for different characteristics of ostrich egg hatchability for the different protein source treatments.

Treatment	Egg production	Min	Max	% Infertile eggs	%DIS*	Number of chicks
COSC	50.3±3.7[a]	5	97	39.3±4.0[a]	26.8±2.5[a]	17.1±3.1[a]
SOC	47.9±3.6[a]	4	91	31.5±3.9[a]	20.2±2.4[a]	36.1±3.0[b]

[a,b]Least square means within column with different superscripts for treatment differs significantly ($P < 0.05$)
*Dead-in-shell

Figure 1. Effect of two different protein sources on the hatchability of ostrich eggs.



CONCLUSION

It can be concluded from this study that the inclusion of cottonseed oilcake meal at the indicated levels in the diets of breeding ostriches will have a detrimental effect on chick production.

40. Albumin: yolk ratios and egg weight of ostrich eggs during the breeding season

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INTRODUCTION

Ostriches are considered to be seasonal breeders; as they are photoperiod dependent, they are dependent on daylight length (Bronneberg *et al.*, 2007). The month of production has an effect on the egg quality, fertility and hatchability of the ostrich egg - due to the effect that daylight length has on the photo-dependant physiological system of the birds (Elsayed, 2009; Bronneberg *et al.*, 2007). The change in egg size and the change in yolk:albumin ratios over the breeding season, are important in modelling the nutrient requirements used by ostrich breeders.

MATERIALS AND METHODS

During the breeding season - from mid-May to mid-December - eggs where collected twice a day from 96 domesticated South African Black ostrich breeding pairs. Sixteen eggs were then chosen randomly each month for further analysis. The breeding pairs of ostriches were kept in breeder camps of ¼ hectare per pair, and received breeder diets *ad libitum*. To determine the total egg weight, the ostrich egg was first weighed and then the albumin, yolk and shell components were separated in an unfrozen state. The weight of each of these components was determined and the Y:A ratios of 107 ostrich eggs were calculated.

RESULTS AND DISCUSSION

Figure 1. Ostrich egg weight change from May to December.

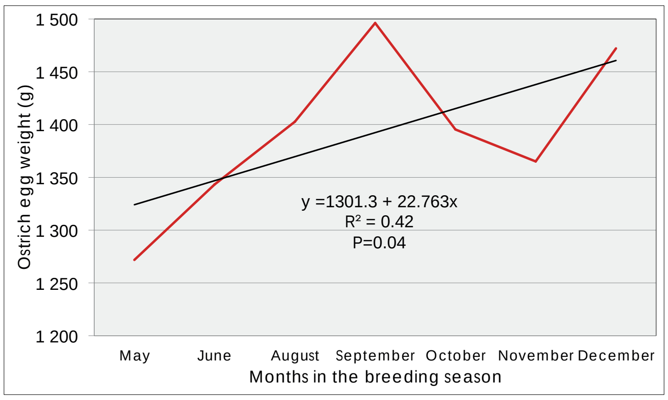
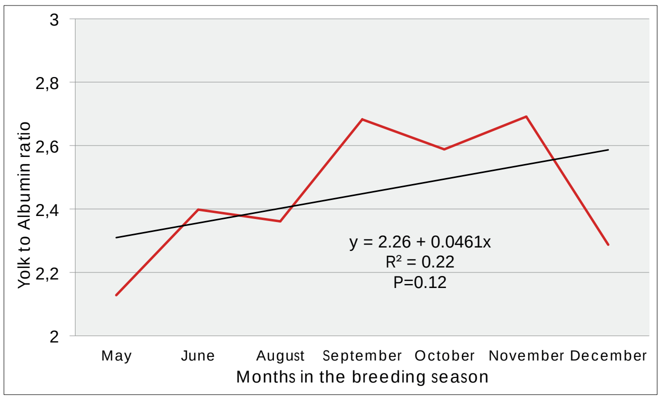


Figure 2. Albumin:Yolk ratio change of an ostrich egg from May to December.



With the data collected, the average ostrich egg weight was 1372.4 g, and consists of 781.0 g albumin, 321.6 g yolk, and 285.6 g shell. It is evident from Figure 1 that egg weight increases by 22.8 g/month over the breeding season. No significant change in albumin: yolk ratio (2.26) of ostrich eggs occurred during the breeding season.

CONCLUSION

The change in egg weight and the albumin:yolk ratio are important in modelling the nutrient requirements that need to be used by ostrich breeders. Egg weight is also an important factor which effects the hatchability and survivability of ostrich chicks.

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Elsayed MA. 2008. Effect of month of production on external and internal ostrich egg quality, fertility and hatchability, *Egypt Poultry Science* 29:547-564.

41. Effects of the inclusion of cottonseed oilcake on the production of grower and finisher ostriches

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INTRODUCTION

Cottonseed oilcake (CSOC) is a rich source of protein and amino acids and can be incorporated into the diets of animals. Its value as an animal feed may, however, be limited by Gossypol - a toxic polyphenolic pigment contained in glands located throughout the plant. The content of Gossypol in whole cottonseed ranges from 0,02% up to 6,64% and is thought to deter insects. Gossypol primarily impacts negatively on the heart and liver of the animal. The purpose of this study was to address the issue of feeding cottonseed oil cake to a monogastric animal like an ostrich.

MATERIALS AND METHODS

A total of 105 ostriches were used to study the effect of the inclusion of cottonseed oilcake on their production. Five different diets with 0%, 3%, 6%, 9%, and 12% of CSOC, respectively, were fed to the animals. Three replicate paddocks with 7 birds per diet were used.

RESULTS AND DISCUSSION

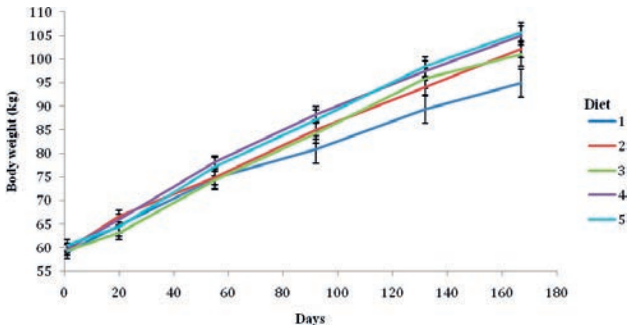
Chemical analysis revealed free gossypol below 10 ppm in the mixed feeds, while results in CSOC showed 82 ppm free gossypol, 4790 ppm chemically bound gossypol, and 4872 ppm total gossypol.

Table 1. Average daily weight gain (ADG), feed intake (FI) and feed conversion rate (FCR) of ostriches that received CSOC at 0, 3, 6, 9 and 12% in their diets.

