

Factors related to high levels of ostrich chick mortality from hatching to 90 days of age in an intensive rearing system

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ABSTRACT

Ostrich chick mortality was studied in 2522 chicks that were hatched artificially during the 1999/2000 breeding season. High levels of mortality were observed, with 1978 (78.4 %) of these chicks dying before 90 days after hatching. A total of 46.7 % (1177) of these chicks died before 28 days of age, and a further 30.7 % (801) died between 28 and 90 days post-hatching. Chick mortality to 28 days of age could not be conclusively related to sex, day of external pipping or breeder diet. Mortality rates were higher ($P < 0.05$) at the beginning and end of the breeding season than in the middle months. Differences in mortality levels of chicks incubated in different incubators could be related to the time of the breeding season during which the incubator was mostly used. The regression of chick mortality to 28 days of age on day-old chick mass followed a 2nd-degree polynomial. Chicks with day-old masses below 762.5 g were particularly at risk of dying before 28 days after hatching. Chicks hatching from eggs where excessive water loss to 35 days of incubation ($> 18\%$) was recorded were also at risk of succumbing before 28 days of age. Chick mortality percentages for the period from 28 to 90 days of age exceeded 80 % in chicks weighing an average of 1050 g at 28 days. Mortality percentages declined sharply at higher live masses, to between 20 and 30 % in chicks weighing ≥ 1950 g. This 'core' level of mortality remained throughout, even in the heaviest chicks. It was concluded that the high levels of chick mortality could be related to stress in chicks, resulting from an inability to adapt to the rearing environment. The high subsequent mortality percentages of low live mass chicks that survived to 28 days after hatching could probably be attributed to residual setbacks suffered earlier. A better understanding of the underlying principles involved in ostrich chick mortality in intensive rearing environments is required for progress in this field, resulting in more predictable survival rates under these conditions.

Key words: chick quality, day-old chick mass, evaporative water loss.

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INTRODUCTION

Ostrich farming is practised in a wide range of farming environments in southern Africa²⁹, ranging from very arid regions to temperate and tropical high-rainfall areas. This results in vastly different farming practices being employed. Ostrich chicks in the Klein Karoo area near Oudtshoorn are often reared under fairly intensive conditions, using housing facilities where it is possible to control the ambient temperature at optimal levels²⁹. These facilities often include an outside run for use during periods of fair weather and high temperatures. Young chicks are usually housed overnight and during periods of inclement weather. Temperatures under such conditions should be

determined by live mass rather than by age¹⁴. Despite fairly intensive care, high levels of mortality are often reported for young ostriches under commercial conditions⁹. The successful rearing of ostrich chicks under commercial semi-intensive and intensive farming conditions is therefore regarded as a challenge²¹.

Published systematic studies of ostrich chick mortality patterns under commercial conditions are scarce²⁹. Against this background, we investigated ostrich chick mortality percentages under conditions where high mortality levels were experienced, as well as relationships of chick mortality with other traits and effects.

MATERIALS AND METHODS

Animals

The experimental animals were derived from the commercial ostrich breeding flock maintained at the Klein Karoo

Agricultural Centre near to Oudtshoorn. The breeding flock mostly consisted of known breeding pairs at the Centre, but a small group of approximately 20 flock-mated ostriches (mated at a male:female ratio of 6:10) also contributed to the study material. The origin of the flock and the production practices have been adequately described^{9,28}. The data were collected during the 1999/2000 production season, which lasted from 29 June 1999 to 29 February 2000. An experiment involving a 3×3 factorial design was conducted during the breeding season, using 90 of the breeding pairs as experimental animals. The experiment involved 3 energy levels (balanced to contain 7.5, 8.5 and 9.5 MJ ME/kg DM) and 3 protein levels (balanced to contain 140, 120 and 100 g crude protein/kg) as factors⁵. The remaining animals were fed on the diet balanced to contain 8.5 MJ ME/kg DM and 120 g crude protein/kg. The breeding birds were fed the experimental diets in the morning on Mondays, Wednesdays and Fridays, and they had unrestricted access to clean drinking water. Specific treatment of the animals included the following:

Incubation details

Eggs were collected, identified and stored as described by Van Schalkwyk *et al.*^{24,25}. Eggs were set directly from the storage facility on Tuesdays in 1 of 3 electronic incubators. The incubators used were a Buckeye[®] machine with a capacity of 1000 eggs, a Prohatch[®] machine with a capacity of 340 eggs, and a Natureform[®] machine with a capacity of 180 eggs. All incubators were operated at 36 °C and 24 % RH. These settings resulted in an evaporative water loss of approximately 15 % over the first 35 days of incubation⁴. In the Natureform[®] and Prohatch[®] machines, the eggs were set in a vertical position with the airsac at the top. During incubation, the eggs were turned through an angle of 90° (45° on each side of the vertical axis) hourly. In the Buckeye[®] incubator, where the maximum turning angle was 60°, eggs were treated as described previously²⁷. Eggs were candled after 14 days of incubation, using a

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150 watt candling lamp. Eggs not fitting the developmental stage of ostriches at that time²⁶ were opened and inspected for embryonic development. After 35 days of incubation, the remaining eggs were transferred to the hatcher room and incubated further at a temperature of 36 °C and 28 % RH. All eggs were in the vertical position at this stage, and not turned again. The day and time of external pipping were recorded. After external pipping, eggs were transferred to the dry-off hatcher, where they were individually housed in separate chambers to ensure that individual identities were known. On the 43rd day of incubation, a portable candling lamp was used to inspect remaining eggs for signs of life, before assistance to hatch. Embryonic deaths and the hatching of live chicks were recorded individually at this stage.

Post-hatching management

Chicks were allowed to dry off for a maximum of 24 hours before being weighed, sexed and supplied with a temporary identity tag on the wing. All chicks were subsequently transferred to an intensive chick rearing facility where they were kept in groups of 80–150 chicks at a constant temperature of 25 °C. They remained in this facility for approximately 1 week (depending on climatic conditions), before being allowed outside to graze lucern (*Medicago sativa*) pastures, together with a crumbed, pre-starter diet (balanced to contain 12.5 MJ ME and 230 g CP per kg of diet²²). According to live mass (approximately 18 kg), birds were gradually transferred to a crumbed starter diet, which was balanced to contain 11.5 MJ ME and 190 g CP per kg of diet²². Birds were subsequently supplied with a permanent identity on a neck tag, and placed on a grower diet (balanced to contain 10.5 MJ ME and 155 g CP per kg of diet²²) from an age of 3 months or a live mass of 36 kg. Chicks were weighed at an age of 28 days after hatching. The death of chicks was recorded daily.

Recordings

A total number of 2522 chicks was available after the database was edited. A total of 397 chicks were deleted from the data beforehand. Of the latter chicks, 89 were used for experimental purposes, while 88 were known to have died but with the exact date of death unknown. The remaining 220 chicks either lost their identity tags, or were found to be missing at some stage.

Details with regard to the egg mass after collection, incubator used, paddock identity (and therefore breeding pair identity and diet), hatching date, evaporative

water loss from collection to 35 days of incubation, external pipping date and time, day-old chick mass, 28 day-old chick mass, as well as the date of death (if applicable) were known for individual chicks. Day-old chick mass was also expressed as a percentage of chick mass at collection.

Statistical methods

Means and standard deviations were calculated for continuous traits (egg mass, evaporative water loss to 35 days of incubation as well as chick mass at day-old and 28 days). Chi square procedures were used to assess the effects of sex, incubator, breeder diet and day of external pipping on chick mortality to 28 days²⁰. In analyses necessitating the comparison of >1 proportion, the Bonferoni correction was applied to ensure valid comparisons. Chick mass at day-old and at 28 days after hatching was categorised in either 25 or 100 g intervals. Percentages of chick mortality were calculated within these categories and presented graphically. The numbers of chicks represented in these categories ranged from 96 to 264 in the case of day-old chick mass, and from 43 to 84 in the case of 28-day-old chick mass. These percentages were regressed on the categorised live mass, using polynomial regression techniques. Similar procedures were followed for evaporative water loss, which were categorised into 1 % intervals. The numbers of chicks represented in these categories ranged from 56 to 354.

