Ostrich Management

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Summary

Ostrich (*Struthio camelus*) numbers and demand in Australia have risen dramatically over recent years. Although they have the potential to be prolific breeders, problems with nutrition, incubation and chick rearing have resulted in low levels of production across the industry.

The ostrich is an avian herbivore. There is little detailed knowledge of its nutritional requirements. Du Preez (1991) calculated amino acid, protein and energy requirements for breeding and growing ostriches. By analysing defeathered carcass composition, body weight, egg composition, egg weight and frequency of lay, and using conversion ratios, he was able to make these calculations. Vitamin and mineral requirements have not yet been determined, however Fleig (1973) has described disease processes associated with individual deficiencies.

The artificial incubation of ostrich eggs is resulting in low percentages of chicks alive at three months of age. It has been estimated by Finger (1992) that this figure was 25% in Australia over the 1989/90 breeding season, but could be up to 70%.

The incubation period can be divided into three stages:

* before lay, when nutrition, toxins, and female fertility all play major roles during this time;

* storage period, when the environment of the egg is of major importance. Most problems in this stage are management related such as handling, cleanliness, egg position and storage length; and

* Incubation and hatching, when incubation humidity is the major problem in this area. Most chicks die at or just before hatching because of insufficient water loss due to elevated humidity levels. Temperature, egg position and turning efficiency are other contributing factors. Ostrich chicks hatch over 12-24 hours and so patience should be exercised at this time. Many chicks must be assisted at hatching, and when doing this, extreme care should be practised.

Understanding chick requirements and the common disease conditions affecting growing chicks, can reduce losses in the first three months (critical period). They are similar to young chickens in being precocial, requiring a heated environment, and needing to be taught to eat and drink. They should be put into long run ways after two to three weeks and encouraged to exercise.

The major disease conditions are omphalitis, impactions and rotational limb deformities. By paying attention to the chick's environment and growth rate these problems can be reduced.

1 Introduction

Although the ostrich has been farmed in Australia since the late 1860's, its numbers over this period have fluctuated. The numbers of farmers interested in ostriches has again risen dramatically since the early 1980's (Hastings 1991b). Information on farming and breeding of ostriches has not been available, and this has stimulated research in this area in recent years.

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In a study conducted by Hastings (1991a), it was found that from eight breeding pairs in different areas in southern Australia, the average number of eggs was 52, the average fertility 60% (seven pairs had fertility of 40-70%) and only 25% of eggs laid produced viable chicks.

The important areas in ostrich reproduction which can be controlled by the farmer include nutrition of adult and growing birds, egg storage and incubation, and chick rearing practices.

2 Nutrition

The ostrich is an avian herbivore, with an elongated hind gut (particularly the caeca) for fibrous retention and degradation. It lacks a crop but has an enlarged proventriculus (Swart, 1987).

There is little detailed knowledge of the nutritional requirements of the ostrich. Most of the current diets are formulated by extrapolation of knowledge from the poultry industry, and from trial and error within the ostrich industry. The variation in diets fed to ostriches indicates our lack of knowledge in this area. However, nutritionists are working with veterinarians to construct the most suitable diet.

2.1 Nutrition of Breeding Ostriches

The availability of nutrients to the developing embryo is completely dependent upon the female. Therefore breeder nutrition has a definite influence on embryonic livability and hatching success. Nutrition has an even greater effect on the rate of egg production (Thornberry, 1989a).

To efficiently supply the increased nutrient demand for a laying hen, the date that the first egg is to be laid must be known. In the domestic fowl there is a seven to eight day follicular growth phase before the egg is laid. In the ostrich it is estimated to begin 18 days before the egg is laid. The nutrient demand rises in a sigmoidal pattern, peaking approximately eight days prior to the egg being laid, and then plateauing until a lay day is skipped (du Preez, 1991).

Estimates of adult nutrient requirements have been made by analysing adult body mass, body composition, egg mass, frequency of lay, and egg composition. From this information, using conversion factors for each nutrient, the requirements can be calculated (Table 1).

From this table, it can be seen that the size of the egg considerably alters the daily amino acid requirement, while an increase in the size of the female by five kilograms, has a lesser effect. A reduced production rate less than one egg every second day (their normal pattern of lay) will also have a great effect. Therefore by changing the daily feed allocation, in accordance with the observed pattern of lay, compensation for either over consumption (results in fattening) or inadequacy (results in sub-optimal egg production) can be made.

The estimated energy requirement or breeding ostriches is shown in Table 2. It can be seen from this table that a bird weighing 105kg producing a 1.2 kg egg every second day requires : 15.53 + 0.5 x 6.14 = 18.6 MJ/d

Vitamin and mineral requirements have not been evaluated precisely in the ostrich. Instead figures have been determined by extrapolation from poultry requirements (du Preez, 1991).