Diet	CSOC content (%)	ADG (g/bird/day) ± SE	Feed Intake (kg/bird/day) ± SE	FCR (kg feed/kg weight gain) ± SE
1	0	219^{b}±21	1.775^{ns}±0.052	8.471^{ns}±0.554
2	3	248^{ab}±10	1.915^{ns}±0.153	7.528^{ns}±0.608
3	6	266^{ab}±19	1.867^{ns}±0.044	8.130^{ns}±0.986
4	9	277^{a}± 9	1.917^{ns}±0.076	7.454^{ns}±0.427
5	12	287^{a}±12	1.927^{ns}±0.110	7.403^{ns}±0.574

^{a,b}Columm means with common superscripts do not differ (P>0.05)

Figure 1. Growth curve of ostriches fed five different diets containing increasing levels of cottonseed oilcake as a protein source. Values presented as means ± SE.



No significant effect of the inclusion of CSOC – up to 12% – in the diets of finisher ostriches on either feed intake or feed conversion ratio was observed. Birds consuming the diet with 9% and 12% CSOC grew significatly faster compared to the groups with 0% CSOC in their diet.

CONCLUSIONS

The study suggests that CSOCM may by used up to 12% in the diets of ostriches without any detrimental effect on production. It is, however, important to analyse the Gossypol content of the source of CSOCM before it is included in the diet - to make sure that the content of the final diets is within safe limits.

42. The prediction of oleic and linoleic acid content of sunflower seeds by using near-infrared reflectance spectroscopy (NIRS)

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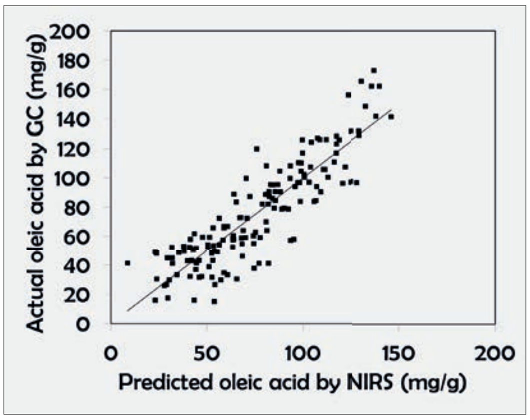
INTRODUCTION

Sunflower (*Helianthus annuus L.*) is one of the major oil production crops in the world. Sunflower seeds provide high-energy feed for livestock due to their high fat content and are a good source of protein. Sunflower oil is widely used for food products such as salad oil, as animal feed and is also used in non-foods, such as paints and cosmetics. Fatty acid analysis with gas liquid chromatography (GC) is time consuming and expensive, thus the screening of fatty acids using a cost effective method, such as the NIRS, was tested.

MATERIALS AND METHODS

A total of 100 samples of sunflower seeds with a large range in variation in their fatty acid composition were used in the development and validation of NIRS calibrations. The milled sunflower seeds were analysed by GC and were scanned on a Bran + Luebbe InfrAlyzer 500.

Figure 1. Predicted vs. actual oleic acid values.



RESULTS AND DISCUSSION

Calibration equations for oleic and linoleic acid were developed using modified partial least square regression (MPLS) with internal cross validation. Table 1 shows the results obtained in the calibration equations developed from samples scanned for fat, oleic acid and linoleic acid. The coefficient of determination in calibration (r^2cal) and the standard error in calibration (SEC) for crude fat were 0.79 and 1.31respectively; for oleic acid 0.77 and 16.80 respectively and for linoleic acid 0.87 and 12.51 respectively. NIRS is a technique used on a large scale for routine analysis. The NIRS technique is non-destructive, fast, cost-effective, environmentally safe and it allows the simultaneous estimation of several analyses. Figure 1 represents the laboratory reference values against NIRS-predicted values for oleic acid (mg/g).

Table 1. Calibration and cross validation statistics in NIRS equations for fatty acid composition.

Fatty acid	Calibration		Cross validation		Actual lab values (mg/g)	NIRS predicted values (mg/g)
	r^2	SEC	r^2	SEC	Mean	Mean
Crude fat	0.79	1.31	0.64	2.69	37.04	37.49
C18:1 (Oleic acid)	0.77	16.80	0.71	41.34	74.48	76.05
C18:2 (Linoleic acid)	0.87	12.51	0.75	24.30	49.51	48.00

r^2 – coefficient of determination in calibration
SEC – standard error in calibration

CONCLUSION

The data suggest that NIRS is a tool which can be used for the rapid prediction of the nutritional value of fatty acids in sunflower seeds with a precision which can be used as a routine quality control tool.

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43. Prediction of the chemical composition of ostrich meat with near-infrared reflectance spectroscopy

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INTRODUCTION

Ostrich meat is perceived and marketed as a healthy alternative to other types of red meat, due to a favourable fatty acid profile and a low intramuscular fat content. The high ultimate pH value of ostrich meat makes it an ideal processing meat, since the natural water-binding capacity is high, which in turn could reduce the use of moisture-retaining agents such as phosphates when being processed. Frequent analysis of the chemical composition is very important in the processing of meat. NIRS analysis is a rapid and accurate technique for the determination of the chemical composition in the industrial meat-processing industry. This study was done to determine to what extent NIRS could be used as a rapid technique for predicting the composition of ostrich meat.

MATERIALS AND METHODS

Samples used for calibrations consisted of freeze-dried tender loin (*M. ambiens*), big drum (*M. iliofibularis*) and fan fillet (*M. gastrocnemius*). Standard laboratory chemical analyses were performed on all the samples. NIRS analyses were done with an InfraAlyzer 500 Near Infrared Reflectance Analyser (IA-500) using Bran+Luebbe SESAME Version 2.00-software (BRAN+LUEBBE GmbH, Norderstedt, Germany).

RESULTS AND DISCUSSION

SEP values for CP (0.64%) and fat (0.18%) were within two multiplications of the SEL and could therefore successfully be used to predict the chemical composition of ostrich meat (Table 1). The SEP value of DM (0.75%) was more than double the SEL value (0.27%). Ash had a low r value, together with a high SEP value. NIRS is therefore unsuitable for predicting the moisture and ash values of freeze-dried ostrich meat.

Table 1. Statistics of the calibration equations (for freeze-dried ostrich meat) of best fit and validation, including the number of PLSR factors used for each equation, standard error of calibration (SEC), standard error of performance (SEP) and standard error of laboratory (SEL).

Chemical component	Number of PLSR factors	r	Calibration set SEC (%)	r	Validation set SEP (%)	SEL (%)	Laboratory Mean Values (%)	Predicted Mean Values (%)
Ash	10	0.72	0.29	0.71	0.23	0.05	4.84	4.89
DM	4	0.72	1.01	0.85	0.75	0.27	97.01	97.05
CP	7	0.98	0.55	0.97	0.64	0.47	90.59	90.67
Fat	3	0.99	0.29	0.99	0.18	0.29	3.83	3.83

CONCLUSION

The NIRS calibrations developed in this study showed high correlation coefficients and SEP values relative to analogous AOAC methods, particularly for fat and CP. The calibrations for ash and DM were not that accurate on freeze-dried ostrich meat. The authors, however, suggest that calibrations should be developed on raw meat samples, due to the time and cost implications of freeze-drying.

