OSTRICH NUTRITION AND MANAGEMENT

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SUMMARY

In spite of the relatively long involvement of agriculturalists with the ostrich (*Struthio camelus*) as a domesticated bird to produce food and other commodities, only a small volume of published information on nutrition and management exists. More information is available on topics such as physiology, ecology and practical aspects like artificial incubation. A summary of the scant information on nutrition and management is given in this paper and it is attempted to fill the gaps with theoretical predictions for practical quantitative feeding of growing and breeding birds. Remarks are made on research priorities to put ostrich farming on a sound scientific basis.

INTRODUCTION

Ostrich farming probably had its origin when an unknown spectator was surveying birds in the open Savannah performing an ambulant display of waltzing, an act of behaviour after periods of tension, according to Hurxthal (1979) and Wood-Gush (1967). The plumes of these ostriches caught the eye of the observer. He became the first entrepreneur who decided to make it his business to hunt these creatures. The vain vision he had was a decor of plumes surrounding and adorning a group of chorus girls performing a jubilant dance to the music of Offenbach. The hunters and many after them did not fully understand the behaviour responses of ostriches but it was discovered in time that these birds need not be hunted because they could be confined to a farm and earn a living for the "owner". The fashion plume market flourished in the late 1800's. Today we still want to know more about the behaviour of ostriches since it may help us to improve management and enhance production of exotic items which now include hides and meat. It will be attempted in this paper to review the present knowledge on the management and nutrition of ostriches and to point out many areas where information is lacking.

NUTRITION AND MANAGEMENT OF YOUNG BIRDS

A model to form the skeleton for nutritional research

To imitate the feeding pattern of the bird in the wild would be one way of feeding ostriches in captivity. The nutritionist could use a different approach by studying the growth of the bird and then attempt to predict it's growth. By applying mathematical skills, basic nutritional knowledge and using chemical analyses, the nutritionist could then postulate the nutrient requirements of the birds. These hypotheses can be tested experimentally. This is perhaps the point in the development of nutritional standards for ostriches that we are at now.

The growth of ostriches from three regions in Southern Africa, covering an area in which most of the ostrich population in the world occurs today, has been studied (Du Preez, Jarvis, Capatos and De Kock 1990a). These curves are shown in Fig. 1.

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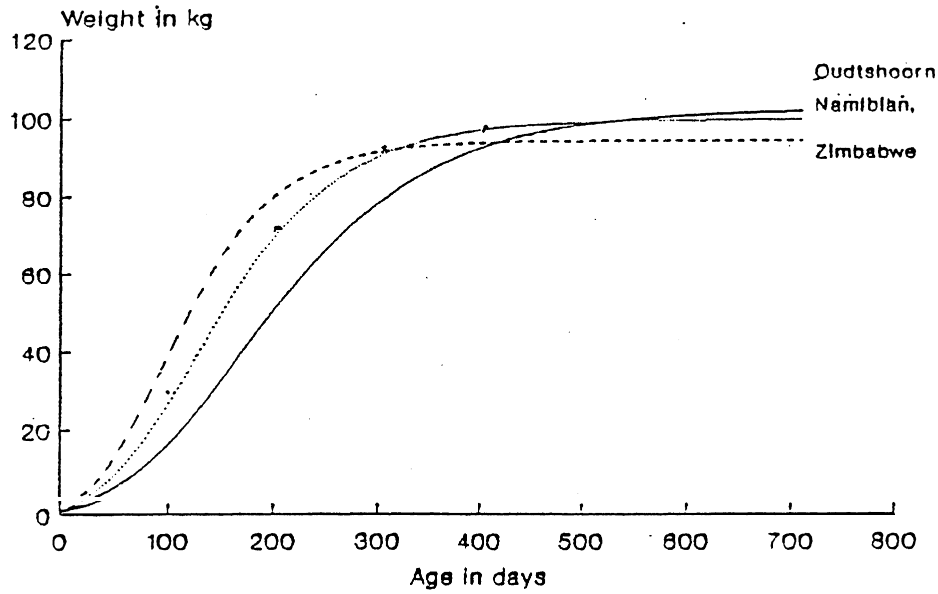