Calcium is a very important mineral required in large amounts by the breeding female. Commercial diets contain around 2% calcium, with a calcium to phosphorus ratio of at least 2:1. Breeding females should always have a calcium supplement of egg shell grit available as well (du Preez, 1991).

In some cases, parental diets which are marginal or deficient in certain nutrients can be adequate for their survival. However, they become noticeable when the stress or increased demand occurs with reproduction. Some examples include:

* Vitamin B_2 (riboflavin) - causes poor hatchability with a high proportion of deaths in mid gestation. The embryos are often dwarfed, have "club-shaped" down feathers, and show some signs of subcutaneous oedema and micromelia (shortening of the long bones);

* Vitamin B_{12} - also causes high mortalities in mid gestation, periocular oedema, short beaks, curled toes and poor leg muscle development; and

* Linoleic acid - can cause poor hatchability-(Hermes, 1989a).

Table 1 **Requirement for some amino acids of breeding ostriches in production (after du Preez, 1991).**

	For maintenance of body mass (kg)			For production of egg (kg) including shell		
	100	150	110	1.2	1.4	1.6
Protein (g)	67	69	72	119	138	158
Amino acid (q*)						
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
Histidine	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			
Tryptophane	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% lysine in the diet

Table 2 Estimated energy requirement (MJ per day) for egg production of the ostrich in breeding pens (0.25 hectare) (after du Preez, 1991)

	Energy expenditure for maintenance and activity (MJ) for body mass (kg)			Energy MJ for production of egg (kg) including 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

Table 3 **Composition of defeathered male ostrich carcasses (after du Preez, 1991).**

	Birth					Mature
Live weight (kg)	0.82	5.7	26.5	30.0	56.0	100.0
Feathers (g)	3.80	94.0	767.0	572.0	1261.0	1432.0
Moisture %	71.50	64.9	62.7	70.4	57.6	61.2
Lipid %	11.30	5.7	11.0	0.9	2.2	10.2
Protein %	15.50	14.7	16.3	19.4	22.4	18.6
Ash %	1.80	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 4 After Fielder's Agricultural Feeding and Management Advice (Anon, 1992)

	Barastoc Ostrich Starter Crumbles	Barastoc ostrich breeder pellets
Minimum Crude Protein	18%	16%
Minimum Crude Fat	2.5%	2.5%
Maximum Crude Fibre	10%	11%
Calcium	2.0%	3.2%
Phosphorus	1.3%	1.0%
Vitamin A	24,000 iu/kg	24,000 iu/kg
Vitamin D_3	7,000 iu/kg	7,000 iu/kg

To reduce the rate of vitamin or mineral deficiency, a supplement can be added to the drinking water. The feed should also be stored in a cool, dark place and be regularly turned over as the vitamin level can decline with age
and exposure (Hermes 1989a).

The requirements mentioned so far are for breeding females. This diet is however totally inappropriate for male birds. It is a difficult problem to solve practically and males are often fed the same diet as females. One method to overcome this problem would be to feed the males separately in a fenced off area, and allow access to the female every second day for mating. This would prevent males from becoming overweight, which is associated with reduced fertility (du Preez, 1991).

In Australia, ostriches are generally fed commercially available diets. An example of the composition of commercial starter and breeder rations is shown in Table 4. The level of pellets fed daily varies according to:

Pasture conditions (quality and quantity);
Amount of green food or grain supplements;
Age, species, weight, level of activity, stress factors; and
Breeding performance.

The following facts are important when feeding pellets:

* Water should always be available as ratites have a high water requirement. Du Preez (1991) found that water deprivation caused an 84% drop in dry matter feed intake.

* Pellets should be supplemented with chopped green lucerne and other greens for eg. lettuce and cabbage.

* Birds should be changed onto pellets gradually over a two to three week period (Anon. 1992)

2.2 Nutrition of Growing Ostriches

The growing ostrich requires a unique diet. These birds grow very rapidly and so any nutrient deficiency or excess soon becomes manifest. Of particular concern are the protein and energy requirements which determine the growth rate of the chick. One of the largest problems with growing chicks in Australia is rotational limb deformities. Nutrition, particularly protein and energy, is thought to be major contributing factor.

2.3 Protein and Amino Acids

To calculate the amino acid requirements of growing chicks, the body composition of defeathered male ostrich carcasses was analysed (Table 3). This information with suitable conversion co-efficients was used in poultry formulae. The estimated protein required for maintenance was calculated using the formula MP = 8 x Pm x U, where

MP = Protein required for maintenance in g/day
Pm = mature body protein mass in Kg
U = P/Pm
P = body protein mass

The estimated requirements for lysine and the sulphur amino acids (SAA) are shown in Figures 1 and 2.

Swart and Kemm (1985) reported on the protein requirements of ostriches weighing 60-110 kg. In their diet lysine was 5% of the total protein. The highest body weight gain occurred when the birds were consuming 15.2 g lysine/day.