44. Effects of different dietary energy and protein levels on the digestive anatomy of ostriches

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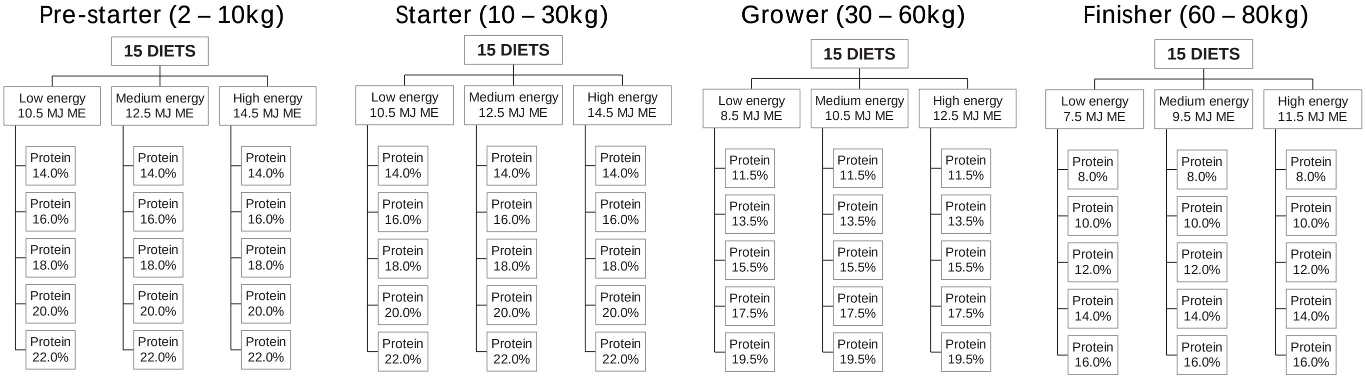
INTRODUCTION

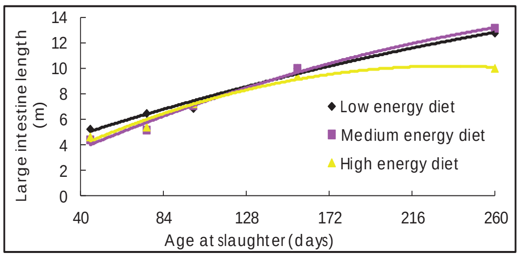
Ostriches are reared on a large variety of diets, due to the incomplete knowledge of their precise nutrient requirements. The effect of adverse nutrition would be most pronounced in early life, when nutrients are required for the development of the gastrointestinal tract (GIT), metabolic maintenance and body growth.

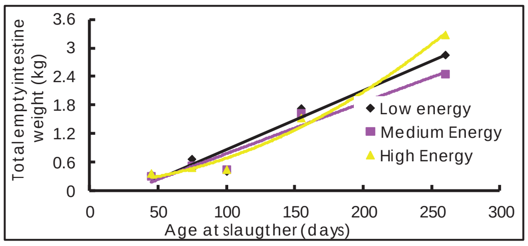
MATERIALS AND METHODS

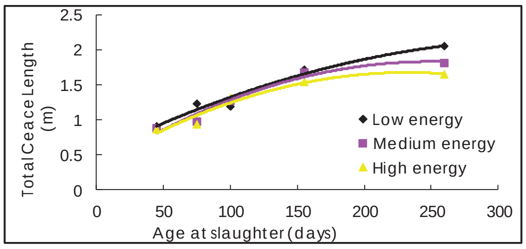
15 diets with 3 energy levels and 5 protein levels were fed to 15 groups of ostriches in a 3 x 5 factorial experimental design.



Ostriches (15 per age group) were slaughtered at 5 kg, 10 kg, 20 kg, 40 kg and 80 kg live weight (45, 75, 100, 155 and 260 days, respectively). The lengths of the small intestine, the large intestine and the caeca were measured. Each segment of the GIT was rinsed with water to remove the gut content and weighed to determine the empty weight. Differences in the intestine components of the different energy and protein ratios per live weight group were determined by multi-factor analysis of variance using a protected F-value. The live weight of birds for each age group was used as co-variant.







RESULTS AND DISCUSSION

The increase in dietary energy concentration led to a decrease in large intestine and total caeca length, as well as total intestine and stomach weight. This was probably due to the higher fibre content of low energy diets. It has been shown in the literature that diets with higher fibre content result in a longer retention time in the digestive tract due to its bulkiness and physical appearance, hence resulting in a larger GI tract.

Generally a decline in the small intestine length was also noted with an increase in dietary energy level, although not significant at all ages. This was most evident at older slaughter ages. This phenomenon can be explained by the fact that the ostrich GI tract switched from one that resembled the typical monogastric animal to that of a hindgut fermenter at about 70-80 days of age. An increase in dietary protein concentration at 20 kg, 40 kg and 80 kg live weight led to a decrease in total intestine weight.

CONCLUSION

The results indicated that a diet lower in both energy and protein results in a larger GI tract in the ostrich. A larger GI tract could lead to better digestion and absorption of ingested feed.

45. The composition of egg yolk of ostrich chicks from one to seven days post-hatching

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INTRODUCTION

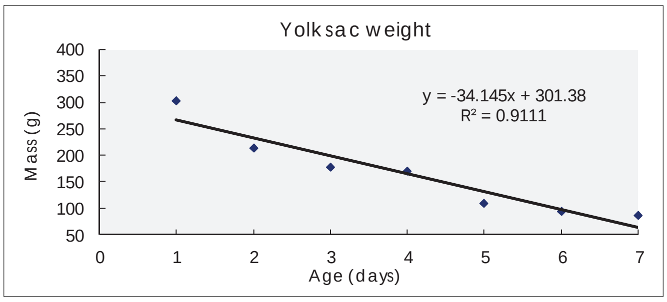
The average ostrich egg weighs about 1455 g, of which 18% comprises shell weight and 82% egg content. The egg content is 34% yolk and 66% albumin. In an ostrich chick with a live mass of 800 g the yolk sac represents a relatively high proportion of the total body and weighs about 450 g. It contains yolk lipids, protein and albumin proteins. The presence of bile deposited during incubation gives it a bright green colour. The yolk mass in the hatching chick amounts to 20-25% of its body weight. Literature reports that approximately 85% of residual yolk from the yolk sac is absorbed by the 5th day post-hatch. Absorption of yolk at the optimal rate occurs under a uniform environment and low-stress conditions. In domestic fowl, consumption of feed actually increases the rate of yolk utilization over that observed in fasted chicks. The current study determined the chemical composition of the yolk sac of starved ostrich chicks up to seven days post-hatch.