Fig. 1 Fitted growth curves for male ostriches in three localities

Although small samples of populations were used, significant differences in the rate of growth between birds from different regions and sex differences were shown to exist. Continuation of this work is anticipated. In recent work Degen *et al* (1990) described a growth curve of ostriches (mixed sexes). It resembles very closely the growth of Namibian birds illustrated in Fig. 1. The theoretical amino acid requirements of Namibian male birds were calculated (Du Preez *et al* 1990b). The requirements of Oudtshoorn males were subsequently calculated and these results will be presented as an illustration of hypothetical requirements for lysine and sulphur-containing amino acids (SAA) during the normal development under non limiting conditions from hatching to maturity. The data presented in Tables 1 and 2 were used to make these calculations. They were obtained from carcass analysis performed on ostriches from birth to maturity to gain information about the development of chemical components of the body during growth. The sacrificed birds were defeathered and the empty body (contents of intestinal tract removed) was analysed for moisture, ash, protein and lipid. The dry, lipid-free samples were also analyzed for amino acids. The results in Table 2 made a fundamental contribution to the predictions of requirements for amino acids, but because of the absence of replicate samples at each age or body size, the variation in protein, lipid and ash composition could not be determined. A growth function for protein could not be fitted to the data. The data relating to the mature bird (Table 1) were essential in the calculations to be illustrated here. Because growth curves of the sexes differ, carcass analyses should be performed for each sex separately. At this point in time the results of analysis of only male birds are available as presented in Tables 1 and 2. Lysine and the sulphur containing amino acids, methionine and cystine will be concentrated on to illustrate the requirements for them graphically.

Table 1 Composition of defeathered male ostrich carcasses

	Birth					Mature
Live weight (kg)	0.82	5.7	26.5	30	56	100
Feathers (g)	3.8	94	767	572	1261	1432
Moisture %	71.5	64.9	62.7	70.4	57.6	61.2
Lipid %	11.3	5.7	11.0	0.9	2.2	10.2
Protein %	15.5	14.7	16.3	19.4	22.4	18.6
Ash %	1.8	3.1	4.6	4.1	6.9	3.7
AT* contents %		11.5	5.4	5.2	10.8	6.2

* Wet alimentary tract contents

Table 2 Amino acid composition of ostrich defeathered empty carcasses of male birds (g/16gN)

	Ostrich feathers	Day old chicken	Growing birds (weeks)					Mature male	Mean**	SEM	CV
			5	6	13	15	21	>190			
Thr	4.72	6.06	4.82	3.78	3.38	4.03	3.27	4.03	3.56	0.33	9.10
Ser	7.84	4.98	4.03	3.02	2.79	3.21	2.62	3.41	2.86	0.25	8.60
Ala	4.75	2.56	3.29	2.49	2.53	2.80		3.57	2.76	0.08	2.89
Val	8.28	5.78	4.79	4.45	4.79	4.46	4.32	3.16	4.58	0.09	1.96
Met	0.26	2.68	2.12	2.26	2.26	2.25	2.11	2.07	2.19	0.03	1.37
Ile	3.50	4.61	3.67	3.82	3.67	3.91	3.75	2.89	3.75	0.05	1.33
Leu	11.67	9.18	7.35	7.70	7.36	7.94	7.54	7.57	7.54	0.09	1.19
Tyr	2.49	3.95	2.82	2.46	2.49	2.51	2.23	2.24	2.51	0.09	3.59
Phe	3.87	4.18	3.87	4.11	4.21	4.36	4.29	3.84	4.13	0.07	1.69
His	0.70	2.25	2.88	2.99	2.77	3.12	3.01	3.31	2.94	0.06	2.04
Lys	1.00	6.29	7.12	5.92	6.57	6.86	6.72	6.85	6.68	0.22	3.23
Arg	6.37	4.81	5.52	5.83	6.44	6.07	5.89	6.97	5.94	0.13	2.19
Cys	9.75							1.44	1.44		
Try*	0.71							0.80	0.80		

*Feather composition C A B Tables of amino acids, Rowett Institute, Bucksburn, Aberdeen, Scotland (1962) for tryptophan
**excluding day-old and adult

To calculate the amino-acid requirements, protein accretion in the body was used as the fundamental system as explained and used by Emmans (1988) for turkeys. The coefficients used in the calculation to convert dietary amino acid, lysine and SAA to body amino acid were 0.73 and 0.63 respectively. The value of the coefficients had in different instances been determined for poultry (Fisher and Emmans 1982). Since values are not available for ostriches, the poultry values were used. Discrepancies between the estimated and experimentally determined lysine and SAA requirements for ostriches would in effect be these coefficients coming under scrutiny. From unpublished results using poultry it would appear that the coefficients for lysine and SAA are not equivalent. The assumed protein in the animal at maturity would have an influence on the estimated amino acid requirement. In our calculation we relied on a single bird analysis and no account could be given of the confidence limits of the estimates. It needs to be pointed out though that the ratio of protein to other body components is the concluding factor and this particular bird reached a constant body mass and was consuming a maintenance diet, excluding superfluous lipid deposition at the time of slaughter. The estimated protein required for maintenance was calculated, using the formula suggested and applied by Emmans (1988), which is as follows:

$$MP = 8\ Pm^{0.73}\ u \qquad (1)$$

where MP is the protein required for maintenance in grams per day
Pm is mature body protein mass in kg
u is P / Pm and P = body protein mass.

Calculated estimates of the daily lysine and SAA requirements of growing ostrich males are shown in Figures 2 and 3.