Gandini *et al* (1986) found that ostrich chicks between 1 and 9.5 kg (10-56 days) on a 20% protein ration showed superior feed conversion. The calculated mean lysine intake was 2.73g/bird/day which is in accordance with the estimated value in Figure 1 (0.8-3.8 g/d; mean 2.3g/d). The lysine intake of 15.2 g/d is very high compared to the calculated requirement (8-9 g/d) indicating a possible amino acid imbalance in this diet. As yet, lysine has not been determined to be an essential amino acid in the ostrich as in poultry.

2.4 Feed Intake

The major energy requirement in young ostriches is for growth, whilst that in older ostriches (greater than 40kg) is for maintenance (see Figure 3). The maintenance required was calculated using the formula MH = 1.63 Pm x U where:

MH = Maintenance heat MJ/d
Pm = mature body protein mass in Kg
U = P/Pm
P = body protein mass (kg)

Estimates of the daily gain in lipid and protein, generated from the growth curve equation, were converted into energy in MJ's. This was added to the maintenance and activity requirements which gave a total energy requirement. The daily feed intake of growing birds on diets with different energy concentrations was also predicted (Figure 4).

Inexpensive water soluble vitamins and electrolytes for poultry should be added to the drinking water for the first two to three weeks The fat soluble vitamins (A,D ,E, and K) are compounded with a starch or protein emulsifier to enhance dispersion and availability in water (Thornberry, 1989a).

Fresh foods including hard boiled eggs are not required nor are green foods such as lettuce or spinach. These greens are low in energy and protein and high in fibre which can be detrimental to chick health. Greens such as spinach contain oxalic acid which inhibits the absorption and use of calcium and can contribute to leg abnormalities (Thornberry, 1989a).

After the third week the chicks should be fed all of the starter ration they can consume in two short (20-30 mins) daily feeding periods. Lucerne pellets should be available *ad lib* from this time, and should not be mixed with the starter ration. They can also have access to small amounts of grit (Thornberry 1989a) as they will be placed in outdoor runs at this time.

Fleig (1973) noticed several clinical syndromes associated with the following nutrient deficiencies:

- Vitamin A - chicks fail to gain weight, have runny eyes, pustule formation on the palate, and stunting of growth.
- Vitamin B2 - causes "curled toe" syndrome (the toes curl medially and in severe cases, result in a clenched foot).
- Vitamin B6 - can cause musculoskeletal problems resulting in a "goose stepping" gait.
- Vitamin D3 - causes a lack of bone mineralisation, manifested as a slow painful gait
- Calcium/Phosphorus - should always be provided in a ratio of 2:1 (in diets fed to ostriches of all ages). Calcium deficiency causes nutritional secondary hyperparathryroidism, excess calcium interferes with the uptake of other minerals.
- Iron - causes anaemia, listlessness and consequent weight loss.
- Manganese - can result in slipped tendon (perosis). This condition can also be caused by methionine or choline deficiencies.
- Vitamin B12 and Vitamin B3 - also cause minor problems.

Selenium and Vitamin E deficiencies are also seen in young ratites. This occurs when the soil and feed are low in selenium, and the feed contains high levels of polyunsaturated fats (e.g., cod liver oil and soybean oil) or rancid fats (which are low in vitamin E) (Bodkin, 1989).

3 Incubation

The period between formation of the egg and hatching may be divided into three stages: before lay (formation period); between lay and setting (storage period); and incubation and hatching.

3.1 Time before lay

The egg must be formed, fertilised and then packaged before it is laid. This begins at the onset of the breeding season. This onset is dependent largely on photoperiod, and on stimulation by the male (Hermes, 1989a). It has been suggested that the egg either commences or recommences development in the ovary some 18 days before it is laid (du Preez, 1991).

Potential problems in this period include:

3.1.1 Infertility

Poor fertility can be the result of:

* Stress - ambient temperature, diet, loud noises and predators;
* Incompatibility or male infertility; and
* Genetics, age, plus other minor factors.

3.1.2 Nutrition

Nutrition has already been discussed. Nutrient deficiencies can lead to infertility or poor hatchability. These deficiencies may be adequate for adult maintenance but unsuitable for reproduction.

3.1.3 Toxins

Can bind nutrients rendering them unavailable, e.g., *Amprolium* (a coccidiostat) binds thiamine when in high concentrations which can reduce hatchability (Hermes, 1989).

3.1.4 Genetics

Can negatively affect hatchability in three ways:

* Discrete or single gene traits - mutations leading to embryonic malformation and death;
* inbreeding - increases the possibility of lethal genes which may cause embryonic death; and
* inadvertent genetic selection - by selecting adults on phenotype, selection is often made against reproductive performance.