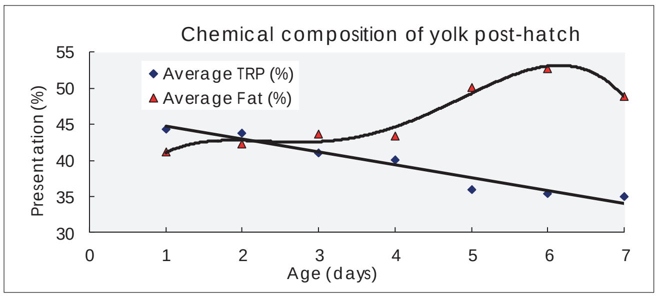
MATERIALS AND METHODS

In this experiment 35 ostrich chickens were used. The chicks were provided with clean drinking water. Five ostrich chicks were slaughtered each day for seven consecutive days, starting from the day of hatching as day one. The yolk sac was removed after slaughtering, weighed, freeze-dried and analyzed for protein and fat content.

RESULTS AND DISCUSSION

The live weight of the ostrich chicks decreased from 832.6 g to 661.4 g over the seven-day experimental period. Live weights showed a linear decline (R^2 = 0.90; SE = 4.81) over the period. The yolk sac weight decreased from 303.01 g to 86.25 g over the 7-day period and showed a linear decline (R^2 = 0.91; SE = 4.77). The protein content decreased from 44.33% to 34.95% and also showed a linear decline (R^2 = 0.95; SE = 0.19) from day one to seven. The fat content of the yolk however increased from 41.17% to 48.89% over the 7-day period. The fat content of the yolk displayed a polynomial increase (R^2 = 0.97; SE = 0.06) up to day six, whereafter it showed a decline at day seven. The weight change of the yolk sac of the ostrich chick up to 7 days post-hatching is similar to values noted for fasted chicks.





CONCLUSION

The chemical composition of the yolk sac of ostrich chicks indicates that ostrich chicks have some ability for selective nutrient withdrawal. This was also found for fasted turkey poults, although in a converse relationship with a decrease in fat and increase in protein percentage.

46. Growth of the reproduction organs of breeding ostriches during the breeding season

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INTRODUCTION

Determining how the reproduction organs of the female breeding ostrich grow during the breeding season, may help to develop a feeding strategy for breeding female ostriches. A study was therefore conducted to monitor the development of the reproduction organs of the female ostrich during the first 49 days of the breeding season.

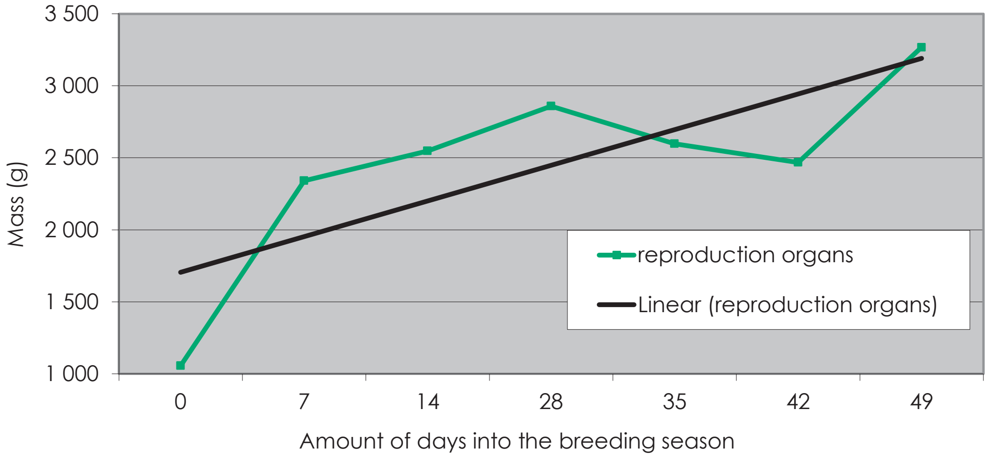
MATERIALS AND METHODS

Forty breeding female ostriches were slaughtered over an 8-week period during the beginning of the breeding season. Five ostriches were slaughtered per week, starting with the first slaughter at the onset of the annual breeding season. The ovary and oviduct were collected and weighed after each slaughter interval.

RESULTS

A linear regression ($y=1734+29x$; $R2=0.59$; SE estimation=480 g; $p<0.05$) fitted on the mean values showed that the organs grew at a rate of 29g/day during the first 49 days of the breeding season.

Figure 1. Growth of reproduction organs of female breeding ostriches during the breeding season.



CONCLUSION

This study revealed the growth rate of the reproduction organs at the beginning of the breeding season. These data will be used to determine protein and amino-acid accumulation in the reproduction organs and will be incorporated in an optimizing model (Brand & Gous, 2006) that will be used to predict the nutrient requirements of female breeding ostriches.

REFERENCE

Brand TS & Gous RM 2006. Feeding ostriches. In: *Feeding in domestic vertebrates: from structure to behaviour*. Ed: Bels V pp. 136-155, CAB Publising, Wallingford, UK.

47. The influence of dietary protein on the production of breeding ostriches (*Struthio camelus*)

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INTRODUCTION

Information about the protein (amino acid) requirements of breeding ostriches is limited. Reliable, scientific evidence is needed for accurate diet formulation. Hence a study was conducted with breeding ostriches to determine the influence of dietary protein on production.

MATERIALS AND METHODS

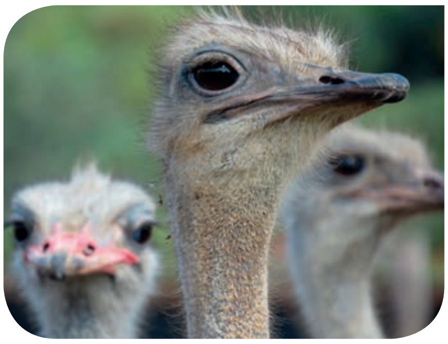
Five rations, each with a different protein concentration, were provided to both females and males over two subsequent breeding seasons at a level of 2.5 kg/bird/day. The respective diets included 7.5%, 9.1%, 10.8%, 12.3% and 14% protein, with an accompanied amino-acid profile. The energy concentration of each diet was 9.2 MJ ME/kg.