FIG. 2 ESTIMATED REQUIREMENT OF OSTRICH MALE FOR LYSINE (OUDTSHOORN STOCK) gam / bird / day

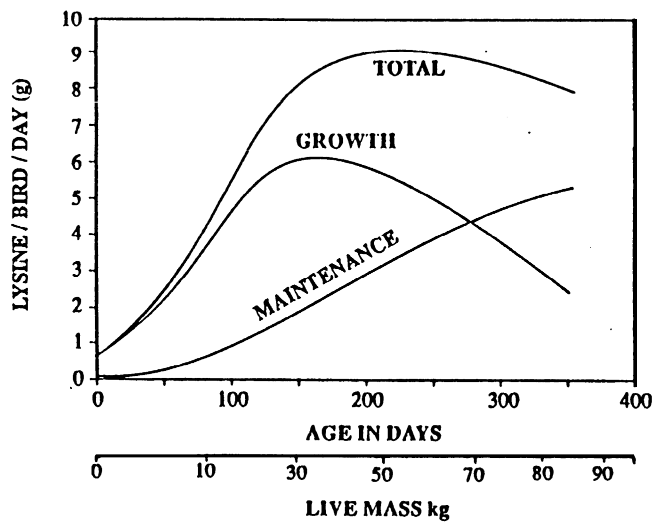
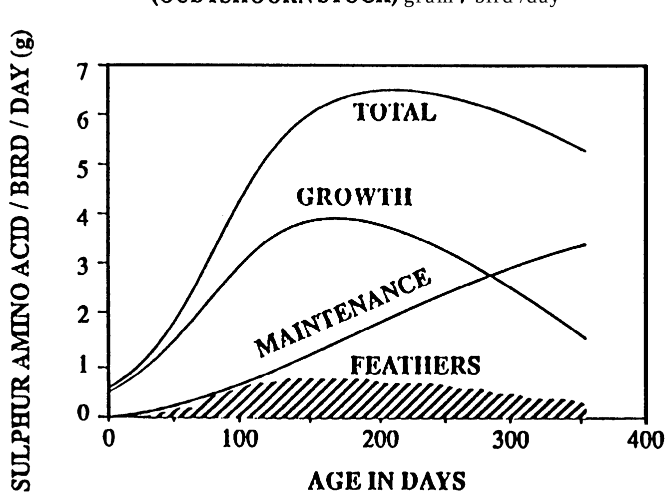


FIG. 3 ESTIMATED REQUIREMENT OF OSTRICH MALE FOR SAA (OUDTSHOORN STOCK) gram / bird /day



The work published by Swart and Kemm (1985) refer to protein required by ostriches between the body weight intervals of 60 to 110 kg. Lysine was 5 % of the protein in the experimental diets . The highest gain of 235 g per day occurred when birds were consuming approximately 2.2 kg per day of a diet containing 14 % protein, thus 15.2 g lysine per day. Gandini et al

(1986) found that ostrich chickens in the weight interval 1 to 9.5 kg (10 d to 56 d) receiving a diet containing 20 % protein showed the superior feed conversion. The calculated mean lysine intake was 2.73 g per bird per day. The average mass gain of these birds was 163 g per day while consuming an average of 275 g diet per day. The lysine input in the latter report is in accordance with the estimated value for young growing birds. However the lysine input of 15.2 g / day in the work published by Swart *et al* (1985) seems very high, indicating a possible imbalance of amino acids in that diet. As yet it has not been proven that lysine is an essential amino acid to the ostrich as had been shown for poultry. Since metabolism and growth of male and female ostriches differ, researchers may use the technique published by Gandini *et* al (1985) to separate the sexes at an age of 3 weeks by cloaca1 examination.