3.2 Male Infertility

Although truly sterile males are rare, sperm quality and/or quantity are more important (Thornberry, 1989b). A successful mating can be determined by examination of the blastodisc on the yolk. Its appearance changes when fertilised from a simple cluster in the centre of the disc, to a thickened ring on the outer edge of the disc with a clear centre (Finger, 1992). Compatibility is vital. By placing young birds in a large paddock and allowing them to naturally pair, the possibility of incompatibility can be reduced.

There is a recognised lag in the onset of semen production, against egg production, and so most early season eggs are infertile (Finger, 1992). Thornberry (1989b) described a procedure of separating males and females (camping off) and subjecting the males to 16 hours day length with artificial lighting for three to four weeks before the commencement of egg production, in order to increase the fertility of these first eggs. It is reasonable to aim for 70% fertility (Hermes 1989a).

It has been noted that the red colouring of the males varies throughout the season and it is presumed that the intense periods are associated with high fertility. Trials of three to four males with eight females have produced higher fertility rates than single pairs. It is thought that there is always a male with high grade semen production available (Finger, 1992).

3.3 Storage Period

Most hatchability problems associated with storage are the result of poor management. The environment of the egg is of major importance whilst handling, cleanliness, egg position and age are other contributing factors (Hermes, 1989b).

3.3.1 **Collection** - the eggs should be collected as soon as possible after being laid, preferably on the same day. Embryonic development has been shown to continue above 80°F (26.7°C) which can be detrimental to subsequent hatchability (Hermes, 1989b). Exposure to cool, wet conditions for extended periods can increase the risk of microbial contamination which also reduces hatchability.

3.3.2 **Handling** - eggs should always be handled very gently. Jarring of eggs increases the rate of malformations, twinnings and floating air cells (Hermes, 1989b). Small shell cracks can be repaired with white water soluble glue. Jordan (1989) stataed that it was important to reduce the rate of water loss from the egg, and Finger (1992) suggested melted wax, cellophane tape and finger nail polish in order to achieve this. Eggs which are cracked often suffer embryonic death due to microbial infections.

3.3.3 **Cleaning** - clean nest eggs have a greater hatchability than dirty eggs cleaned by any procedure (Finger, 1992). Lightly soiled eggs can be cleaned with a dry cloth or fine sandpaper. Very dirty eggs need to be washed. The water must be at least 10°F warmer than the egg (Thornberry, 1989b). Cool water causes the internal membrane to shrink away from the shell, which pulls microbes into the egg through the pores in the shell. The water should be replaced for each egg and contain a disinfectant. It should be done quickly and then air dried (e.g., hair drier). Eggs can also be fumigated with formaldehyde at this stage (Hermes, 1989b).

3.3.4 **Storage time and temperature** - Finger (1992) believed that an egg can be affected negatively in many ways once it is laid for eg. poor handling, but can only be affected positively by providing a delay between lay and set. If not allowed the hatching chicks are much weaker or they do not hatch. He suggested holding for a minimum of 48 hours (7 days ideal) and slowly cooling to the required 12-14°C. Storage temperature and time are inversely related (Hermes 1989b). He found the ideal storage temperature to be 55-60°F (12.8-15.6°C) at which temperature the embryos metabolism virtually ceases. He found temperatures between 60-80°F (15.6-12.7°C) resulted in undefined problems that reduced hatchability.

3.3.5 **Humidity** - the storage humidity level for ratite eggs is as yet undetermined. Most avian eggs require 60-90% relative humidity but by keeping the humidity low, extra water is lost from the egg which may reduce the rate of oedematous chicks (Hermes, 1989b).

3.3.6 **Position** - Finger (1992) stated that position of the egg was not important. The air cell should be located at this time and marked with a pencil so that development can be monitored.

3.3.7 **Turning** - Hermes (1989b) stated that turning was not required for eggs stored less than 14 days, and turning once per day for eggs stored greater than 14 days. Finger (1992) reported that it was important to turn eggs during storage to ensure the membranes did not deform and that the the embryo did not stick to the membranes or shell. It is believed that nutrients are still required by the embryo even if growth is slowed by a drop in temperature. Nutrients can be supplied by turning the egg once daily. As the yolk rotates around the egg the embryo comes into contact with new nutrients.

4. Incubation

Eggs should be prewarmed to room temperature (20-30°C) over several hours (up to 24) before being placed in the incubator. This reduces embryonic shock and minimises egg sweating (Thornberry, 1989b; Finger, 1992).