RESULTS

MEANS AND STANDARD ERRORS FOR PRODUCTION DATA AT DIFFERENT DIETARY PROTEIN AND AMINO-ACID LEVELS						
Crude protein	7.5%	9.1%	10.8%	12.3%	14.0%	P
Lysine levels	0.29%	0.36%	0.44%	0.51%	0.58%	
Egg production (eggs/female/season)	34.7 ± 3.5^{a}	46 ± 3.6^{b}	43.5 ± 3.6^{ab}	35.6 ± 3.6^{a}	35.6 ± 3.6^{a}	p>0.05
Unfertilized eggs (eggs/female/season)	7.6 ± 1.8^{a}	11.4 ± 1.8^{a}	7.9 ± 1.8^{a}	7.1 ± 1.8^{a}	10.4 ± 1.8^{a}	p>0.05
Dead-in-shell chicks (chicks/female/season)	7 ± 1.2^{ab}	10 ± 1.2^{b}	8.6 ± 1.2^{ab}	8.3 ± 1.2^{ab}	6.2 ± 1.2^{a}	p>0.05
Chick production (chicks/female/season)	17.4 ± 2.4^{ab}	22 ± 2.5^{ab}	23.4 ± 2.5^{b}	17 ± 2.5^{ab}	15.9 ± 2.5^{a}	p>0.05
Males' mass change(kg)	-13.3 ± 2.1^{a}	-10.2 ± 2^{a}	-11.7 ± 2^{a}	-3.8 ± 2^{b}	-11.6 ± 2^{a}	p<0.05
Females' mass change(kg)	-15.2 ± 1.7^{a}	-14.3 ± 1.6^{a}	-17.8 ± 1.6^{a}	-14.8 ± 1.7^{a}	-18.8 ± 1.6^{a}	p>0.05
Number of breeding days	222 ± 4.7^{a}	237.5 ± 4.8^{b}	241.5 ± 4.8^{b}	236 ± 4.8^{b}	243.5 ± 4.8^{b}	p<0.05
*rows with different superscripts denotes significant differences						

DISCUSSION

It was concluded that the production of ostrich breeding pairs was independent of the dietary protein and amino-acid concentrations used in this study.



48. Genotype x dietary protein interaction of breeding ostriches (*Struthio camelus*)

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INTRODUCTION

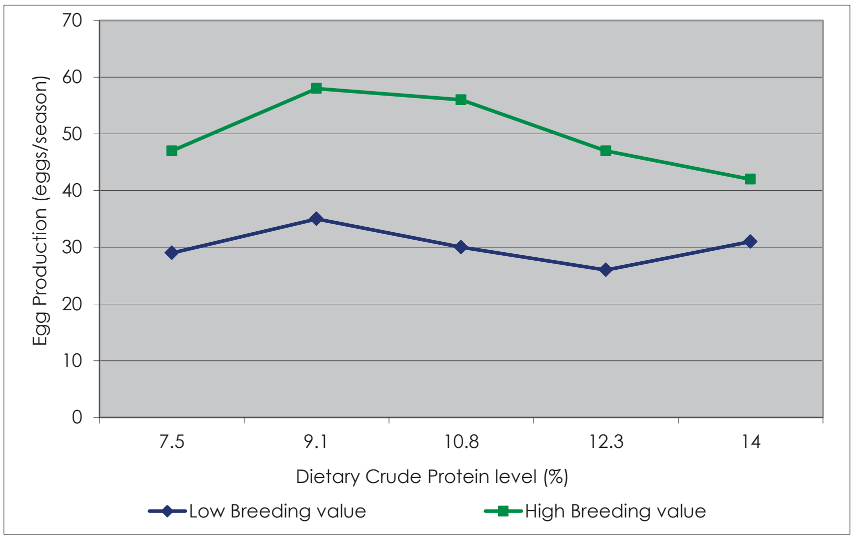
A study was conducted with breeding ostriches to determine if dietary protein/amino-acid level interacts with the breeding value for chick and egg production. The effect of dietary protein was compared within a breeder flock which consisted of females with a high potential for egg production (high predicted breeding value) and females with a low potential (low predicted breeding value).

MATERIALS AND METHODS

Five rations, each with a different protein concentration, were provided to both females and males over two subsequent breeding seasons at a level of 2.5 kg/bird/day. The respective diets included 7.5%, 9.1%, 10.8%, 12.3% and 14% protein. The energy concentration of each diet was 9.2 MJ ME/kg. Egg and chick production was measured.

RESULTS

Figure 1. Low breeding value vs. high breeding value for egg production.



DISCUSSION

No interaction occurred between genotype and the dietary protein concentration for either egg or chick production. The high potential ostriches produced more eggs and chicks than their low potential contemporaries, 49.9±2.1 vs. 30±2.1; (P<0.01) and 25.1±1.5 vs. 13.8±1.5; (P≤0.01), respectively for egg and chick production.

CONCLUSION

It was concluded that the reproduction of both high-breeding-value and low-breeding-value ostrich females was independent of the dietary protein and amino-acid concentrations used in this study.

49. Influence of different dietary energy and protein levels on egg production patterns of breeding female ostriches

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INTRODUCTION

- It is important to provide adequate, but not excessive amounts of nutrients to female ostrich breeders.
- The producer needs cost-effective diets without compromising egg-production, fertility or hatchability of eggs.
- Aim: To assess the effect of different energy and protein levels on the monthly egg production of female ostrich breeders.

MATERIALS AND METHODS

- Ninety adult breeding pairs were randomly divided into nine groups, with 10 pairs each for three production cycles.
- First breeding season - 1998:
  - •Energy levels of 8.5, 9.5 and 10.5 MJ ME/kg feed
  - •Protein levels of 13.5%, 15% and 16.5%
- Second breeding season - 1999:
  - •Energy levels of 7.5, 8.5 and 9.5 MJ ME/kg feed
  - •Protein levels of 10.5%, 12% and 13.5%
- Third breeding season - 2003:
  - •Energy levels of 7.5, 8.5 and 9.5 MJ ME/kg feed
  - •Protein levels of 8.5%, 11.25% and 14%
- Amino-acid profile was balanced and related to the protein content of the diets.
- Egg production distribution for June, July, August, September, October, November, December, January and February, the normal breeding season, was recorded.
- Data were analyzed according to 3x3 factorial design.

RESULTS

- Different levels of dietary energy had no significant effect on monthly egg production for the first breeding season.
- During the two other breeding seasons, females fed diets with energy levels as low as 7.5 MJ ME/kg feed, produced significantly fewer eggs towards the end of each breeding season (Figures 2 and 3).
- Different levels of dietary protein had no significant effect on monthly egg production for the first breeding season.
- Females fed diets with 12% and 13.5% protein produced significantly fewer eggs at the end of the breeding season than breeders fed the diet with 10.5% protein (Figure 5).
- Females fed the diet with 8.5% protein produced significantly fewer eggs during July, while no significant differences occurred during the rest of the breeding season (Figure 6).

DISCUSSION

- During both the 1999 and 2003 breeding seasons, it was evident that energy levels lower than 8.5 MJ influenced egg production negatively, especially towards the end of the breeding season in 2003.
- Dietary crude protein levels as used in these experimental production systems did not comprehensively effect monthly egg-production patterns.

Figure 1. The influence of diet energy on monthly egg productions for the 1998 breeding season.