RESULTS

Mean performance levels

Mean egg mass was 1443 g, with a coefficient of variation of approximately 8 % (Table 1). Evaporative water loss was 14.4 %, with a 22.2 % coefficient of variation. Day-old chick mass averaged 862 g, with a coefficient of variation of 11.3 %. The average day of external pipping was 41.3 days with a low coefficient of varia-

tion of only 2.2 %. In the case of chick mass at 28 days, an extremely high coefficient of variation of approximately 46 % was observed. Chick mortality to 28 days after hatching was 46.8 %. This increased to 78.4 % by 90 days after hatching.

Daily chick mortality levels rose sharply to 6 days after hatching, when 152 chicks – roughly 6 % of the total chick crop and 7 % of the available chicks – died (Fig. 1). This was followed by a sharp decline in daily chick mortality to 11–13 days after hatching, when approximately 44 chicks (1.7 % of the total chick crop and 2.4 % of the available chicks) died per day. Chick losses subsequently declined steadily with an increase in age, and fewer than 10 chicks were lost per day from 69 days after hatching (which translated to below 1 % of total chicks hatched and 1 % of the available chicks). Chick losses were nevertheless high, and close to 80 % of the chicks that were hatched died earlier than 90 days after hatching (Table 1).

External influences on chick losses to 28 days

Chick losses to 28 days of age constituted nearly 60 % of the losses up to 90 days of age. The emphasis is therefore on these losses. Chick mortality to 28 days of age was independent of the sex of the chick (Table 2). Chicks being hatched during the beginning (July/August) and end (February–April) of the breeding season sustained higher ($P < 0.05$) levels of mortality than those hatched from September to December. The small number of chicks hatched during January had even lower ($P < 0.05$) levels of mortality. The mortality of chicks hatched in the Natureform[®] incubator was higher than those hatched in the other 2 incubators. The diet received by the breeding pair did not exert a significant ($P < 0.05$) influence on chick mortality to 28 days of age (Table 2). Mortality levels were independent of day of external pipping, although there was a suggestion of higher mortality

Table 1: Means, standard deviations (SD) and ranges (where applicable) for the traits recorded on 2522 ostrich chicks during the 1999/2000 production season, and mortality rates after hatching. Pipping time was recorded in 2493 chicks, and live mass 28 days after hatching in 1345 chicks.

Trait	Mean ± SD	Range
Egg mass (g)	1443 ± 115	1036–1855
Evaporative water loss to 35 days (%)	14.4 ± 3.2	5.2–40.3
Pipping time (days)	41.3 ± 0.9	39.0–44.2
Day-old chick mass (g)	862 ± 97	558–1179
Live mass at 28 days after hatching (g)	1834 ± 852	773–4526
Chick mortality:		
to 28 days	1177/2522 = 46.7 %	
to 90 days	1978/2522 = 78.4 %	
from 28 to 90 days	801/1345 = 59.6 %	

Table 2: Chick mortality to 28 days of age in relation to sex, incubator, production month and diet of the breeder birds (Brand *et al.*⁵).

Effect	Chicks hatched	Chicks died <28 days	Mortality rate (%)
Sex			n.s.
Male	1314	609	46.3
Female	1208	568	47.0
Incubator			**
Buckeye®	1948	896	46.0 ^a
Prohatch®	395	167	42.3 ^a
Natureform®	179	114	63.7 ^b
Production month			**
July/August	421	284	67.1 ^c
September	486	211	43.4 ^b
October	370	138	37.3 ^b
November	401	164	40.9 ^b
December	386	143	37.0 ^b
January	244	50	20.5 ^a
February–April	214	187	87.4 ^d
Breeder diet*			n.s.
1–LE/LP	122	60	49.2
2–LE/MP	172	75	43.6
3–LE/HP	193	99	51.3
4–ME/LP	208	92	44.2
5–ME/MP	842	377	44.8
6–ME/HP	192	87	45.3
7–HE/LP	372	189	50.8
8–HE/MP	146	81	55.5
9–HE/HP	275	117	42.5
Day of external pipping			n.s.
<41days	688	336	48.8
41–41.9 days	950	423	44.5
≥42 days	884	418	47.3

a,b,c,d Denote significant ($P < 0.05$) differences in columns.

n.s. = not significant ($P > 0.05$).