Brooding and rearing

The young chick does not possess an egg tooth and grows its way out of the relatively strong egg shell possibly aided only by its strong legs and using its third phalange. It can survive without food and water for six or more days depending on its egg yolk reserves. It is recommended that during this period the birds learn to find the food and water which should be easily accessible. Warmth is essential for young ostrich chickens. The type of heat source normally supplied for poultry can be used and temperatures similar to that for chickens (Michie 1977) are recommended for ostriches during the first 4 weeks after hatching . Floor area needed by growing ostriches depends on the type of housing. Semi-intensive rearing of birds is the most widely used method and even during intensive keeping of ostriches in controlled environment houses it is advisable to let them out to minimize occurrence of leg problems (Guittin 1986). The ideal floor area for ostriches will have to be studied using criteria other than economics and yield of product. General consensus concerning optimal population density is not easily found in conclusions drawn from studies with poultry. There is no definite connection between what farmers and some researchers interpret as "perform well" and freedom of stress (Thorpe 1967). The preferred norms should be to compare the behaviour of the whole intact animal in the wild with that in captivity and to note actions such as acoustic and visual communication, preening, cannibalism (redirection activity), abnormal corpophagy and suppression of any instinctive abilities (Wood-Gush 1967). The most economic optimum stocking density of broiler birds is usually higher than the density shown to be ideal for maximum mass gain. The latter is approximately **30** kg live mass (17 birds) per square meter in environmentally controlled houses (Shanawany 1988), and half of these values should be used in houses ventilated by convection. These values should not be directly applied to ostriches during rearing, rather keeping in mind the sensitive nature of this species, even after years of "domestication". The first reaction of an animal to a potentially hostile situation is a change in circulation dynamics and it has been suggested that a rise in deep muscle temperature, indicating active vasodilation, could be used as a measure of the defense reaction, exhibited during stress (Draper and Lake 1967). The normal cloaca1 temperature of the adult ostrich is 39.3 °C (Crawford *et al* 1967). A diurnal cycle was elaborated on by Louw et al. (1969). Stocking density goes hand in hand with ventilation rate. In fact specifying floor area is meaningless without the assumption that ventilation and for that matter feeding and drinking facilities are sufficient. Once the optimal population density of birds is established the ventilation standards applicable to poults and poultry could be used with less chance of error for ostrich chickens. The general rule of thumb is 4 m^3 per kg live mass per hour (Tilley *1967*), with the appropriate minimum and maximum rates of ventilation during respective low and high outdoor temperature conditions (Charles *et al 1981*). Dim light causes chickens to be docile and 5 lux (lumens/sq meter) is normally recommended in broiler houses. If light has a similar effect on young ostriches it would be beneficial to apply this principle. Feeding space of 4 cm/kg live mass and water space 20% of that would also work with ostriches. Raising the feed level to correspond to the back height of the bird would also save energy and prevent food wastage as it does for poultry.

Peed intake

Assuming that ostriches are kept in such circumstances that their environmental heat demand is met and the efficient energy system (EE) (Emmans *1984*) is used to adjust the ME of the diet, an estimate can be made of the daily feed allowance to meet it's energy needs. The major energy requirement is that used for maintenance. A formula proposed by Emmans *(1988)* was used to predict the maintenance requirement :

$$MH = 1.63\ Pm^{0.73}.u \qquad (2)$$

where MH is maintenance heat (MJ / day)
Pm is mature body protein mass (kg)
u is P/Pm and P = body protein mass (kg)

Estimates of the daily gain in protein and lipid, generated from the growth curve equation, was converted into energy required daily in kilojoules. This was added to the maintenance requirement to arrive at a total energy requirement to which the energy for activity and locomotion was added. To convert lipid and protein gain into EE requirement (MJ / day) values of 56 MJ / g lipid 50 MJ / g protein were respectively used as explained by Fisher *1987*.

In Fig.4 the expected intake of EE is graphically illustrated and in Fig. 5 an estimated feed allocation is shown using the EE contents of diets (MJ per kg) that would normally be formulated for birds at different ages. (body weights).

FIG.4 PREDICTED DAILY EFFECTIVE ENERGY INTAKE
(OUDTSHOORN MALE OSTRICHES)

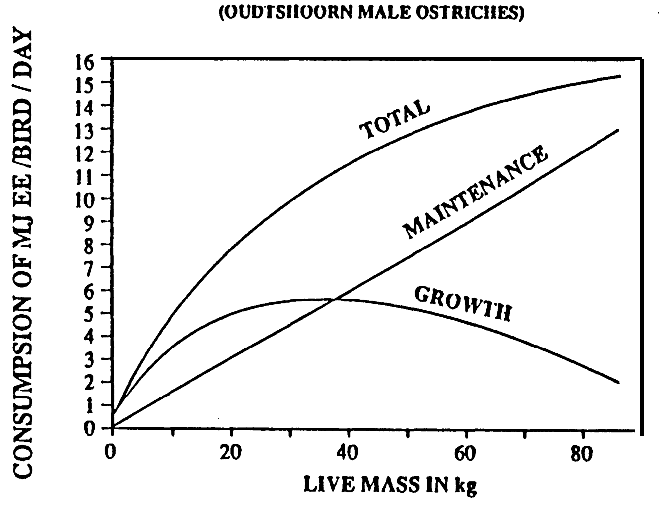
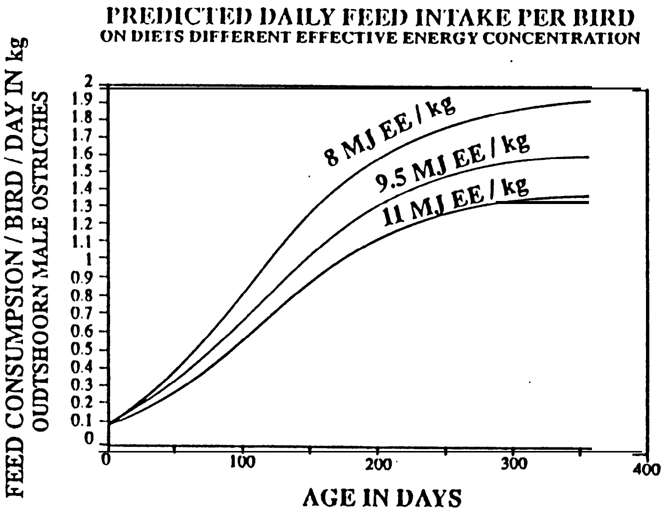