4.1 **Temperature** - the actual temperature setting depends on the relative humidity level, air flow in the incubator, condition of hatched chicks, thermometer accuracy and thermostat variation. The ideal incubation temperature has been found to be 97-97.5°F (36.1-36.4°C), slightly lower than that required for other avians (99°F) (Finger, 1992). Stewart (1989a) recommended a temperature between 95-98°F (35.0-36.7°C) and relative humidity of 20-40% (lower humidity for higher temperature and *vice versa*). Dolensk (1978) suggested temperature of 96.8-97.6°F (36.0-36.7°C) in a forced air incubator and 99°F (37.2°C) in a still air incubator. Embryos subjected to persistent high temperatures consistently hatch early (average incubation period is 42-45 days) with a large proportion of fully formed "dead in shell" chicks. These chicks will be small and have unabsorbed yolk sacks. Embryos exposed to persistent low temperatures have delayed hatches, and are soft and large (Finger, 1992).

4.2 **Humidity** - ostrich eggs require lower humidity levels than most avian species. However, the ambient humidity is nearly always above the required level. Therefore the best incubators are fitted with a dehumidifier. Crawford (1989) recommended a humidity of 35-40% (wet bulb 70-74°F) with a temperature of 97°F. As mentioned above, the desired level is 20-40% depending on incubated temperature. The major problem is therefore one of over humidity. The features associated with excess humidity during incubation are:

* swollen, oedematous chicks;
* sluggish chicks at hatch;
* small air cell during incubation;
* low egg weight loss during incubation;
* increased number of chicks in malposition II; and
* open navels which are slow to heal (Finger, 1992)

It is recommended to register humidity readings every 7 days to coincide with weighing and candling of the eggs.

4.3 **Water loss** - the avian egg loses water by two means:

* evaporation - through the shell and its membranes; and
* respiration - through the blood vessels. This increases as the chick grows since the increased rate of gas exchange carries more moisture (Finger, 1992).

There are two variables that control the rate of water loss:

* incubator humidity, which is inversely related to evaporation; and
* incubator temperature and carbon dioxide levels (amount of ventilation - control respiration).

Natural incubation sees a water loss of 11-15% of total egg mass (Burger and Bertram 1981). Finger (1992) suggested an ideal water loss of 15% by day 38 plus another 3% by hatching (total of 18%). Stewart (1989a) recommended 13-15% weight loss. A weight loss chart is best used to monitor water loss. The eggs should be weighed weekly in association with candling. Burger (1981), Ley *et al*. (1986), and Philbey *et al*. (1991b) all described insufficient water loss as the major problem of incubation.

4.4 **Candling** - candling of ostrich eggs is different to candling the eggs of other avian species. The light rays bend around the yolk, instead of passing through it, producing a shadow of slightly darker yolks. The shadow darkens considerably as the embryo grows and the yolk membranes develop. Candling is used initially to determine which end contains the air cell (since ostrich eggs are symmetrical). Fertility is determined by candling at three weeks incubation. It is also used in conjunction with egg weighing, to monitor water loss. An air cell 30% of the egg size corresponds to a 15% weight loss.

4.5 **Turning efficiency**

The incubation period can be divided into three stages;

4.5.1 early (day 0-14) This is the crucial time in the incubation process. Egg rotation causes yolk rotation, the embryo is moved into a region of fresh nutrients away from waste products, and the membranes are prevented from sticking. The embryo in the first two weeks has a limited vascular system and therefore requires contact with fresh nutrients regularly. The turning also ensures good and even blood vessel development which provides the embryo with a greater nutrient supply (Finger, 1992). Finger (1992) also believed that horizontal position and rolling in the first two weeks were better than 45° standing with the air cell uppermost, since this only provides 60% of the turning force on the yolk compared to the horizontal method. This would lead to a larger number of "missed turns" where the yolk does not turn when the egg is turned.

4.5.2 middle (day 14-38) The egg should be changed to the 45° position at this time to reduce the number of malpositioned embryos. Stewart (1989a) stated that in the chicken, the critical period when embryo orientation is determined is the second week of a 21 day incubation, specifically starting about day 10. Although the incubation period of the ostrich is longer, most of the early developmental stages are similar and the later longer period involves extra growth phases. He therefore inferred the same critical time period in the ostrich, and showed direct relations between egg position and the incidence of malpositioning and recommended 45° positioning of the egg at this time.

Finger (1992) stated that where the eggs are turned manually they should be turned three to five times daily. More than this is disadvantageous due to the loss of heat by opening the door, and the time taken.

Semi-automatic systems should be rolled every hour of the day and then once or twice at night. Automatic turners are best at one hour turnings. If the egg is rolled one way then it needs to be rolled 180° back the other on the next turn to prevent unwinding of the chalazae. The egg should also be turned 180° over its longitudinal axis an odd number of times daily to prevent the embryo resting in same position for two nights in a row (Finger, 1992).

4.5.3 late (after day 38) Turning ceases and the egg is left the air cell slightly raised (due to the size of the air cell it should naturally sit in this position [Stewart, 1989b]). From day 30, candling should be performed every day (Finger, 1992).

5. Hatching

The egg should be transferred to the hatcher when the embryo has penetrated the air cell (internally pipped) which is usually on day 40 (Stewart, 1989b).