**Significant ($P < 0.01$)

*Energy (E) and protein (P) levels of the diet: L = low, M = medium, H = high; see Materials and Methods.

levels in chicks pipping early and late.

Mortality percentages to 28 days after hatching were quadratically related to day-old chick mass (Fig. 2). Mortality percentages declined from approximately 70 % in chicks weighing an average of 687.5 g at hatching, to between 40 and 50 % in chicks that weighed ≥ 762.5 g

at hatching. The relationship of mortality percentages to 28 days with egg mass at collection is not given, but it reflected the same basic trend depicted in Fig. 2, albeit somewhat less marked.

No conclusive tendency could be discerned for the mortality rates of chicks hatched from eggs with a low evaporative

water loss (< 11 %) to 35 days of hatching (Fig. 3). Mortality rates increased in chicks hatched from eggs with an excessive evaporative water loss to 35 days of hatching (> 18 %). A 3rd degree polynomial fitted the tendency best, with a R^2 value of 78 %. When the mortality of chicks to 28 days of age was related to day-old chick mass expressed relative to initial egg mass, essentially similar results were obtained. High levels of chick mortality were observed in chicks with a low day-old mass relative to initial egg mass. These results are thus not presented.

Regression of chick losses from 28 to 90 days of age on live mass at 28 days

A 3rd degree polynomial best described the regression of mortality percentages from 28 to 90 days of age on chick mass at 28 days after hatching (Fig. 4). In this case, the chick mortality percentage exceeded 80 % in chicks weighing an average of 1050 g at 28 days. At higher live masses, mortality percentages declined sharply, to between 20 to 30 % in chicks weighing 1950 g and heavier. This 'core' level of mortality appeared to remain throughout, even in the heaviest chicks.

DISCUSSION

Mean performance levels

Means and standard deviations for egg mass, evaporative water loss to 35 days and chick mass were consistent with previous reports^{4,9,10}. The mean day-old chick mass was within the range of 780–975 g proposed by Verwoerd *et al.*²⁹ as ideal for ostrich chicks. We did not find comparable published data with regard to the stage of external pipping. Mortality of ostrich chicks under farming conditions is known to be highly variable. Figures published in South Africa were 40–50 % to 3 months of age^{1,22}, as well as 10–20 % within one week of hatching and 10–30 % within three months of hatching³⁰. Under Australian conditions, More¹⁷ found great variation in chick mortality between farms. Survival to 30 days of age ranged from as low as < 20 % on some farms to > 90 % on other farms. Mortality of 2 batches of quarantined ostrich chicks to 3 months of age was 33 and 22 % in Britain¹². Deeming and Ayres¹¹ reported a mortality rate of 19 % in ostrich chicks up to an age of 5 weeks. In another study³, annual mortality rates ranging from 17 to 61 % were reported. The birds in our study sustained somewhat higher levels of mortality than that observed in most sources cited. When the extreme range of mortality levels in ostrich chicks is considered, our results are still within these limits.

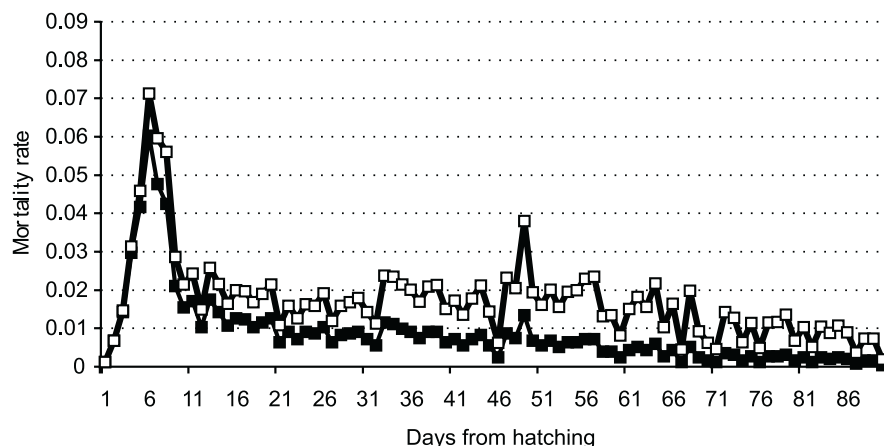


Fig. 1: Daily chick losses after hatching in 2522 ostrich chicks hatched during the 1999/2000 production season, expressed as a proportion of all chicks hatched (solid squares) or from live chicks at that stage (open squares).