FIG. 5



The greatest lack of information lies in the nutritional values of feedstuffs used in diet formulations for ostriches. Few attempts were seen where an evaluation of ingredients has been undertaken. Energy values of diet components are essential for prediction of feed consumption. The water requirement of ostriches was determined and reported by Withers (1983). It amounted to 8 liters/day under experimental conditions for adults while the birds were feeding on dry alfalfa (5 kg per day). In the experiment reported by him, deprivation of water caused feed intake to drop by 84 percent. The ratio of water consumption to dry matter feed intake according to Degen et al (1991) was nearly constant at 2.31.

NUTRITION AND MANAGEMENT OF ADULT BIRDS

Breeding bird management

Most birds are slaughtered at 12 to 14 months of age, after the first feather crop has been harvested, to produce a hide which accounts for 75% of the income and meat accounting for another 15%. The first selection of birds destined for breeding is done at this point in time. A surplus of animals, which could be slaughtered later subsequent to selection of productive pairs, should be allowed for. Wild ostriches require 3 or more years (males 4 years) to become sexually mature (Hurxthal 1979). The males show a flush of pink skin pigmentation in the anterior of the tarso-metatarsal limb and the beak. While the females are stimulated to sexual activity by the former and other, mostly visual, courtship activities by the male, both sexes would be stimulated by an abundant supply of food before the breeding season. Breeding is seasonal as can be seen from the graph shown in Fig. 6. The breeding season usually starts in winter and shows a fluctuating pattern due to egg production cycles which most individual females exhibit.

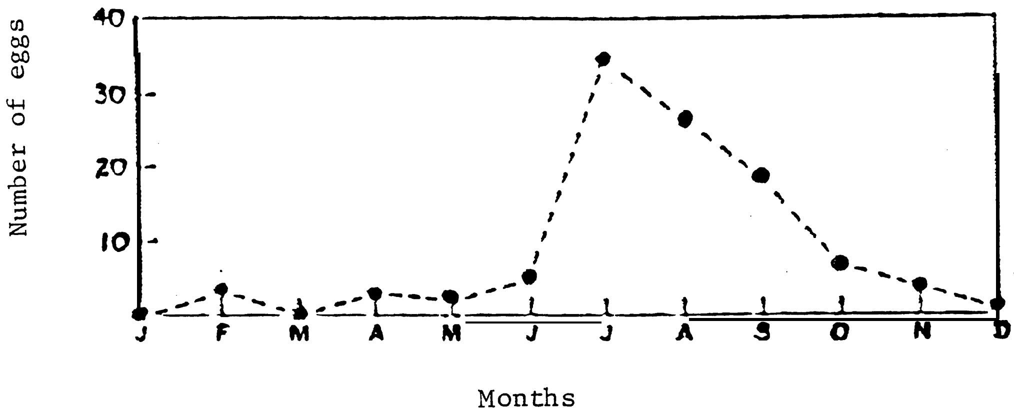


Fig. 6 Seasonal production of wild Zimbabwe Ostriches. Laying season based on next records cards of Ornithological Association of Zimbabwe (Jarvis et al 1985a)

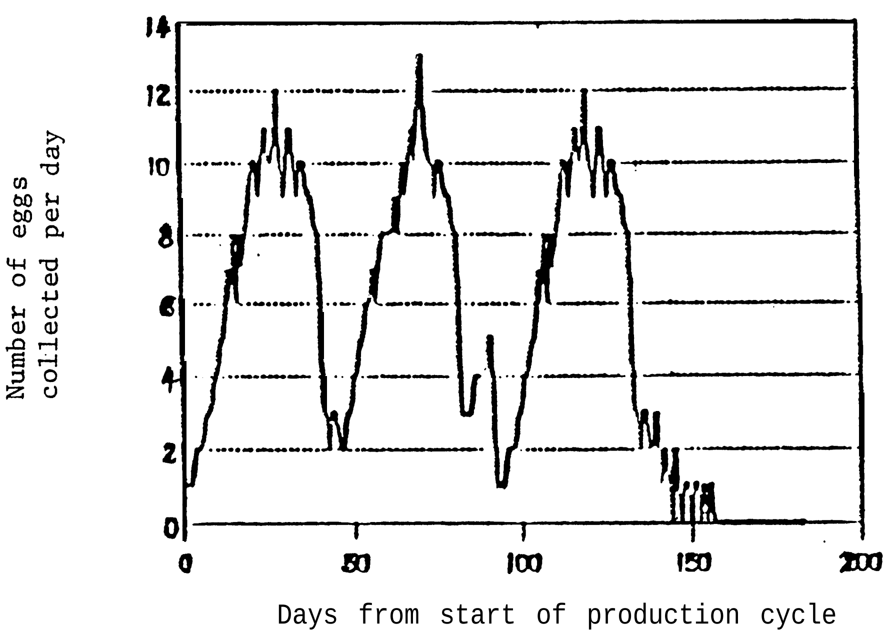


Fig. 7 Natural pattern of lay of wild ostriches, 13 female pairs, one male per pair

On average a female lays 15 eggs, one every second day then takes a rest (pause) for 7 days. This pattern is illustrated in graph (Fig. 7) generated from a sample population of 26 females (13 pairs).