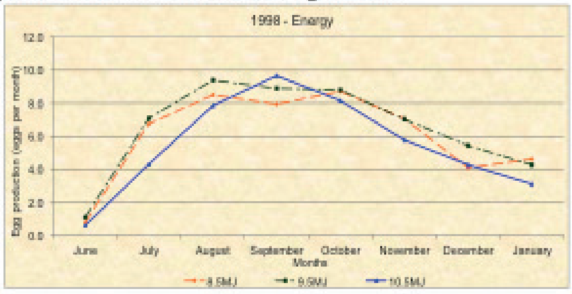


Figure 2. The influence of diet energy on monthly egg productions for the 1999 breeding season.

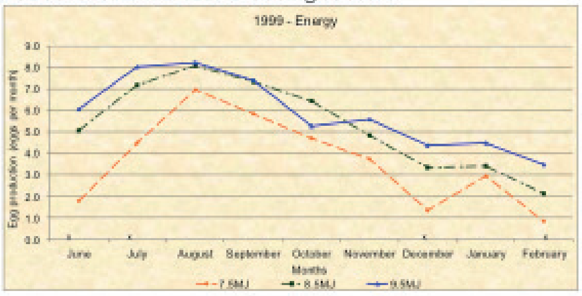


Figure 3. The influence of diet energy on monthly egg productions for the 2003 breeding season.

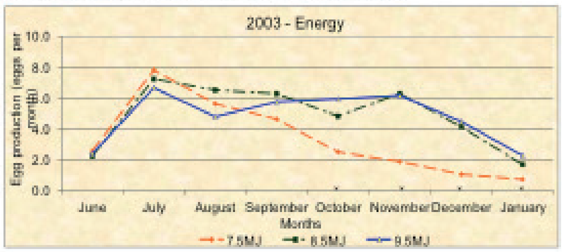


Figure 4. The influence of diet protein on monthly egg productions for the 1998 breeding season.

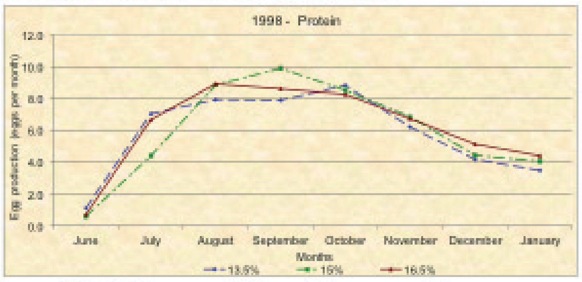


Figure 5. The influence of diet protein on monthly egg productions for the 1999 breeding season.

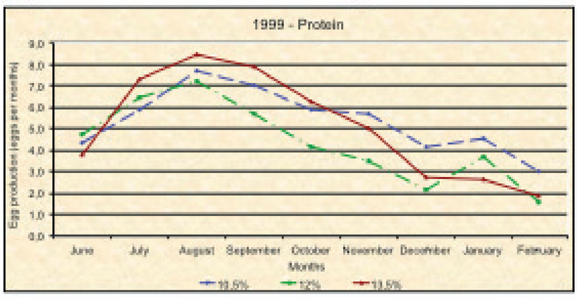
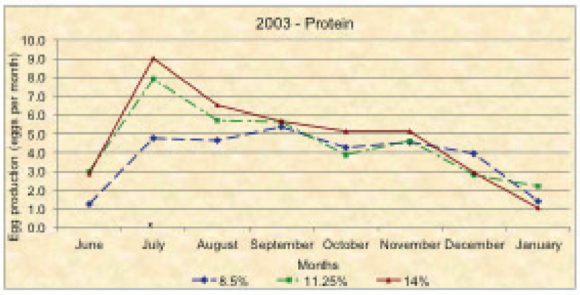


Figure 6. The influence of diet protein on monthly egg productions for the 2003 breeding season.



50. Effect of dietary energy and protein levels on the composition of ostrich eggs

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INTRODUCTION

- The yolk and albumin in the egg supply the developing embryo with nutrients and water for normal growth. Nutrient deficiencies in the egg at laying may result in embryonic mortality and reduced hatchability.
- Aim: To assess the influence of different dietary energy and protein levels on the composition of ostrich eggs.

MATERIALS AND METHODS

- Ninety pairs of adult breeding ostriches were divided randomly into nine groups of ten pairs per group.
- The groups were fed dietary levels of 7.5, 8.5 and 9.5 MJ/kg metabolizable energy and protein levels of 10.5, 12 and 13.5%.
- Data on collected eggs were statistically analyzed according to a 3x3 factorial design.

RESULTS

- Dietary energy and protein levels had no effect on the physical characteristics (i.e. yolk and albumin fractions) of ostrich eggs.
- Dietary protein levels had no effect on the nutritional content of albumin and yolk of ostrich eggs, but energy levels resulted in significant differences (Table 1).
- Dietary protein levels had no effect on the concentration of amino acids in the albumin of ostrich egg, except for arginine which showed no consistent pattern.
- Dietary energy levels did have an effect on the concentration of amino acids in the albumen of ostrich eggs (Table 2).

Table 1. The effect of dietary energy levels on the nutritional content of albumin and yolk of ostrich eggs. (Mean ± S.E.).

Egg composition	Energy level (MJ/kg)		
	7.5	8.5	9.5
YOLK			
Moisture, %	47.0 ± 0.3^{a}	48.2 ± 0.2^{b}	48.1 ± 0.3^{b}
Dry matter, %	53.0 ± 0.3^{a}	51.8 ± 0.2^{b}	51.9 ± 0.^{b}
Ash,%	3.8 ± 0.2^{ab}	4.2 ± 0.1^{a}	3.8 ± 0.2^{b}
Crude protein, %	31.0 ± 0.6	32.2 ± 0.4	31.9 ± 0.6
Lipid, %	57.9 ± 0.6	57.3 ± 0.3	57.3 ± 0.5
ALBUMIN			
Moisture, %	90.0 ± 0.6	90.3 ± 0.4	89.8 ± 0.6
Dry matter, %	10.0 ± 0.6	9.7 ± 0.4	10.2 ± 0.6
Ash,%	7.1± 0.2	7.4 ± 0.1	6.9 ± 0.2
Crude protein, %	76.4 ± 0.7	76.8 ± 0.4	78.0 ± 0.7
Lipid, %	0.09 ± 0.07^{a}	0.30 ± 0.04^{b}	0.19 ± 0.06^{ab}

a,b Denote significant ($P \leq 0.05$) difference in rows.

Table 2. The effect of dietary energy levels on the amino-acid content of the albumin of ostrich eggs. (Mean ± S.E.).

