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CAUSES OF MORTALITY AMONG OSTRICHES (*STRUTHIO CAMELUS*) AND EMUS (*DROMAIUS NOVAEHOLLANDIAE*) RAISED COMMERCIALLY IN SAUDI ARABIA

(With 4 Tables and 4 Figures)

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أسباب ومعدلات النفوق في طيور النعام والإيميو تحت نظم التربية التجارية بالمملكة العربية السعودية

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ترصد الورقة معدلات وأسباب النفوق وسط الصيصان والطيور النامية وأمهات النعام والإيميو في مزرعة كبرى للتربية التجارية للرواكض (النعام والإيميو) بالمملكة العربية السعودية وذلك على مدى أربعة أعوام في الفترة من ١٩٩٨ إلى ٢٠٠١م. بلغ متوسط معدل النفوق السنوي وسط صيصان النعام والإيميو خلال فترة الرعاية (١ – ٣ شهور) نحو ٢٩,١% و٢١,٦% على التوالي بينما كان متوسط النفوق العام وسط الصيصان خلال فترة الأربعة أعوام ٤٦,٣%. تمثلت أهم أسباب النفوق وسط الصيصان من نوعي الرواكض في تكسح الأرجل ، ظاهرة ذبول الصيصان ، مرض السمير ، الإختناقات الناتجة عن التكدس الليلي ثم الإلتهابات المعوية. بلغ متوسط معدل النفوق وسط الطيور النامية لنوعي الرواكض (٣ شهور إلى سنتين) خلال أعوام الدراسة الأربعة ١٨,٧%. كانت أهم أسباب النفوق وسط هذه الشريحة هي تلبك المعدة بالرمال ثم مرض السمير ثم حالات تكسح الأرجل. أما أهم أسباب النفوق وسط أمات طيور النعام والإيميو فتمثلت في الإنتان الدموي الباستوريلي ، الحوادث والإصابات ، إلتهابات البريتون ثم الإلتهابات المعوية.

SUMMARY

The incidence and causes of mortality in a mixed ratite farm which produced ostriches and emus were recorded over four production seasons (1998 – 2001). The mean annual mortality rates for ostrich and emu chicks during the rearing phase were 29.1% and 21.6%, respectively. The mortality rate was 46.3% for the whole chick

population during four production seasons. Notable causes of chick mortality were leg deformity, fading chick syndrome, Newcastle disease (NCD), suffocation and enteric infection. The crude mortality rate for ostrich and emu growers throughout the study period was 18.7% with an annual mean of 12.3%. Sand impaction, NCD and leg deformity were the main causes of mortality among this group of birds. Septicaemic pasteurellosis was the major cause of death among breeding ostriches, while wound infection and peritonitis assumed minor roles. Egg peritonitis, accidents and enteritis were the most important causes of death among emu breeders.

Key words: Ostriches (*Struthio camelus*), emus (*Dromaius novaehollandiae*), chick mortality

INTRODUCTION

The ratite family includes flightless birds with a flat, keel-less breastbone. Ostriches (*Struthio camelus*), emus (*Dromaius novaehollandiae*) and rheas (*Rhea americana*) are the ratites most commonly raised as livestock in increasingly many countries in the world. Ratites produce red meat that is similar to beef or venison. Hides and leathers, particularly of ostriches, make fine leather products. Other significant ratite products include oils and fat as well as feathers (Carbajo, 2006). Currently, many countries, particularly in the Middle East, are witnessing increasing interest in the breeding of ostriches and emus as new alternative sources of healthy red meat. Ratite birds adapt well to most climates, particularly if sufficient protection and management requirements are provided (Huchzermeyer, 1998), however, the rearing of young chicks is considered as the most critical phase in their commercial production and has been incriminated as the cause of significant problems wherever these non-flying birds are kept. Best rearing results are achieved with the selection of high quality day-old chicks (Deeming *et al.*, 1996). Young ratites are described by many workers as delicate creatures and are prone to high mortality rates despite the adoption and provision of adequate managerial practices (Deeming *et al.*, 1996; Huchzermeyer, 1998). Ostrich chick mortality in South Africa was reported to be ranging between 40% and 78.4% (Smith *et al.*, 1995; Cloete *et al.*, 2001) whereas it was reported to be 21.7% and 33.3% in two batches in Britain (Deeming, 1997). Little is known about the survivability of ostrich and emu chicks in the wild. Hurxal (1979) suggested that ratite chick survivability is low in the wild; only 10% - 15% of the hatched chicks in Kenyan bushes could survive to one year

