EFFECT OF WINTER CLIMATIC CONDITIONS ON THE BEHAVIOUR OF ADULT OSTRICHES (*STRUTHIO CAMELUS*) ON A BRITISH FARM

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Ostrich welfare on farms of is great importance, particularly because little is known about appropriate husbandry conditions for these birds in a northern European environment. Rain has been shown to influence the pattern of behaviour during the spring months. This study examined the effects of four different climatic conditions (raining, dull but overcast, bright but overcast and sunny) on the behaviour of ostriches during the winter. Compared with dry conditions, there was a significantly higher rate of sitting during rainy periods – apparently at the expense of foraging (from pasture) and pacing (around the perimeter). The rate of sitting was much lower than that reported for the same birds during rain in the spring. During all climatic conditions, feeding (on concentrate feed provided) and foraging were the most dominant behaviours. Feeding was not significantly affected by rain but the frequency of foraging was reduced. Standing was a common behaviour. There were significant gender differences for standing (males>females) and foraging (females>males). These results show that winter conditions require ostriches to feed and forage at higher rates than during the spring or summer, presumably to consume more energy for thermoregulation. Gender differences in pacing and feeding behaviours previously observed in breeding birds were absent in non-breeding ostriches (presumably because males were not defending territories); although non-breeding males appeared to be more vigilant than females and needed to consume more food. Improvements in ostrich husbandry should take into account the need to provide both adequate shelter and more concentrate rations during the cold weather of winter. Energy requirements will be higher at this time, yet the ability of the birds to forage will be diminished. Without such considerations, ostrich welfare during the winter in northern Europe will be compromised.

Keywords: *animal welfare, behaviour, farming, ostrich, winter weather*

Introduction

There is much concern about the effects of cold weather on the welfare of ostriches (*Struthio camelus*) on farms in northern Europe (Bertram 1993; Deeming 1997), yet the effects of the different climatic conditions on behaviour in a farming environment are poorly documented. Most studies to date have been carried out during the summer months, either in Israel (eg Sambraus 1994) or in Britain (eg McKeegan & Deeming 1997; Ross & Deeming 1998), and have not investigated the specific effects of different climatic conditions on behaviour. Although Degen *et al* (1989) described a time-activity budget for juvenile ostriches in the winter in Israel, this study is not particularly relevant within a European context. Reiner *et al* (1996) surveyed German ostrich farms in order to assess the effects of a winter climate on the birds but behaviour was not measured directly.

The only study to date on the effects of specific weather conditions on ostrich behaviour (Deeming 1997), has shown that ostriches react to the prevailing climate. The frequency of sitting in both male and female ostriches was 2 to 5 times greater when it rained than when the weather was dry, while there was no significant difference in the frequency of feeding and foraging during rainy and dry periods. Furthermore, there was no gender difference in reactions between males and females as had been described for birds in the summer (McKeegan & Deeming 1997; Ross & Deeming 1998). Deeming (1997) concluded that, to ensure continued development of appropriate husbandry systems in northern Europe, it was necessary to repeat the observations on ostriches during winter months.

This report describes an observational study of the behaviour of adult ostriches maintained outdoors during February and March 1997. It complements that of Deeming (in press) which described the time-activity budget of the same adult ostriches during February 1997 where, because of the nature of the observations, it was not possible to relate specific weather conditions to behaviour. The goals of the present study were, therefore: i)to describe the effects of specific weather conditions on behaviour; ii) to look for effects of gender on behaviour; and iii) to compare the behaviour patterns with those observed during the spring.

Methods

Observations were carried out at Hangland Farm, a commercial ostrich farm in Oxfordshire, UK (51°16'W, 52°6'N). Male and female adult ostriches from farmed flocks, originally from Namibia, Zimbabwe and Israel, and all over 4 years old were observed. Birds were maintained in pairs consisting of one male and one female, or in trios consisting of one male and two females. These groupings had been established for at least 12 months before the study commenced. During the period of observation the birds were not mating and no eggs were laid.

The ostriches were kept under conditions fully described in McKeegan and Deeming (1997) and Deeming (1997). Enclosure area ranged from 1200-1900 m^2. All enclosures were permanent pasture, predominantly covered with short grass with some bare earth patches. Shelter in the form of small, three-sided huts (measuring 2.5x3.7 m with a 2.5m opening to the eaves and 3.7m rise to the top of the pitch), hedges and trees was available to all the ostriches. Wire and wooden fencing and hedges provided boundaries around the enclosures. All birds had visual contact with other ostriches.