In practice one male would be placed with each pair of females in a breeding paddock of a quarter hectare. It will be noted in Fig. 7 that over a period of 147 days (21 weeks) three peaks emerged at about 49 day intervals. This corresponds with field observations reported by Jarvis et al (1985). They noted three peaks of egg production in 150 days. At the end of the last peak ostriches in the wild would gradually stop laying but domesticated birds would continue laying at a slow rate during midsummer, showing a slight peak in February before egg laying is discontinued until the next winter. The predicted number of eggs from the 26 females in 3822 potential days was calculated to be 940 (24,6%). Since the ostrich lays an egg every second day the percentage could be doubled i.e. 49.2% to compare with that of poultry. Jarvis et al (1985) suggested a method to estimate the number of productive females in a breeding season. The estimate was 22 productive females in this model flock which increased the production from 49.2% to 58%. The number of eggs per female per season is a more practical norm to work with and these calculations predict 36 and 42 eggs per female per season for total and productive females respectively. On some commercial breeding farms birds are kept in lay for more than 9 months a year. Males and females are separated during April and May. Improvement in egg production ability should be pursued by selection for the trait. It was learned from private communication that 75 eggs by individual females were recorded on established breeding farms (Schmitt 1990) indicating that breaking of the pause after 15 consecutive eggs was achieved using selection methods. The use of artificial light would be a useful tool in stimulating the breeding birds to extend the laying season or to manipulate pattern of lay to two seasons per year as was demonstrated by Olver et al (1970) for geese. (See Fig. 8).

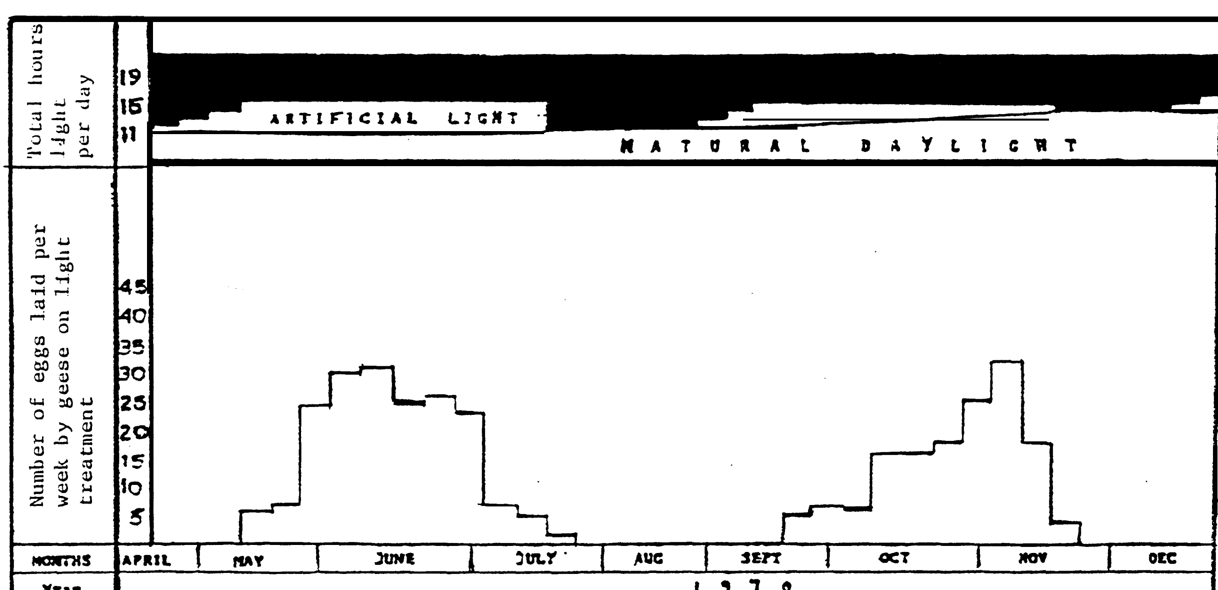


FIG. 8 LIGHT REGIME AND EGG PRODUCTION OF EXPERIMENTAL GEESE. FROM : OLVER ET AL (1973)