of age. Better survivability rates were reported under farming conditions, though highly variable (Deeming *et al.*, 1996; Huchzermeyer, 1998; Verwoerd, 2000). The ability of ratite chicks to survive to an older age is a key factor for increasing flock size and achieving investors objectives. The literature on ostrich and emu diseases is scanty and is dominanted by single case reports or incompletely investigated outbreaks (Verwoerd, 2000). In this paper the results of field studies on the incidence and causes of mortality among ostriches and emus in an intensive ratite farm in Saudi Arabia throughout four production seasons (1998–2001) are presented and discussed. The data presented in this paper were part of a study intended to determine the constraints facing ratite farming in Saudi Arabia (Agab, 2005). The objective of the present study was to determine the possible causes of mortality among ostriches and emus raised commercially in a private ratite farm in Saudi Arabia.

MATERIALS and METHODS

The ratite farm in which this study was conducted has been established in Al-Qassim region, Central Saudi Arabia in 1997. The original breeding stock was imported from France as ready-to-lay adult birds and was composed of 400 *Black-neck* ostriches (*Struthio camelus* var *domesticus*) and 400 emus (*Dromaius novaehollandiae*). The birds were housed in communal pens measuring 100 X 200 m^2 at a stocking rate of 60 – 70 birds per pen. The fence for all pens was made of a special wire net (*Cyclone*®, McArthur Cyclone, Bristol, England). Each pen was provided with sufficient amount of feeders and drinkers as well as adequate shaded areas. Feed was manufactured in the farm and was provided in sufficient quantities according to the age and production status of the different bird groups (starter, grower or breeder feed) following standard recommendations (Huchzermeyer, 1998). The hatchery section was composed of several ratite incubators and hatchers (*Mayenne Eclosion, St. Jean Sur Mayenne, FRANCE*). The chick rearing section, in which the birds were kept for up to three months of age, was composed of 24 rooms of varying sizes ranging from 9 to 32 m^2 each. An outer exercise area of 30 X 120 m^2, one third of which was shaded and attached to each rearing pen. The floors of the rearing rooms and exercise areas were made of rough surfaced concrete. Each room was supplied with one or more air-conditioner with cooling and heating abilities. The grower birds were housed in several pens of varying sizes, ranging in dimensions from 20X30 m^2 to 100X200 m^2.

Farm Operations: Starter mash feed and water were provided, *ad libitum*, to newly hatched chicks upon arrival from the hatchery to the rearing section. Vitamins were also added via drinking water or feed. Chicks were transferred to the growers section at three months and were then provided with grower or finisher pelleted feed. Growers were either sent for slaughter at the age of 10 to 14 months or allowed to grow and become breeders. Ostrich and emu chicks were immunized against Newcastle disease at one-day old using a live attenuated tissue culture vaccine (*Twinvax-MR®*, Schering Plough Animal Health, USA) as aerosol. Second and third booster doses of the vaccine were administered subcutaneously at days 21 and 90 of age, respectively, using an oil adjuvant killed virus vaccine (*Binewvax* or *Imopest, Merial, Lyon, FRANCE*). Breeders were also immunized annually at the end of each breeding season. The birds were followed daily for deviations in health or vitality. Dead birds were necropsied to determine the cause of mortality. Randomly selected batches (Table I) of ostrich chicks were followed during rearing period throughout the year 2000 season to determine the mortality rate. Pathological samples were obtained and examination was conducted in the diagnostic unit while bacteriological cultures were carried out at the Department of Microbiology, College of Agriculture and Veterinary Medicine, Al-Qassim University, Saudi Arabia.