In addition to grazing pasture, the birds were provided with concentrate ration delivered daily into troughs, usually between 0900-1000h. This consisted of equal proportions of 'Mazuri Ratite

Feed' breeder diet (a pellet concentrate with 193g kg^{-1} crude protein and 125g kg^{-1} crude fibre based on cereal by-products and grass cake; Mazuri Ratite Feeds, Witham, UK) mixed with grass pellets, whole barley and an unpelleted feedstuff based on oat husks, food cereal and potato by-products mixed with molasses (Berry Stock Feeds, Rugby, UK). Approximately 4kg of this concentrate food was available to each bird and drinking water was available at all times in the enclosures.

Weather conditions were recorded at the time of observations (Deeming 1997) and included: estimated percentage cloud cover; the average of two readings (taken at the middle and end of observations) for temperature (in °C, using a garden thermometer); and relative humidity (%RH at 1m from the ground using a Soar Ltd electronic probe; Brinsea Products Ltd, Sandford, Somerset). A light meter reading of a standard view of some of the enclosures was taken using an single lens reflex camera (Pentax KX) with a centre-weighted, through-the-lens exposure meter using a lens of a focal length of 50mm with an aperture set at F16. With the film speed set at 200ISO, shutter speed readings were recorded and converted to light values and then to foot lumen. Instrumentation to measure wind speed was not available. The prevailing weather conditions were observed and categorized as: i) overcast and raining; ii) overcast but dull and dry; iii) overcast but bright and dry; and iv) sunny, bright and dry (Deeming 1997).

Data were collected from six trios, all of which had previously been observed in the spring of 1996 (Deeming 1997). To increase the sample size, data were also collected from four pairs of birds. McKeegan and Deeming (1997) showed that there was no significant difference between the time-activity budgets of males and females maintained in pairs and trios. Birds were observed from a distance of at least 50m using binoculars and the naked eye because adult breeding ostriches exhibit changes in behaviour when humans are close to their enclosures (McKeegan & Deeming 1997; Bubier *et al* in press). Observations were made at 1000h, 1300h and 1600h on 25 days during a 7-week period from early February to mid March 1997. The order in which enclosures were observed was randomized between observation periods.

During each observation period, a scan frequency method using instantaneous sampling (Martin & Bateson 1993) was employed to record the behaviour of the male and one of the females in each enclosure. The positioning of the enclosures on the farm meant that observations took about 10min to complete. As it was difficult to reliably identify individual females from a distance, and because marking ostriches can affect their social behaviour (Chapman & Deeming personal observation 1996), records were made of the behaviour of the first female observed in each enclosure (Deeming 1997). Data were recorded using pencil and paper. The frequency of each behaviour was calculated as the proportion of all the behaviours observed for each male bird and the female birds during the each of the four, defined climate conditions.

Statistical analysis

To maximize sample size, data for all males were combined – as were data for all females irrespective of whether they were maintained in pairs or trios. Frequency data (x as a proportion of 1) were transformed by $\log_e(x+1)$ prior to analysis. Two-way analysis of variance (ANOVA) tests were carried out to assess the influence of gender and climatic condition on individual behaviours. Paired Wilcoxon signed-rank tests compared the behaviours of each gender under the differing climatic conditions and examined behavioural differences between the climatic conditions for each gender. All analysis was carried out using Minitab (version 8.1; Minitab Inc, State College, Pennsylvania, USA) on an IBM-compatible computer.

Results

Over the observation period, the climatic conditions varied in frequency (Table 1). The highest temperatures, lowest humidities, smallest cloud cover and highest light intensities were recorded during sunny periods. There was little difference between the temperatures measured during rainy and other weather conditions (Table 1).

Table 1 **Summary of climatic conditions in each weather category (SD - standard deviation).**

Variable	Raining	Dull and overcast	Bright and overcast	Sunny
Observations	10	17	25	23
Temperature (°C)				
Mean	9.5	8.8	9.9	11.0
SD	1.0	1.8	2.3	4.5
Range	8.0-11.0	6.0-12.0	5.5-14.0	0.3-18.0
Humidity (%RH)				
Mean	74.9	60.6	53.1	43.0
SD	15.3	11.2	11.2	8.8
Range	43.9-91.7	37.7-89.0	31.6-77.6	30.3-65.3
Cloud cover (%)				
Mean	100	99.7	81.7	21.8
SD	0	1.2	18.4	20.3
Range	-	95-100	40-100	0-60
Light intensity (foot lumen)				
Mode[1]	167	336	668	668
Range	83-668	83-668	167-1340	668-2680

[1] Modal (rather than mean) values are listed as these data were not uniformly distributed.