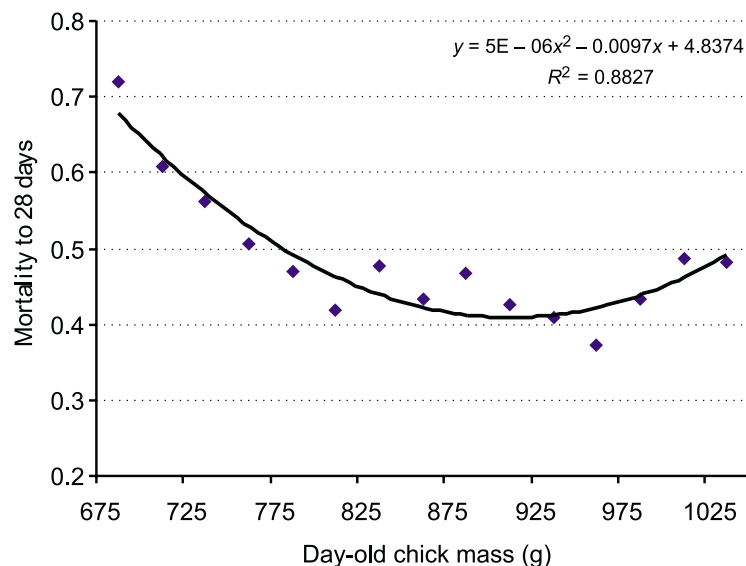


Fig. 2: Relationship of chick mortality before 28 days after hatching with day-old chick mass in ostrich chicks reared intensively.

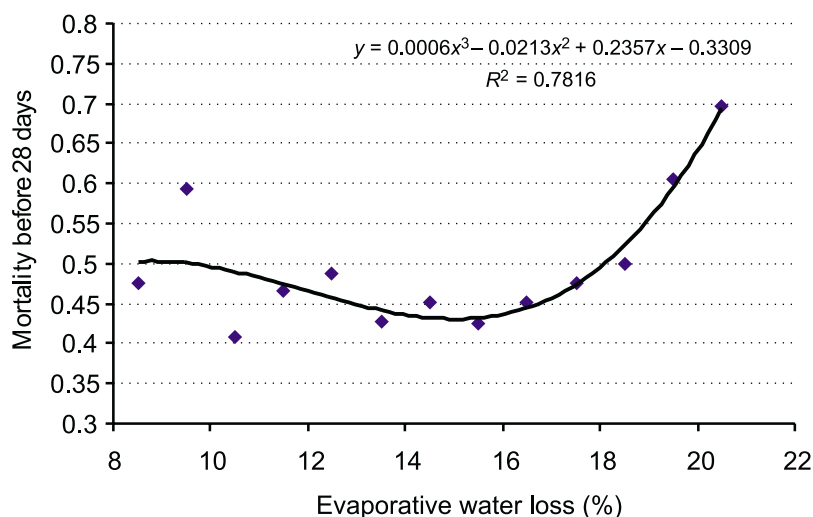


Fig. 3: Relationship of chick mortality before 28 days after hatching with evaporative water loss percentage to 35 days of incubation in ostrich chicks reared intensively.