Statistical Analysis: Data were analyzed by commercially available computer soft wares (SP9.O, Maxel, U.K.). Complete Randomized Block Design was used for data analysis (Steel and Torrie, 1980).

RESULTS

Ostrich chick mortality during rearing phase (up to three months of age) of randomly selected batches throughout the season 2000 is shown in Table 1. The overall average mortality rate during the season was found to be 29.1%. High mortality rates (<30%) were recorded during January, March, May and June. Similar high mortality rates were also recorded in November and December. The pattern of mortality was found to be fluctuating and non-consistent. The mortality in emu chicks during rearing phase for the season 2000/2001 is also presented in Table 1. It can be noticed that the overall emu chick rearing mortality for the whole season (21.6%) was lower than the ostrich chick rearing mortality rate (29.1%). The emu chick mortality during rearing period in two

production seasons (1999/2000 and 2000/2001) were found to be fluctuating, non-consistent and had no specific pattern.

The causes of mortality in ostrich and emu chicks throughout four production years (1998–2001) are presented in Table 2. A total of 2087 ostrich chicks died during the four production seasons giving a crude mortality rate of 35.1%. The mean annual chick mortality rate was 46.3%. Leg deformities were the main causes of mortality (33.7%) followed by fading chick syndrome (FCS) (19.4%). Other notable causes of mortality in ostrich chicks included Newcastle disease (NCD) (17.7%) and enteritis (15.0%). In emu chicks a total of 928 birds died during the study period giving a crude mortality rate of 14.6 % with a mean annual mortality rate of 12.8 %. Leg deformities were the most common causes of mortality (37.1%) followed by suffocation (31.1%) and the fading chick syndrome (19.9%). In comparing the causes of mortality in ostrich and emu chicks, it can be noticed that leg deformities comprised the most common cause of mortality in both species (37.1% and 33.7%). Enteritis was more common in ostriches than in emus (15% versus 0.6%, respectively). No mortalities due to Newcastle disease or sand impaction were detected in emus.

The causes of mortality in ostrich and emu growers throughout the same four seasons are shown in Table 3. The crude mortality rate in the group was 18.7% during the four seasons, with a mean of 12.3 % per year. Sand impaction was the main cause of death (55.3%) while Newcastle disease (14.0%), leg deformities (12.5%) and enteritis (4.2%) were other less common causes of mortality. For emu growers, a total of 350 birds died during the study period with a crude mortality rate of 6.5% and an annual mortality rate of 5.5%. Leg deformities were the main cause of mortality in emu growers (45.4%) followed by suffocation and infected wounds inflicted during fighting (14.6%, each). Foxes were found to be the main predators attacking emu growers during nights. When comparing the different causes of mortality in ostrich and emu growers, accidents of the leg and neck regions were more prevalent in emus. This is probably due to the fact that growing emus have more incidence of fighting wounds than in ostriches (14.6% versus 0.3%, $p<0.001$). Likewise emus suffered from more cases of suffocation than ostriches ($p<0.0001$).

The causes of mortality in ostrich and emu breeders throughout the four years of study are shown in Table 4. Septicaemic pasteurellosis was found to be the most killing problem in ostrich breeders (65.6%). All mortalities due to septicaemic pasteurellosis occurred during the

summer when the ambient temperatures were at the maximum. Other important causes of mortality among ostrich breeders included infected wounds (9.4%), accidents leading to broken necks as a result of head being trapped on the fence during fighting (7.3%) and traumatic peritonitis (6.3%). For emu breeders, a total of 36 birds died during the study period giving a crude mortality rate of 9% and a mean annual mortality of 2.3%. Egg peritonitis (27.8%) was the main mortality factor among emu breeders followed by accidents involving the neck (25%) then infected fighting wounds (13.9%) and enteritis (11.1%) followed by septicaemic pasteurellosis (8.3%). Ostrich breeders were found to be more affected by septicaemic pasteurellosis than emu breeders (65.6% versus 8.3%). Emu breeders, on the other hand, had more mortality rate due to enteritis, egg peritonitis, accidents on the neck region and infected fighting wounds in contrast to ostrich breeders.