Six major behaviours were recorded (defined by McKeegan & Deeming 1997): sitting (head up), standing (head up), pacing (around the perimeter), walking (across the enclosure), foraging (from the pasture), and feeding (on concentrate ration). Several other behaviours were seen but, because of their low frequency, these behaviours were combined in to a single 'other' category for analysis. The frequency of the six major and the 'other' behaviours are shown for male and female ostriches for each climatic condition in Table 2.

Both males and females were rarely seen sitting except during rainy periods. Standing appeared to be unaffected by climate although males stood more than females. Pacing by both genders was more prevalent during bright and sunny conditions but walking, which was of low incidence, was largely unaffected by weather type. Foraging and feeding were the most common behaviours for most of the climatic conditions and females generally had higher rates than males. Males carried out more 'other' behaviours but there appeared to be little effect of different climatic conditions on frequency.

Gender had a significant effect on the overall frequency of standing and foraging (Table 3). Although males stood more than females (Table 2), paired Wilcoxon signed-rank tests for male and female ostriches revealed no significant differences between paired climatic conditions. Females foraged more than males (Table 3) but these differences only approached significance (Wilcoxon signed-rank tests, $P < 0.1$ in each case). There was no significant effect of gender on the frequency of the other behaviour types (Table 3). The only exception was a significantly lower frequency of walking by females during bright but overcast weather ($z = 21.0$, $P = 0.036$, $N = 6$).

Table 2 **Time spent (mean % ± standard deviation of behaviour type) for male and female ostriches during four climatic conditions. A dash indicates that the behaviour was not observed.**

Behaviour	Gender	Raining	Dull but overcast	Bright but overcast	Sunny
Sitting	Males	22.0 ± 18.1	1.8 ± 2.9	1.6 ± 3.9	0.4 ± 1.4
	Females	22.0 ± 17.5	-	0.8 ± 1.7	0.9 ± 1.8
Standing	Males	24.0 ± 15.1	24.7 ± 14.9	16.8 ± 11.3	20.0 ± 10.7
	Females	15.0 ± 14.3	18.2 ± 10.9	11.6 ± 9.1	15.2 ± 9.2
Pacing	Males	8.0 ± 7.9	9.4 ± 7.9	14.0 ± 10.9	12.2 ± 13.9
	Females	4.0 ± 5.2	7.7 ± 7.4	11.2 ± 9.2	12.6 ± 9.9
Walking	Males	5.0 ± 7.1	5.9 ± 6.8	6.8 ± 4.2	7.4 ± 5.0
	Females	4.0 ± 5.2	8.3 ± 5.0	3.2 ± 4.1	4.3 ± 4.6
Foraging	Males	12.0 ± 12.3	26.5 ± 12.8	34.4 ± 19.3	20.9 ± 13.3
	Females	19.0 ± 12.0	33.5 ± 7.4	42.8 ± 21.0	29.6 ± 11.2
Feeding	Males	22.0 ± 16.2	24.7 ± 7.8	16.4 ± 4.8	32.2 ± 10.7
	Females	28.0 ± 13.2	28.8 ± 11.6	22.0 ± 9.8	33.0 ± 10.5
Other	Males	6.0 ± 5.2	7.1 ± 6.7	10.0 ± 5.4	6.9 ± 4.7
	Females	7.0 ± 8.2	3.5 ± 5.0	8.4 ± 5.5	4.3 ± 3.5

Climatic conditions significantly affected the frequency of sitting, foraging and feeding behaviours, although other behaviours were not significantly affected (Table 3). There was no significant interaction between gender and climatic conditions for any behaviour (Table 3).