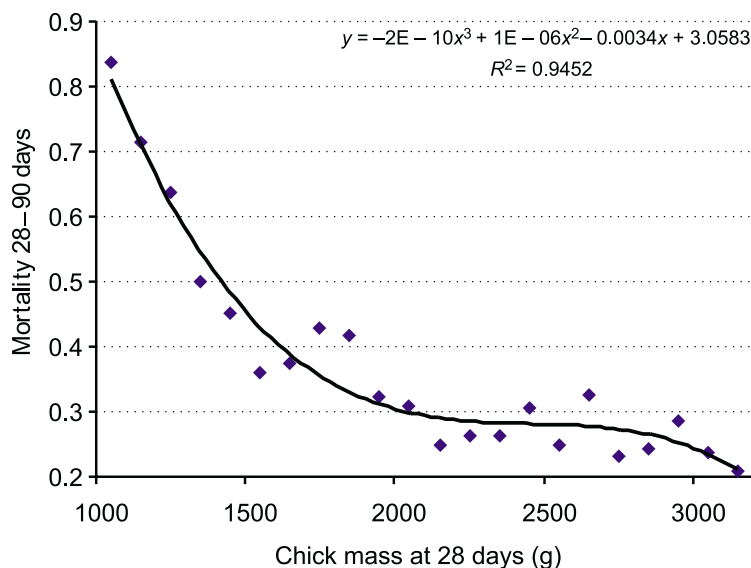


Fig. 4: Relationship of chick mortality during the period 28-90 days after hatching with chick live mass recorded at 28 days of age.

External influences on chick losses to 28 days

There was no conclusive evidence that sex, the diet of the breeding birds or the day of external pipping influenced chick mortality to 28 days. Poultry chicks hatched at the beginning and end of the hatching period sustained higher levels of mortality to 10 days of age than those that hatched during peak hatching¹⁵. The tendency observed for ostrich chick mortality in relation to the day of external pipping followed the same pattern, but no significant differences were found (Table 2). Although assistance to hatch was not recorded in the present study, it should be stated that higher levels of early chick mortality were observed in ostrich chicks assisted to hatch than in those hatching naturally¹¹. The quality of chicks was correspondingly affected by assistance to hatch in one study².

Chicks that hatched early (July/August) or late (February–April) in the breeding season sustained higher levels of mortality than those hatching in the period September to January. No conclusive explanation can be presented for this result. Lower levels of chick survival to 28 days were found in eggs incubated in the Natureform[®] incubator (Table 2). Since all 3 incubators were not employed throughout the incubation season, it was impossible to relate chick survival exclusively to the incubator used. In the case of the Natureform[®] incubator, a proportionally large percentage of eggs that were recorded, were hatched during July/August 1999. These months were characterised by a relatively low percentage of chicks that survived to 28 days of age (Table 2). No eggs were, for instance, incubated in the Prohatch[®] incubator during this period. It was therefore impossible to separate the relationship between the incubator being used and the seasonal trend observed for chick mortality. The likelihood of marked differences among the 3 incubators, however, appears to be remote. All 3 incubators were set to provide the same conditions with regard to temperature and relative humidity.

The relationships of the percentage of mortality with egg mass and chick mass followed a 2nd-degree polynomial. Very small day-old chicks (<762.5 g), in particular appeared to be at risk (Fig. 2). Chicks that were hatched from eggs with an excessive moisture loss to 35 days of hatching also appeared to be at greater risk of dying before reaching an age of 28 days (Fig. 3). This association could not be confirmed from published data, but it was previously reported that shell-deaths were higher in eggs showing excessive moisture loss⁴. Poor quality chicks are

thus likely to be obtained from such eggs if they survive to hatching.

Regression of chick losses from 28 to 90 days of age on live mass at 28 days

A strong association was evident with chick mass at 28 days in chicks that succumbed between 28 and 90 days after hatching. Chicks that weighed less than 1950 g at this stage were at greater risk of dying between 28 and 90 days (Fig. 4). Survival was compromised particularly in those chicks weighing less than 1300 g, where mortality percentages exceeded 60 %. This association is probably a reflection of an underlying problem that the affected chicks experienced with adapting to the rearing environment. In broiler chicks, it was found that egg mass and day-old chick mass ceased to be the major determinant of live mass at an early age of 5 days¹⁹. At later ages, food intake appeared to make the most important contribution to final mass. This topic has not been researched in ostriches to the same extent. The fact that the genetic correlations of egg and chick mass with live mass at later ages were low⁷, suggested that the principle may also apply to ostriches.

Lack of functional development of the digestive tract of ostrich chicks as soon as possible after hatching, predisposes chicks to being 'non-starters' or 'fading chicks' at the end of the yolk-dependent phase^{8,23,29}. The excessive variation of live mass at 28 days of age and the telling role it played in subsequent survival fits in with these contentions.