Table 1: Ostrich and emu chick mortality during rearing phase.

Ostrich chick mortality (Season 2000)				Emu chick mortality (2000/2001)			
Month of hatch	No. of chicks followed	Mortality		Month of hatch	No. of chicks followed	Mortality	
		No.	%			No.	%
January	81	26	32.1	December	104	21	20.2
February	146	38	26				
March	153	63	41.2	January	376	158	42
April	71	17	23.9				
May	255	122	47.8	February	810	122	15.1
June	419	161	38.4				
July	555	124	22.3	March	556	96	17.3
August	395	57	14.4				
September	129	33	25.6	April	42	9	21.4
October	155	27	17.4				
November	216	79	36.6	May	38	10	26.3
December	141	42	29.8				
Total and Percentage of mortality	2716	789	29.1	Total and percentage of mortality	1926	416	21.6%

Table 2: Causes of mortality in ostrich and emu chicks.

Species	Year	Number of dead birds													Total mortality
		Leg deformity	Enteritis	Sand impaction	N C D	Yolk sac retension / infection	Congenital deformity	Intestinal torsion	Accidents	F C S	Suffoca-tion	Cold stress & rains	Eye problem	Unidenti-fied causes	
Ostriches	1998	23	0	1	0	13	1	0	0	1	0	0	0	0	39
	1999	103	39	0	0	38	1	0	2	12	5	0	0	3	203
	2000	205	8	30	369	19	2	1	11	12	9	30	0	2	699
	2001	373	266	39	0	34	10	3	5	379	8	18	5	6	1146
	Total	**704**	**313**	**70**	**369**	**104**	**15**	**4**	**18**	**404**	**22**	**48**	**5**	**11**	**2087**
	%	**33.7**	**15**	**3.4**	**17.7**	**5**	**0.7**	**0.2**	**0.9**	**19.4**	**1.1**	**2.3**	**0.2**	**0.5**	**100%**
Emus	1998	0	0	0	0	0	0	0	0	0	0	0	0	3	3
	1999	85	0	0	0	4	6	0	3	55	66	0	0	0	219
	2000	92	5	0	0	14	5	0	1	73	106	0	0	3	299
	2001	167	1	0	0	12	50	0	2	57	117	0	0	1	407
	Total	**344**	**6**	**0**	**0**	**30**	**61**	**0**	**6**	**185**	**289**	**0**	**0**	**7**	**928**
	%	**37.1**	**0.6**	**0**	**0**	**3.2**	**6.6**	**0**	**0.6**	**19.9**	**31.1**	**0**	**0**	**0.8**	**100%**

Abbreviations:

F C S: Fading chick syndrome.

N C D: Newcastle disease.

Table 3: Causes of mortality in ostrich and emu growers.

Species	Year	Number of dead birds										Total mortality
		Leg deformity	Enteritis	Sand impaction	N C D	Accidents	Intestinal torsion	Infected fighting wounds	Predation	Suffocation	Unidentified causes	
Ostriches	1998	3	0	1	0	0	0	0	0	0	0	4
	1999	23	0	1	0	4	0	0	0	0	0	28
	2000	53	1	100	101	16	6	0	8	3	8	296
	2001	14	29	297	0	12	7	2	6	13	14	394
	Total	**90**	**30**	**399**	**101**	**32**	**13**	**2**	**14**	**16**	**22**	722
	%	**12.5**	**4.2**	**55.3**	**14**	**4.4**	**1.8**	**0.3**	**1.9**	**2.2**	**3.1**	**100%**
	Year	**Number of dead birds**										
		Leg deformity	**Enteritis**	**Sand impaction**	**N C D**	**Accidents**	**Intestinal torsion**	**Infected fighting wounds**	**Predation**	**Suffocation**	**Unidentified causes**	**Total mortality**
Emus	1998	0	0	0	0	0	0	0	0	0	0	**0**
	1999	30	0	0	0	6	0	0	16	0	0	52
	2000	62	1	0	0	19	0	27	0	11	2	122
	2001	67	1	0	0	43	0	24	0	40	1	176
	Total	**159**	**2**	**0**	**0**	**68**	**0**	**51**	**16**	**51**	**3**	350
	%	**45.4**	**0.6**	**0**	**0**	**19.4**	**0**	**14.6**	**4.6**	**14.6**	**0.9**	**100%**