An integral part of stimulus for improved egg production, apart from nutritional aspects that will be dealt with next, is the daily collection of eggs. In natural breeding in the wild approximately 21 eggs are found in one nest. It is deduced from observations in Zimbabwe (Jarvis et al 1985) who reported an average of 13, Hurxthal (1979) in Kenya, 35 to 47 and Sauer (1966) in Namibia, 16 to 23 eggs per nest. Normally more than one female would contribute to this clutch and each female laid not more than 8 or 9 in each nest. Removing all but one or two eggs regularly counteracts the instinct of broodiness, thus enhancing potential for egg production. Nidification includes some rituals such as selection of a site for the nest and preparing it (scraping) by the male and soliciting by the male and female. **No** pair bonding was found with ostriches. There appears to be a dominant female which undertakes most or all of the daytime incubation of

Breedinq bird nutrition

Sexual maturity can take as long as 4 years to attain (Hurxthal 1979) but domesticated ostriches given the adequate quantities of nutrients required to develop can be ready for breeding in just over 2 years of age (Osterhoff 1979). The accretion of body substance is relatively small after 14 months and can be considered equal to maintenance. Depending on when the bird hatched the changes in preparation of sexual activities specifically in females has to be taken into consideration as the first breeding season, after the age of 2 years, approaches. Estimates of the nutrient requirements for egg production can be made using information like egg mass, frequency of lay and composition of the egg. More important though is to know the onset of formation of structures related to egg production eg. the oviduct and follicle development in the ovary. It is also necessary to anticipate the increased requirements for minerals, mainly calcium, amino acids, vitamins and energy, before the first egg is formed. King (1972) demonstrated with the aid of a sine model that the peak energy expenditure in egg production for birds laying in clutches is determined by the overlap among cycles for individual eggs (period of synthesis for a single egg including follicular growth in days), the rate of production and the clutch size. King (1972) cited the period of follicular growth in the domestic fowl as 7 - 8 days. The period for ostriches is not known and could be 16 days in which case the demand for additional nutrients would start 18 days before the first egg is laid. The demand on extra nutrients would increase in a sigmoidal pattern reaching a maximum approximately 8 days before the first egg is laid. From that point in time the nutrient requirements for egg production would remain at the plateau level until a laying day is skipped. The quantity of a nutrient while the plateau remains is independent of the time taken for egg formation and is only dependant on the quantity of nutrient in each egg. In the case of an ostrich it amounts to half an egg per day since an egg is laid only every second day. Synchronization of commencement of egg laying and timing of supply of additional nutrients is necessary. Daily requirement for amino acids by breeding ostriches were calculated and the values are shown in Table 3. The amino acids determined in egg protein is given in Table 4.

The requirement of amino acids for maintenance was taken to be the same as that for protein growth in these calculations. This is a point that should be investigated. Fisher (1989) used different amino acid profiles for proteins required for maintenance and for growth to calculate the amino acids required for poultry.

Table 3 Requirement for some amino acids of breeding ostriches in production

	For maintenance of body mass (kg)			For production of egg (kg) incuding shell		
	100	105	110	1,2	1,4	1,6
Protein (g)	67	69	72	119	138	158
Amino acid (g*)						
Arginine	5.70	5.87	6.12	3.56	4.15	4.74
Lysine	5.78	5.95	6.21	6.41	7.48	8.55
Methionine	1.86	1.90	2.00	2.67	3.10	3.56
Histedine	2.54	2.61	2.73	1.91	2.20	2.50
Threonine	3.54	3.64	3.80	6.85	8.00	9.13
Valine	4.32	4.46	4.65	5.50	6.40	7.30
Iso-leucine	3.50	3.60	3.76	4.55	5.30	6.10
Leucine	6.90	7.14	7.45	9.00	10.50	12.00
Tyrosine	2.33	2.40	2.50	3.70	4.30	4.90
Phenylalanine	3.82	3.90	4.10	4.06	4.67	5.30
Cystine	0.89	0.92	0.96			
Tryptophan	0.73	0.75	0.78			

*Daily quantities of dietary amino acids required per day in grams eg. A female weighing 110 kg producing a 1,2 kg egg each 2nd day will require :

$$\frac{(6.21 + 6.41)}{2000} \times \frac{100}{1} = 0.63\% \text{ lysine in the diet}$$

TABLE 4 Amino acid composition of ostrich egg and chicken (g per 16 g N)

	Egg (shell removed)	Day old chicken
Thr	8.44	6.06
Ser	6.93	4.89
Ala	2.63	2.56
Val	6.76	5.78
Met	3.29	2.68
Ile	5.60	4.61
Leu	11.13	9.18
Tyr	4.56	3.95
Phe	5.00	4.18
His	2.37	2.25
Lys	7.89	6.29
Arg	4.39	4.81

It will be noted that the size of the egg alters the daily requirement for amino acids considerably while an increase in bird size of 5 kg has lesser effect. Decrease in production rate or skipping a few days would have a great effect. Changing the daily allocation of feed in accordance with the observed pattern of lay would compensate for either over-consumption, which may cause fattening, or inefficiency which is the result of unnecessary feed input with no output in return. The estimated requirement for energy is shown in Table 5.