Stewart (1989b) recommended having a hatcher temperature 0.9°F (0.5°C) lower than the incubator with a relative humidity of 40-50°. Finger (1992) suggested raising the hatcher temperature by 1°F. This aided the chick in two ways:

- increased metabolic rate - induces an increased vigour of the chick which results in an increased speed of hatch. The stimulus for causing the neck muscle spasm which results in the head being thrown against the shell causing breakage of the shell, is increased carbon dioxide tension in the air cell. By increasing metabolic activity, this stimulus is stronger.

- decreased relative humidity - aids in removing excess water from slightly overweight chicks to give a cleaner hatch. Hoyt (1980) showed that temperature changes have less effect on the rate of oxygen consumption at higher temperatures and in older embryos. He suggested this was due to the development of thermoregulatory abilities by the embryo.

It is also desirable to place the eggs in contact with each other in the hatcher. Inter-egg communication is a reported phenomenon in both artificially and naturally incubated eggs (Stewart, 1989a) and is one reason why many eggs in a natural nest hatch together, even though they were laid over many days (Finger, 1992).

Most chicks hatch by themselves but some need assistance. The chick should not be hurried out of the egg as it often takes 12-24 hours to hatch after external pipping (Crawford 1989; Dolensk, 1978). Helfer (1978) described losses from over vigorous assistance.

If the head of the chick is at the wrong end, or its movements have ceased without internal pipping, then a small hole can be cut into the air cell. Using sterile water and cotton buds, the membrane over the chick can be moistened and if red vessels appear, the chick is not ready and the egg should be placed back into the incubator for 24 hours. If there are no vessels, the membrane can be peeled back to further assess the chick. The shell can be chipped away piece by piece over a further 12 hours. Extreme caution and patience must be used. Two problems associated with assistance are damage to blood vessels and unresorbed yolk sacks. It is believed that vigorous struggling is required to fully resorb the yolk sack (Finger, 1992; Dolensk, 1978).

Stewart (1989a) described the normal orientation of the embryo during incubation. The spine is aligned along the long axis of the egg, with the tail at the base of the egg and the neck at the air cell end of the egg. This orientation is achieved by at least two mechanisms:

- positioning of the head of the embryo against gravity; and
- directing the head towards the greater oxygen tension which is in the air cell. As mentioned, it is thought that this occurs in the second week of incubation.

The normal position of the developing chick within the egg is with the feet along side the body with toes near the wings. The head is initially pointed straight down the abdomen between the legs with the beak pointing towards the cloaca. Several days prior to hatching, the head rotates to the right so that the beak is directed towards the chick's right shoulder, which allows the chick to penetrate the air cell.

Six embryonic malpositions have been described by Stewart (1989b):

5.1 **Head between the thighs**.

Embryos which die three to four days before expected hatch will have an external yolk sack and the head in this position (since it is a normal position in development). However if the yolk is enclosed in the body and the head remains in this position at hatch time, it is a true malposition and results in death. It is one and a half times as common in horizontal eggs against the upright position.

5.2 **Head in small end of egg**.

The incidence of this malposition is three times as common in horizontal eggs against upright in poultry. In the upright position, the higher oxygen tension and gravity induces the chick to position itself the right way around. However in the horizontal position these forces are not acting the same which therefore results in the higher incidence of malpositioning. Only about 50% of these will hatch on their own.

5.3 **Head to left instead of under right wing**.

This is the one malposition that is increased in vertical verses horizontal incubators in poultry, where it is common. It is however very uncommon in ostrich incubation (Stewart [1989b] has never seen or heard of it occurring), without the beak directed into the air cell they have poor hatchability.

5.4 **Embryo rotated in such a way that beak is not oriented towards the egg cell**.

Chicks are most commonly oriented sideways in the egg (most likely where the chick has tried to correct a malposition 2). This is five times higher in horizontal verses vertical eggs and the chicks rarely hatch.

5.5 **Feet over head**

The feet and entrap the head preventing it from rotating and pipping. This is extremely uncommon.

5.6 **Beak above right wing instead of underneath.**

The wing of the ostrich is so rudimentary that the beak of the embryo never reaches it, therefore this malposition does not exist in ostriches.

Malpositions 2, 3 and 4 are the most significant in regards of the effects on hatchability. Malpositions 2 and 4 are reduced by incubating the eggs in the "air cell up" position, whilst malposition 3 is increased. Malposition 2 is very common and 3 is very rare in ostrich practice (Stewart 1989b).

It is important to note the following points:

* eggs in a natural ostrich nest do stand on end. This is the result of the eggs being tightly bunched together under the adult. When the egg loses weight through incubation it will naturally sit more and more vertical.