Abbreviations:
N C D: Newcastle disease.

Table 4: Causes of mortality in ostrich and emu breeders.

Species	Year	Number of dead birds											Total mortality
		Septicaemic pasteurellosis	Enteritis	Sand impaction	Egg peritonitis	Accidents	Infected fighting wounds	Traumatic peritonitis	Snake bite	Infected fighting wounds	Unidentified causes	Traumatic peritonitis	
Ostriches	1998	58	0	0	0	1	0	5	0	0	0	5	64
	1999	1	0	0	0	1	0	0	0	0	2	0	4
	2000	2	1	0	2	4	4	1	0	4	1	1	15
	2001	2	1	1	1	1	5	0	0	5	2	0	13
	Total	63	2	1	3	7	9	6	0	9	5	6	96
	%	65.6	2.1	1	3.1	7.3	9.4	6.3	0	9.38	5.2	6.25	100%
	Year	Number of dead birds											Total mortality
		Septicaemic pasteurellosis	Enteritis	Sand impaction	Egg peritonitis	Accidents	Infected fighting wounds	Traumatic peritonitis	Snake bite	Infected fighting wounds	Unidentified causes	Traumatic peritonitis	
Emus	1998	0	1	0	0	0	0	0	0	0	0	0	1
	1999	1	0	0	1	2	0	0	0	0	0	0	4
	2000	1	2	0	5	4	3	1	1	3	0	1	17
	2001	1	1	0	4	3	2	0	0	2	3	0	14
	Total	3	4	0	10	9	5	1	1	5	3	1	36
	%	8.3	11.1	0	27.8	25	13.9	2.8	2.8	13.9	8.3	2.8	100%

Fig. 1. Leg deformity in an ostrich chick.

Fig. 2. The intestines of a dead ostrich chick filled of sand.

Fig. 3. Septicaemic pasteurellosis in an ostrich. Note the froth in the mouth of the bird.

Fig. 4. An adult ostrich breeder drowned in a drinker.

DISCUSSION

High mortality rate in young ratites can be considered a major constraint in the intensive production of these birds. The ratite chick mortality during rearing period was found to be highly variable and unstable throughout the seasons. The negative influence of growth inhibiting factors on young ratites could be involved in this fluctuating and non-consistent pattern of rearing mortality (Deeming *et al.*, 1996). Certain periods of the seasons experienced higher mortality rates than other periods particularly when the ambient temperatures were high and density in the pens reached its maximum (Verwoerd *et al.*, 1999). The ostrich chick rearing mortality throughout one year (29.1 %) was far less than the rates reported in South Africa by Smith *et al.* (1995) (40% - 50%) and Cloete *et al.* (2001) (78.4%). However, rearing chick mortality in two batches in Britain was found to be 21.7% and 33.3% (Deeming *et al.*, 1993). In this study, it was noticed that chicks needed assistance for external pipping during hatching showed higher rearing mortality rates (75%) compared to those hatched without assistance (9.8%). Cloete *et al.* (2001) reported higher chick rearing mortality rates at the beginning and end of the breeding season and noted that chicks with low body mass (below 762.5 grams) at day-one or chicks hatching from eggs with excessive (>18%) water loss had higher mortality rates. Management had a direct effect on chick mortality. For example, Verwoerd *et al.* (1999) reported reduced mortality rates when a semi-extensive rearing method was adopted in place of a more intensive one.