Amino acid g/100 g	Energy (MJ/kg ME)		
	7.5	8.5	9.5
Essential			0.95 ± 0.21
Methionine	0.63 ± 0.22	1.07 ± 0.15	4.6 ± 0.09
Lysine	4.6 ± 0.10	4.4 ± 0.07	3.2 ± 0.11^{c}
Arginine	2.1 ± 0.11^{a}	2.9 ± 0.8^{b}	3.6 ± 0.09^{b}
Threonine	3.4 ± 0.09^{ab}	3.3 ± 0.06^{a}	5.1 ± 0.05^{a}
Valine	5.0 ± 0.06^{a}	4.8 ± 0.04^{b}	4.1 ± 0.05^{b}
Phenylalanine	3.9 ± 0.05^{a}	3.9 ± 0.04^{a}	4.5 ± 0.05^{a}
Isoleucine	4.4 ± 0.05^{a}	4.2 ± 0.04^{b}	6.6 ± 0.07^{b}
Leucine	6.4 ± 0.07^{ab}	6.2 ± 0.05^{a}	1.3 ± 0.22
Histidine	1.7 ± 0.23	1.5 ± 0.16	
Non-essential			4.0 ± 0.22
Serine	4.0 ± 0.24	3.5 ± 0.16	4.4 ± 0.17
Tyrosine	4.0 ± 0.18	4.0 ± 0.12	
Acidic amino acids			6.2 ± 0.11^{a}
Aspargine	6.1 ± 0.12^{a}	5.7 ± 0.08^{b}	9.3 ± 0.11^{a}
Glutamine	9.1 ± 0.12^{a}	8.8 ± 0.08^{b}	
Aliphatic amino acids			2.4 ±
Glycine	2.5 ± 0.06^{a}	2.3 ± 0.04^{b}	0.06^{ab}
Alanine	3.4 ± 0.09^{ab}	3.2 ± 0.06^{a}	3.5 ± 0.09^{b}
Basic amino acids			
Proline	3.2 ± 0.07^{a}	2.9 ± 0.05^{b}	3.1 ± 0.6^{a}
Hydroxyproline	0.04 ± 0.04	0.01 ± 0.02	0.01 ± 0.03

a,b,c Denote significant ($P<0.05$) difference in rows.

DISCUSSION

- Neither energy nor protein dietary levels had any significant effect on the physical characteristics of ostrich eggs.
- Dietary energy levels affected the lipid content of the albumin fraction of the egg.
- Dietary energy levels, in several cases, affected the amino acid composition of ostrich eggs.
- Dietary protein did not have any significant effect on the amino acid composition of the egg.

ACKNOWLEDGMENTS

This study was financially supported by the Klein Karoo Cooperation, Oudtshoorn and THIP.

51. Effect of the nutritional regime in the previous breeding season on production of female ostriches in the successive year

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INTRODUCTION

- Feed cost represents 70-80% of the total production cost of an intensive ostrich enterprise.
- In times of economic hardship farmers have the tendency to cut production costs.
- Aim: To determine the effect of the previous breeding season's nutritional regime on the production of female birds in the following breeding season.

RESULTS

- Dietary energy levels, as used in 1999, had no effect on production of female ostriches during the first successive breeding season, but during the second successive breeding season dietary energy levels as used in 2000 lead to significant differences as shown in Table 1.
- Dietary protein levels had no effect on production of female ostriches during the first and second successive breeding seasons.

DISCUSSION

- Neither energy nor protein had a carry-over effect on the mass of breeding ostrich females.
- Energy levels of 7.5 MJ/kg fed in the previous breeding season reduced egg production in the successive season.
- Dietary energy levels fed during the previous season had no effect on the hatching mass of chicks.
- The proportion of chicks hatched was lower due to lower energy fed the previous year.
- It may be concluded that a diet of less than 8.5 MJ/kg DM fed the previous year may reduce production of female ostriches in the successive year.

ACKNOWLEDGMENTS

This study was financially supported by the Klein Karoo Cooperation, Oudtshoorn and THRIP.

MATERIALS AND METHODS

- The trial ran over three breeding seasons (1999, 2000 and 2001).
- Dietary energy and protein levels used:
  - o First season(1999) - 8.5, 9.5 10.5 MJ/kg DM and 13.5, 15 and 16.5% protein
  - o Second season(2000) - 7.5, 8.5 and 9.5 MJ/ kg DM and 10.5, 12 and 13.5% protein
  - o Third season(2001) - 0.5 MJ/kg DM and 12% protein
- Data were statistically analyzed according to a 3x3 factorial design.

Table 1. The effect of dietary energy levels received in the previous year on production of female ostriches during the successive year. (Mean ± S.E.).

Production Parameters	PRODUCTION IN THE SECOND SUCCESSIVE YEAR Energy level (MJ/kg) fed the previous year		
	7.5	8.5	9.5
Starting mass, kg	111 ± 3.0	117 ± 4.3	115 ± 3.1
End mass, kg	120 ± 4.6	117 ± 6.3	124 ± 4.6
Egg production, n	28.7 ± 4.5^a	51.3 ± 6.3^b	40.6 ± 4.6^{ab}
Chicks hatched, n	14.2 ± 3.7^a	30.8 ± 5.1^b	23.2 ± 3.7^{ab}
Chicks hatched, %	40.8 ± 6.6	58.8 ± 9.0	50.7 ± 6.5
Chick hatch mass, g	874 ± 10.4^a	842 ± 11.0^b	876 ± 10.6^a
Initial egg mass, g	1438 ± 28.8	1418 ± 31.1	1391 ± 24.2

^{a,b} Denote significant (P ≤ 0.05) difference in rows.

52. Effect of lower dietary energy and protein levels on production of female ostriches

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INTRODUCTION

- Information is sparse on the nutritional requirements of breeding female ostriches.
- Cost-effective diets are needed without compromising egg production, fertility and hatchability.
- Aim: To feed breeding female ostriches diets with different energy and protein levels and to assess the effect on body mass, condition and productivity.

RESULTS

- Females fed diets with energy levels 7.5, 8.5 and 9.5 MJ/kg all lost mass, but females on the 7.5 MJ/kg diet weighed significantly less at the end of the season than those on the higher energy levels (Table 1).
- Females on the 7.5 MJ/kg diet laid significantly fewer eggs, but there was no significant difference in the percentage of chicks hatched.
- Females fed diets with different protein levels lost mass during the season, but no significant differences between the groups occurred (Table 2).
- Dietary protein levels had no significant effect on the number of eggs laid, embryonic mortality, or the percentage of chicks hatched.

Table 1. Effect of different dietary energy levels on the production of breeding female ostriches. (Mean ± SE).

Measurements	Energy levels (MJ/kg)		
	7.5	8.5	9.5
Mass change (kg)	-24.2 ± 1.9^{a}	-14.4 ± 1.9^{b}	-13.8 ± 1.9^{b}
Egg production (n)	38.1 ± 4.0^{a}	50.9 ± 4.0^{b}	55.2 ± 4.0^{b}
Embryonic deaths (%)	18.7 ± 2.3	20.1 ± 2.3	19.5 ± 2.3
Hatchability (%)	54.9 ± 4.5	45.3 ± 4.5	57.2 ± 4.5

^{a,b} =Denotes a significant difference between diets.

Table 2. Effect of different dietary protein levels on the production of breeding female ostriches (mean ± SE).