* the adults can know which end contains the air cell even though the egg is symmetrical in shape and appearance. The weight however is not symmetrical due to the air cell, one end being heavier than the other. The egg therefore has a natural tendency to stay upright and does this as the nest is shuffled by the adult.

* current practice in South Africa has eggs incubated horizontally for the first ten days before candling and if fertile, the completion of incubation is done vertically (Stewart, 1989b).

6. Paediatrics

6.1 Husbandry

Ostrich chicks are precocial hatching with a full coat of natal feathers, open eyes and the ability to stand within hours (Stewart 1989a). When they hatch, Betadine® solution or cream should be applied to their umbilicus to reduce the risk of omphalitis and yolk sac infections (Finger, 1992).

Chicks should remain in the hatcher for one to two days and are then placed in a first stage brooder with chicks up to two weeks of age (Stewart, 1989a). They can be given a multivitamin injection at this stage (Blyde, 1992 pers. comm.). Chicks do not need to eat for the first three to four days as the yolk supplies all of their required nutrients (Dolensk, 1978).

Eating and drinking are learned behaviours; newly hatched chicks are taught by older chicks. If older chicks are unavailable, healthy young poultry or water fowl are adequate. The brooder should be heated with either infra red lamps, heating pads, or space heaters (Stewart, 1989a). Helfer (1972) suggested temperatures of 39.2-35°C (90-95°F) for two weeks then 26.7-29.4°C (80-85°F) for a further two weeks. The flooring should be inedible, provide good traction and easily cleaned. Bin feeders and automatic waterers designed for poultry can be used (Stewart, 1989a). During the first three weeks they should have continuous light at the feeder (Thornberry, 1989b). Droppings should be closely observed for the three day period from commencement of feeding. With any signs of diarrhoea, cultures should be made and antibiotics started immediately (Dolensk, 1978). After two weeks of age the chicks should be moved to a large runway, preferably outside, which is important for exercise. Short grass or earth are excellent surfaces. Fencing should be flush to the ground, with small mesh to prevent neck and feet entanglement. Up to six months of age, the run should have a protective shelter and heat source in which chicks can be enclosed at night and during cold weather (Stewart, 1989a).

A time-activity budget study on ostrich chicks five to six months of age, fed concentrate feed and kept in outdoor pens, was conducted by Degen (1989). They were active for 12 hours during the day and sat for 12 hours at night. The day was divided into: 20% sitting; 61% walking; 6% standing; 7% eating; 5% foraging; and 1% drinking. Sitting was done with their legs folded under their bodies. They therefore spent 14.5 hours per day sitting and so it is important to encourage chicks to exercise. Blyde (1992 pers. comm.) recommended imprinting the chicks onto the keeper which they then follow all day. Gestier (1991) suggested fostering chicks back onto adults to reduce the problems associated with growth.

6.2 Disease

Some of the major pathological conditions affecting ostrich chicks include omphalitis, impactions and rotational limb deformities (RLD's).

6.2.1 Omphalitis

The open umbilicus provides a pathway for pathogens to gain access to the yolk sac which invariably results in death unless treated. The clinical signs include: swollen abdomen, dyspnoea, exercise intolerance, inability to stand or walk, inappetence, weight loss or failure to grow (Kenny, 1992; Philbey, 1991a). Gram negative rods are the most common isolates which indicate an environmental contamination problem. The most common method of egg contamination is from improper handling (Kenny, 1992). To reduce the incidence of this disease it is good practice to handle eggs with disposable gloves; keep the environment very clean and use fumigation; use topical Betadine® solution applied regularly to the umbilical stump; and use masking tape over the umbilical stump (belly wrap).

Kenny (1992) suggested a simple method of surgical removal of the infected yolk sac. He was able to save 70% of chicks presented to him which would have otherwise died.

Poor incubation conditions such as low temperature or humidity are other causes of unresorbed yolk sacs (Kenny, 1992). Finger (1992) described the disease "gut hypothermia". Chicks sitting on cool surfaces under an overhead lamp will have their yolk cooled. This slows the digestive tract which can lead to impactions, and omphalitis. He therefore recommended lining the floor of the brooder with outdoor carpet, or heating the brooder from the floor.

6.2.2 Impactions

Chicks up to a year of age are especially prone to ingesting foreign bodies. Philbey (1991a) recommended that rearing pens be covered with a light and fine substrate (e.g., saw dust or wood shavings). Acute impactions can be caused by sand, straw, astroturf or the like, and present as sudden depression followed by death in one to two days (Stewart, 1989a). Blyde (1992) believed that in Australia, long grass, especially kikuyu, readily caused impaction. Mineral oil and laxatives, in addition to supportive care may be of benefit if administered early. Chronic impactions are often caused by over consumption of stones that will not pass from the gizzard. These chicks may present with stunted growth or weight loss and progressive unthriftiness over several weeks. Impactions are readily identifiable by abdominal palpation and radiographic examination. Proventriculotomy is the most frequent treatment of choice (Stewart, 1989a).