The present study demonstrated the role of leg deformities as a leading cause of mortality in ostrich and emu chicks (Fig. 1). Leg deformities were identified as a major problem of farmed ostrich in Australia (Jensen *et al.*, 1992) and South Africa (Bezuidenhout and Burger, 1993). Serum calcium:phosphorus ratios of leg-deformed ostrich chicks showed greatest variation when compared to ratios of normal ostrich chicks (Agab and Abbas, 2007). Fading chick syndrome and Newcastle disease were other important causes of mortality, particularly in ostrich chicks. Fading chick syndrome is a phenomenon of not so well known aetiology characterized by wasting out of affected chicks till mortality ensues. Verwoerd *et al.* (1999) incriminated the delay in immediate provision of feed to young chicks as a predisposing factor of this syndrome while others attributed the condition to a multiplicity of microbial agents (Shane and Tully, 1996; Huchzermeyer, 1998). Newcastle disease was the cause of high mortality during one season

(the year 2000) but was successfully controlled thereafter and was not incriminated in further mortality among ostrich chicks and growers beyond that season. In this study, ostrich chicks below 21 days of age were affected with Newcastle disease, proving that maternal immunity was not sufficient to protect chicks against infection with NCD virulent virus strains. Vaccination of ostrich chicks of one day old was effective in controlling the disease. Enteritis, a multifactorial cause of mortality in intensively reared ostrich and emu chicks, has assumed more severity during unfavourable conditions which lowered the birds resistance. Hines *et al.* (1995) reported combined adenovirus and rotavirus infection with *Escherichia coli* septicaemia in an emu chick. Woolcock *et al.* (1996) isolated paramyxovirus serotype 7 and *Campylobacter jejuni* from the intestinal contents of two ostrich growers manifesting proliferative nonsuppurative enteritis. Necrotic or ulcerative enteritis caused by *Clostridium perfringens* type C could also be involved as a cause of chick mortality since these young birds were frequently subjected to stress conditions, particularly environmental extremes such as excessive cold and heat (Huchzermeyer, 1998). For prevention against enteritis, young chicks should be reared on pasture and enough fibre included in the feed. Moreover, stressors and excessive use of antibiotics or proteins in the chick diet should be avoided (Deeming *et al.*, 1996). Sand impaction constituted the main cause of mortality in ostrich growers and was also an important cause of mortality in ostrich chicks (Fig. 2). Mushi *et al.* (1998) considered this problem as one of the major causes of debility and death among intensively farmed ostriches in Botswana. Mortality due to this condition most probably resulted from an eventual haemorrhagic enteritis as a result of clostridial enterotoxaemia. Although Mushi *et al.* (1998) claimed that this condition has no age predisposition, we observed the problem only in young and juvenile ostriches (< 5 months). Adult birds were not clinically affected although they were often seen ingesting large amounts of sand. The problem of sand impaction was successfully controlled by using dried lucerne hay as litter in the grow-out runs. Sand impaction causes gastric and intestinal stasis leading to starvation due to cessation of food passage, loss of weight and eventually death of the affected bird. It is also a leading predisposing factor for clostridial entrotoxaemia (Shane and Tully, 1996). Adequate housing, better nutrition and care were considered as crucial in preventing sand impaction (Yuksek *et al.*, 2002). Avoidance of using sand as bedding for young chicks is a common-sense preventive measure. Sand impaction was not encountered

as a cause of death in emu chicks or growers in this study. This is perhaps because emus, unlike ostriches, are selective and good discriminate feeders.