Table 5 Estimated energy requirement (MJ per day) for egg production of the ostrich in breeding pens (0.25 hectare)

	Energy expenditure for maintenance and activity (MJ) for body mass (kg)			Energy MJ for pdoduc-tion of egg (kg) in-cluding shell		
	100	105	110	1.2	1.4	1.6
Maintenance*	13.64	14.12	14.60			
Activity	1.37	1.41	1.46			
Egg lipid				2.30	2.68	3.07
Egg protein				3.58	4.18	4.77
Shell** (18% of egg mass)				0.26	0.30	0.35
Total	15.01	15.53	16.06	6.14	7.16	8.19

*1.63 Pm $^{0.73}$ where Pm = protein mass in body at maturity (Emmans and Fisher 1986)
**1.2 mJ per kg shell formed

A calcium supplement in the form of grit offers a choice to the females. The dietary calcium level then need not be very high although sufficient quantities of vitamins and minerals should be supplied in the diet, as well as linoleic acid. It should be investigated whether ostriches have a specific requirement for beta-corotene as has been shown recently for turkeys (Stevens et al 1989). The breeding diet is totally inappropriate for the males but it is very difficult to find a practical way around this dilemma. The male could be fed separately in a fenced off area in the pen and they can be let in for mating every second day. This would prevent males from becoming overweight and likely reduced fertility.

Practical animal management for adults

Individual birds behave differently and some birds, particularly males in the breeding season, may show aggressive behaviour. A person entering a pen should carry a 2.5m long forked stick with a black plastic bag attached to the end. When planning the pen layout, construct fences 2 m high, using seven strands of barbless wire with the bottom wire high enough above the ground to serve as an escape route if necessary (Thornberry 1989). In some areas ostrich ranch farming may be the preferred method of breeding. The mating ratio in this case is 3 to 4 females to a male bird. Mesh wire should then be used in addition to normal fencing to keep predators out. Loading chutes and catch pens should be constructed of solid wood, 2.5 meters high to prevent birds injuring themselves. A hood fitted loosely over the head is an acknowledged method to manipulate a bird after it has been hooked by the neck with a specially designed U-shaped rod fixed to the end of a 3 m stick .

Hatching and survival

Ostrich chicks are typically precocious at hatching, which may last for 10 hours after piping and after 36 hours they are completely mobile. They are very dependent on their parents to learn to feed adequately. Most farmers collect eggs from the nests and use incubators that have been adapted to hatch the ostrich eggs. Thus the stimulus of seeing the parents feeding which is necessary for chicks to respond and learn to feed, will be absent and this void has to be fulfilled by management. Hatching of ostrich eggs has been studied and documented (Jarvis et al 1985 ; Swart 1988 ; Bertram *et* al 1981) and hatchability of fertile eggs as high as 85% can be expected. Shade in the breeding pen, observing and monitoring mating activity, regular collection and proper handling of eggs and treatment of eggs before setting, including preheating, are all factors that could enhance the yield of chicks from the eggs produced. Normal hatchery hygiene must be practised.

Collected eggs should be cooled to 16°C as soon as possible and set within 2 to 5 days. Longer storage will reduce hatchability.

Field observations in a natural African habitat showed a variable but on average poor survival during two seasons of 36.9 and 43.4 % to 16 weeks of age (Hurxthal 1979). Poor survival, probably as a result of poor management, does occur on some farms but on the other hand reports from successful farmers state survival of 90% and more to 16 weeks of age.

CONCLUSIONS

We are faced with many unanswered questions about nutrition and management of ostriches. A few may be mentioned: Body composition of male and female birds, of different genotypes, should be determined. The coefficients for conversion of dietary amino acids to body substance and eggs have to be determined experimentally, also the question of whether the amino acid requirement for maintenance and growth differs significantly and warrants separate attention, has to be addressed. At the same time the hypothesis, that ostriches' requirements include essential amino acids, could be tested by measuring the response of graded levels of particular amino acids. De *novo* appearance of amino acids in sections of the alimentary tract is not excluded. An important aspect of estimates as presented in this paper is to know the confidence intervals of the estimates and the variables exerting an influence. Five to ten birds of a body size need to be slaughtered to determine the variation, especially at maturity. This data could also be used to fit a Gompertz curve to protein growth. The values of all constants used in quantitative energy metabolism calculations need to be confirmed with ostriches. The comfortable thermal environment for the ostrich has to be investigated since all theoretical calculations involving energy metabolism, are dependant on it. Energy expenditure for activities eg. walking, browsing and feeding at a trough are not known.

Last, but not to be ignored is the routine evaluation of the availability of nutrients in feedstuffs used to formulate ostrich diets: a formidable task !

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