Measurements	Protein levels (%)		
	10	12	14
Mass change (kg)	-15.4 ± 1.9	-18.1 ± 1.9	-18.8 ± 1.9
Egg production (n)	50.5 ± 4.0	43.8 ± 4.0	49.9 ± 4.0
Embryonic deaths (%)	19.8 ± 2.2	22.2 ± 2.2	16.2 ± 2.2
Hatchability (%)	53.2 ± 4.5	47.2 ± 4.5	56.8 ± 4.5

^{a,b} Denotes a significant difference between diets.

MATERIALS AND METHODS

- Ninety adult breeding pairs were randomly divided into nine groups, with 10 pairs each.
- During the breeding season the birds were fed diets comprising:
  - Energy levels of 7.5, 8.5 and 9.5 MJ/kg
  - Protein levels of 10%, 12% and 14%
- Females were weighed at the beginning and end of the season.
- Number of eggs laid, fertility, and hatchability were recorded,
- Data were analysed according to 3x3 factorial design.

DISCUSSION

- Although all females lost mass during the breeding season, production - in terms of the number of eggs produced - was only affected in those females fed on the diet with the lowest energy level.
- The results suggest that 8.5 MJ/kg should probably be regarded as the minimum dietary energy needed for breeding female ostriches.
- Although females fed diets with different protein content all lost mass, the different dietary protein levels had no effect on egg production, embryonic mortality, and the proportion of chicks hatched.
- Results present important guidelines for feeding breeding female ostriches in a cost-effective way.

53. Effect of lower dietary energy and protein levels on body mass and measurements of male ostriches

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INTRODUCTION

- Information on nutritional requirements for ostriches at specific stages of production is sparse.
- High levels of energy and protein diets result in overfeeding and obesity, a factor that has been implicated as one of the main causes of infertility.
- Aim: To feed breeding male ostriches on diets with lower energy and protein levels and to assess the effect on body mass and condition.

RESULTS

- Body mass of males at the beginning of the season was similar.
- Males fed the low energy levels (7.5MJ/kg) lost 13 kg body mass over the breeding season, those on the medium energy diet maintained mass, and those on the high energy diet gained mass (Table 1) - resulting in significant differences in mass at the end of the season.
- Body measurements were similar for all treatments at the beginning of the season, and, tail circumference excepted, were not affected by different energy levels in the diets. Tail circumference of males fed the 8.5 MJ/kg diet was larger than birds on the other diets (Table 1).
- Males fed diets with different protein levels all lost some mass over the breeding season, but there were no significant differences in their body mass at the end of the season (Table 2).
- Body measurements of males were not affected by the amount of protein in the diet during the breeding season.

MATERIALS AND METHODS

- Ninety adult breeding pairs were randomly divided into nine groups, with 10 pairs each.
- During the breeding season the birds were fed diets comprising:
  - o Energy levels of 7.5, 8.5 and 9.5 MJ/kg
  - o Protein levels of 10%, 12% and 14%
- Males were weighed at the beginning and end of the season and measurements of their chest and tail circumference were made, and this was used as an indicator of their general body condition.
- Data were analysed according to 3x3 factorial design.

DISCUSSION

- Lower energy levels resulted in breeding male ostriches losing mass during the breeding season, but higher energy levels resulted in birds gaining mass.
- Different levels of protein in the diet did not affect the mass of breeding male ostriches.
- Body measurements and an estimation of body condition, were for the most part not affected by different energy and protein levels in the diets.
- This study provides valuable guidelines for the formulation of a male ostrich breeder diet with respect to the energy and protein needed to economically maintain the birds' condition without leading to obesity and a possible reduction in fertility.

Measurements	Energy levels (MJ/kg)		
	7.5	8.5	9.5
Mass change (kg)	-24.2 ± 1.9[a]	-14.4 ± 1.9[b]	-13.8 ± 1.9[b]
Egg production (n)	38.1 ± 4.0[a]	50.9 ± 4.0[b]	55.2 ± 4.0[b]
Embryonic deaths (%)	18.7 ± 2.3	20.1 ± 2.3	19.5 ± 2.3
Hatchability (%)	54.9 ± 4.5	45.3 ± 4.5	57.2 ± 4.5

[a,b] Denotes a significant difference between diets.

Table 1. Effect of different dietary energy levels on the live mass and body measurements of breeding male ostriches (mean ± SE).

Measurements	Protein levels (%)		
	10	12	14
Mass change (kg)	-15.4 ± 1.9	-18.1 ± 1.9	-18.8 ± 1.9
Egg production (n)	50.5 ± 4.0	43.8 ± 4.0	49.9 ± 4.0
Embryonic deaths (%)	19.8 ± 2.2	22.2 ± 2.2	16.2 ± 2.2
Hatchability (%)	53.2 ± 4.5	47.2 ± 4.5	56.8 ± 4.5

[a,b] Denotes a significant difference between diets.

Table 2. Effect of different dietary protein levels on the live mass and body measurements of breeding male ostriches (mean ± SE).

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54. The support of farmers with Satanbos eradication

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EARLY STAGES OF GROWTH

DURING WINTER SEASON

AFTER APPLICATION OF HERBICIDE, BROWSER

Satanbos is a species which has an enormous effect on the farming industry - making crop production a difficult task for farmers. According to research, Satanbos has extensive root systems and once it produces plants it becomes a difficult process – using practical methods – to destroy large areas of plant invasions.

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55. The support of farmers with stock watering systems

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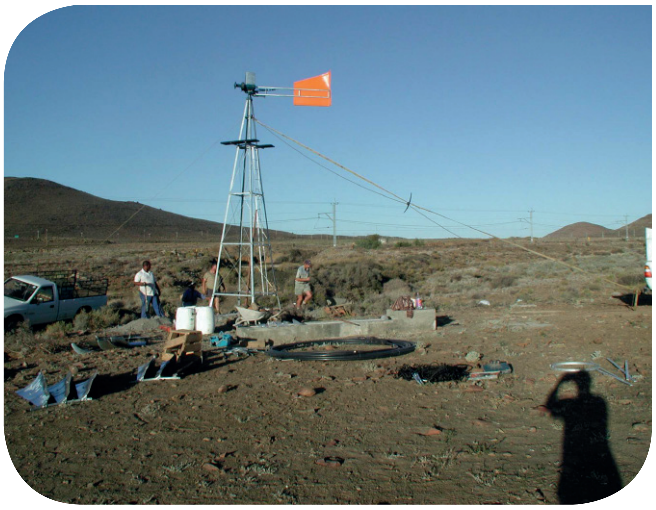
SOLAR PANELS

WINDMILLS



STORAGE FACILITIES

56. Stabilising river embankments with Gabion structures

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PLANNING

SURVEYING

FOLDING OF BASKETS

CONSTRUCTION PHASE

FINAL PRODUCT

FINAL PRODUCT AFTER 13 YEARS USE AGAINST FLOODS

57. Rehabilitation of wetlands

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