6.3.3 Rotational Limb Deformities.

Limb deformities are very common in ostrich chicks. Affected birds have usually been artificially incubated and the newly hatched chick fed a high protein diet. This results in a rapid growth rate and frequently becomes apparent at two to six weeks of age, when an osteodystrophy develops and there is a lateral rotation of the distal tibia. This progresses until the gastrocnemius tendon luxates over the medial condyle of the metatarsus and the chick is unable to stand or walk normally (Reece, 1984). The exact aetiology is uncertain, and is probably multifactorial. Chicks raised on substrates that provide poor traction, such as straw and loose sand, frequently show these signs. Chicks reared in confinement are considerably more prone to RLD's than those allowed adequate space to run and exercise. Rapid growth is an associated factor such that chicks given restrictive protein diets have a reduced incidence of RLD's. (Stewart 1989a). Nutrient deficiencies causing perosis in poultry include manganese, choline, biotin, folic acid, niacin and pyridoxine (Stewart 1989a). Similar deficiencies are believed to play a role in the ostrich.

Selenium and vitamin E have been suspected aetiologies in many cases. Bodkin (1989) described "exudative diathesis", a vitamin E/selenium deficiency mainly recognised in the poultry industry. Deficiencies are usually seen in young chicks and appear as subcutaneous oedema; encephalomalacia (resulting in loss of balance, inability to stand and a twisted neck, and muscular dystrophy.

Van Heerden (1983) treated two four-month old paretic ostrich chicks with a vitamin E/Selenium preparation. Both chicks improved, with one recovering; the other was initially in a very poor condition and later died. Both chicks had been fed primarily crushed maize. Dolensk (1978), Hastings (1991b) and Vorster (1984) also suspected the involvement of vitamin E and selenium in the developmet of RLD's. Further research is required to determine the required dietary levels of vitamin E and selenium in ostriches (Hastings, 1991b).

Other causes of RLD's include calcium and vitamin D deficiencies. This was reported by Gandini (1986) where RLD's developed in ostrich chicks in a feeding trial, and reverted to normal with calcium supplementation. Chang *et al*. (1988) also described calcium deficiency causing RLD's which reverted when the diet was rectified.
Dolensk (1978) reported that a reduced growth rate reduced the incidence of leg problems. This can be achieved by restricting feed intake; by feeding the chicks only once or twice daily instead of *ad lib*. He also suggested that the development of RLD's was related to any condition resulting in severe restriction of food intake. This results in a concurrent development of multiple nutrient deficiencies. Such conditions as gastrointestinal impactions, gut hypothermia and infections are common causes. Frank (1992) described chicks diagnosed with coronaviral enteritis. The clinical signs included inappetence, weight loss, diarrhoea, and reduced feed consumption. Leg deformities were seen and were explained by multiple nutrient deficiencies associated with these clinical signs.

If detected early, mild deformities may be corrected with a variety of slings, hobbles and restrictive enclosures. For example an internal dimension of 50xl5x40cm is appropriate for a two week old ostrich chick. Young birds are maintained in the box for about two weeks and removed for two hours twice daily to eat and drink. Ostrich chicks tend to sit in these boxes rather than exercise and therefore require encouragement. A "traction block" can also be used for RLD's. A solid block (20x6x10cm for a one week old chick) is padded and positioned between the chick's legs and the legs padded and taped to the block. The chick should be allowed to run and exercise at least twice per week (Stewart, 1989c).

Chicks over two months of age with RLD's, or with RLD's of 90° or greater, may require surgical correction. Fowler *et al*. (1985) described a derotational osteotomy that was successfully performed on an emu, which may also work in the ostrich. Once RLD's appear, the prognosis is very guarded and most chicks are eventually euthanased.

7 Conclusion

The recent rise in interest in ostrich farming in Australia is associated with many benefits and heartaches. If a farmer is fortunate enough to have a successful breeding pair, with good nutrition, incubation and rearing techniques, they are able to earn very large incomes. Hastings 1991b describes a pair which earned $190,000 in the 1989/90 breeding season. The majority of farmers, however, are experiencing poor reproductive rates. With the current (1992) price of a three month old chick at $5,000 any extra chicks reared will be of great financial benefit. With breeding pairs valued between $70,000-90,000, the veterinarian can play a prominent role in the health and reproductive performance of these birds.

Farmers should be encouraged to keep detailed records for each pair such as: joining date where camping off is used; date egg is laid; date egg is set; egg fertile?; egg weight loss and candling pictures; and date hatched and any assistance required.

From this information a sum total of: eggs laid, eggs fertile, eggs hatched, and chicks reared can be listed for each pair. A veterinarian can then assess this information, along with nutrition, egg storage and incubation, and rearing techniques, and determine which areas require attention and suggest practises to improve production.

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