Due to the propensity of ostriches to sit out in rainy weather rather than seeking shelter (Deeming, 1997) and as ostrich chicks have little subcutaneous fat (More, 1996), some mortality rate among ostrich chicks (2.3%) was caused by cold stress and rains. Therefore, ostrich chicks should be cared for and brought into shelter during weather extremes. This also helps to avoid certain thermoregulatory behaviours like huddling together, as it might compete with other important activities such as feeding (Brown and Prior, 1998). Yolk sac retention could result from low yolk utilization due to lowered overall energy expenditure for tissue maintenance in ratites as compared to other species (Gefen, 2001; Huchzermeyer, 1998). Lack of yolk utilization and absorption facilitates for microbial infection by pathogens such as *Escherichia coli* and *Staphylococcus aureus*. (Grilli *et al.*, 1996). Although adult ostrich breeders are relatively resistant to diseases (Gonzalez, 1992), septicaemic pasteurellosis was a significant cause of mortality in adult ostriches (Fig. 3). The disease was predisposed by the heat stress during the summer season and the causative agent, *Pasteurella multocida*, is a known opportunist normally inhabiting the respiratory tract of birds and other animal species (Verwoerd, 2000). Migratory birds were also suspected to transmit the infection to ostriches in Saudi Arabia (Elfaki *et al.*, 2002). Sudden rainfall or change in relative humidity and temperature were claimed as the main predisposing factors for an outbreak of pasteurellosis which affected several wild species including ostriches in Kano Zoo in Nigeria (Okoh, 1980). Due to the serious effects of this disease on adult and grower ostriches, it might be justifiable to recommend the vaccination of ostrich birds using locally isolated serotypes of *Pasteurella* species (Elfaki *et al.*, 2002). On the other hand, emu breeders were relatively resistant to *Pasteurella* infection, since less mortalities among adult emus were attributed to pasteurellosis compared to ostrich breeders (8.3% versus 65.6%). The main causes of mortalities in emu chicks and growers were leg deformities and suffocation. Enteritis resulted in only 0.6% of the mortalities among emu chicks. Emu chicks and growers were far less affected by microbial infections than ostriches. This result could also be supported by the fact that NCD outbreaks which affected the ostrich chicks and growers during the 2000 season did not involve emu chicks which were sharing the same premises with the affected ostrich chicks.

However, Heckert *et al.* (1999) was able to reproduce NCD by experimental infection of two emus using a mesogenic strain of NCD virus. Further study of the pathology of NCD in emus is warranted before deciding whether vaccination should be recommended or not. Deaths due to suffocation in emus could be avoided or reduced through managerial precautions such as keeping birds in smaller groups because emu chicks and, to a lesser extent, growers tend to huddle together during cold nights. It is notable that no mortalities in emu chicks or growers were attributed to either sand impaction or Newcastle disease throughout the four years study period. Emu growers also have great tendency towards fighting and usually the defeated or injured birds isolated themselves and roamed along the fences seeking their way out of the pen. This roaming often lead to more skin injuries and aggravated the clinical condition of the bird terminating into death. Deaths in emu growers due to predators, particularly foxes, could be lessened or controlled through control of these foxes or by use of better fencing material. This latter precaution could also be useful in reducing deaths due to accidents of the neck and legs. These injuries took place mainly when the birds were frightened or disturbed and gotten crowded or injured by inadequate or unsuitable fencing. Accidents, particularly those leading to neck and leg fractures or accidents on fences during rainy nights as well as fighting between incompatible couples, constituted important causes of mortality among adult ostriches. Mortality is thus directly linked to management conditions (Huchzermeyer, 1998); adequate shelter, proper fencing and enough space allocation are considered as the foundations of ratite flock health (Dinnes, 1972; Raines, 1998). The use of well-designed and protected feeders and drinkers for each age group can reduce mortality due to falling in feed troughs or drowning in the drinkers (Fig. 4). Mounting of feeders or drinkers at the bird's chest height would be an additional satisfactory precautionary measure. Deaths due to egg peritonitis in emu breeders is most probably due to the breakage of the thin-shelled immature emu eggs inside the oviduct and passage of the contaminated yolk material into the peritoneal cavity. Therefore, mortality due to egg peritonitis in emus could be minimized through better management and closer observation of the breeding stock.

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