CONCLUSIONS

The study was characterised by high mortality in chicks up to 28 days after hatching, as well as high subsequent mortality in 28 day-old chicks with a low live mass. These problems could be related to stress resulting from an inability to adapt to the rearing environment. Studies on the behaviour of ostrich chicks under captive conditions provide an indication of factors related to adaptation to the more intensive environment. Such studies have suggested that feeding behaviour differed markedly between chicks. Most chicks would more readily consume food that was scattered on the floor than from feeding bowls⁶, while a definite preference for green items was evident. Habitual pecking at non-food objects was negatively related to pecking at food, leading to poorer growth in individuals that indulged in this habit^{16,18}. The hypothesis that growth in some individuals in mixed-mass groups was restricted because of harassment by larger birds was

not supported, although it was found that pecking of companions resulted in slower growth¹⁶. Although marked behavioural differences were found between chicks (of which some could be related to performance), there is still a need for further research on this topic¹³. This could assist in the development of more appropriate husbandry techniques, taking cognisance of the environmental requirements of young ostrich chicks.

The high subsequent mortality percentages of low live mass chicks that survived to 28 days after hatching could probably also be attributed to setbacks suffered earlier. It stands to reason that the transitional period during which chicks become dependent on nutrients derived from digestive processes instead of nutrients derived from the yolk, would be a critical phase in this whole process. The further study of this process of adaptation appears to be a prerequisite in establishing the aetiology of ostrich chick mortality. It is imperative that the processes experienced by the chicks as traumatic, and which are reflected in the observed high levels of mortality, are properly understood. Strategies to alleviate the problem by improved management, health care, nutrition and breeding are unlikely to succeed if the problem is not properly understood.

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Book review — Boekresensie

International animal health code: Mammals, birds and bees, 10th edn

2001. Office International des Épizooties, Paris, soft cover, 485 pp., price €45, ISBN 92-9044-526-2.

The Office International des Épizooties is to be congratulated on achieving publication of the 2001 edition of the Code long before the end of 2001. The code consists, as before, of sections relating to general provisions (definitions, notification, obligations and ethics, import risk analysis including a chapter on biologicals for veterinary use, import/export procedures), recommendations applicable to specific diseases, and appendices. The appendices contain valuable guidelines for diagnostic tests for international trade, collection and processing of semen and embryos/ova, health control and hygiene (with particular reference to poultry and bee-keeping), quarantine recommendations, inactivation of pathogens and vectors, transport of animals, and epidemiological surveillance systems. The final section is devoted to model international veterinary certificates.

While the layout remains virtually identical to the previous issue, various important changes and improvements have been made. A new definition, 'Official control programme', has been added. Section 1.2 has been rearranged in a way that users will find more logical and easy to follow. The title has been changed to 'Obligations and ethics in international trade'. As before, the section comprises two chapters, but the general obligations and ethics, including harmonisation of methods and accountability, are covered in the 1st chapter, while the 2nd chapter is devoted completely to certification procedure. The chapter on international transfer and laboratory containment of animal pathogens has been rearranged so that the table providing guidance on the level of laboratory con-

tainment required is printed on facing pages for easier perusal. Requirements for importation of ova or embryos derived *in vivo* and *in vitro* have been added to the chapter on contagious bovine pleuropneumonia, and for embryos/ova derived *in vitro* in the chapters on foot-and-mouth disease, leptospirosis and bovine brucellosis. The chapter on bluetongue has been extensively revised, with more detail on the determination of status, surveillance, and an increase in the infective period from 60 to 100 days. The appendix (3.2.1) relating to bovine semen has been extensively revised. Surveillance and monitoring systems for BSE have been expanded to include fallen stock and other unnatural deaths in cattle over 24 months of age. For readers like myself, with a particular interest in pig diseases, there are some disappointments. A sentence has been added to the chapter on African swine fever relating to lifelong carrier status that is not supported scientifically, and the chapter is generally in need of revision. The recommendations for importation of pigs free from porcine progressive atrophic rhinitis should include a diagnostic test, and the disease is presented non-specifically as a single entity, which it is not. While certain shortcomings are inevitable in such a comprehensive work, it is definitely mandatory reading for all who are concerned in animal health in general and in the import/export of animals in particular.

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