Male ostriches exhibited slightly different patterns of behaviour during the different weather conditions. The frequency of sitting was significantly higher during rainy periods than during the other three climatic conditions ($z = 36.0$, $P = 0.014$, $N = 8$ in all cases). During rainy periods, less foraging was recorded than during dry conditions and this reduction was also significant in comparisons with both dull and bright conditions ($z = 6.0$, $P = 0.032$, $N = 10$; and $z = 0.0$, $P = 0.006$, $N = 10$ for rain versus dull and rain versus bright respectively). During sunny conditions, foraging behaviour was significantly reduced compared with bright conditions ($z = 48.0$, $P = 0.041$, $N = 10$). There was also a significant reduction in the frequency of feeding during bright periods compared with both dull and sunny conditions ($z = 54.0$, $P = 0.008$, $N = 10$; and $z = 0.0$, $P = 0.006$, $N = 10$ respectively). The highest frequency of feeding, during sunny weather, was also significantly higher than feeding during dull weather ($z = 6.0$, $P = 0.032$, $N = 10$). There were no significant differences in the frequencies of standing, pacing, walking and 'other' behaviours between the four weather conditions.

Table 3 **Results of two-way ANOVA for each behaviour type examining the effect of gender, climatic condition (rainy, dull, bright or sunny) and the interaction between these variables. Sig - significance; ns - not significant; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.**

Behaviour	Gender		Climatic condition		Interaction	
	$F_{1,72}$	Sig	$F_{3,72}$	Sig	$F_{3,72}$	Sig
Sitting	0.09	ns	29.04	***	0.08	ns
Standing	5.43	*	1.25	ns	0.12	ns
Pacing	0.90	ns	2.35	ns	0.25	ns
Walking	1.19	ns	0.90	ns	1.34	ns
Foraging	6.53	*	9.27	***	0.02	ns
Feeding	2.89	ns	5.01	**	0.26	ns
Other	1.88	ns	1.98	ns	0.56	ns

The behaviour patterns of female ostriches showed a significant increase in sitting during rain compared with the three dry weather conditions ($z = 36.0$, $P = 0.014$, N = 8; $z = 36.0$, $P = 0.014$, N = 8; and $z = 44.0$, $P = 0.013$, N = 9 for comparisons with dull, bright and sunny conditions respectively). Apparently this increase was partly at the expense of the frequency of pacing when compared with bright and sunny weather ($z = 0.0$, $P = 0.009$, N = 10; and $z = 1.0$, $P = 0.013$, N = 10 respectively). There were also significantly higher frequencies of foraging during dull, bright, and sunny conditions compared with rainy periods ($z = 1.0$, $P = 0.008$, N = 10; $z = 1.0$, $P = 0.008$ N = 10; and $z = 6.0$, $P = 0.032$, N = 10 respectively). The frequency of walking during dull conditions was significantly higher than during bright or sunny weather ($z = 50.0$, $P = 0.025$, N = 10; and $z = 42.0$, $P = 0.024$, N = 9 respectively). The frequency of 'other' behaviours during bright weathers was shown to be significantly higher than those observed during dull conditions ($z = 2.0$, $P = 0.03$, N = 8). There were no other significant differences between the frequency of any behaviours during dull, bright, or sunny weather.

Discussion

Only one study has investigated the influence of weather on ostrich behaviour (Deeming 1997) and these observations were carried out during the spring in Britain when the weather, although changeable, was relatively equable. The present study sought to examine the influence of more prolonged, severe, winter weather on behaviour patterns and revealed that differences existed in the patterns of behaviour of adult ostriches during spring and winter conditions.

There was an obvious reduction in the frequency of sitting during winter, compared with data collected during the spring, irrespective of the climatic condition (Deeming 1997). In the spring, sitting during rain appears to be at the expense of pacing activity, while in the winter months it was at the expense of foraging but not feeding. In comparison with behaviour during the spring (Deeming 1997), the observed frequency of sitting when it was raining was lower in the winter. This may simply reflect the birds opting to carry out other behaviours. Deeming (in press) found that the behavioural repertoire of adult ostriches was more diverse in the afternoon than the

morning, when feeding on the concentrate ration was their priority. The reasons why the frequency of sitting during rain is significantly higher than under dry conditions (for both spring and winter months) remain unclear but are likely to be multifactorial.

Adult ostriches used shelter available within the enclosure although it was difficult to quantify usage because some activities may have been combined, eg foraging in the lee of a hedge during a period of rain (Deeming in press). Ostriches in Germany have been shown to respond to adverse weather conditions by using the shelters provided for them (Reiner *et al* 1996) although only 20 per cent of birds in the survey did so. The design of the present study precluded further investigation of the use of shelter by ostriches and it would be of great interest to investigate the use of shelters by adult ostriches exposed to different environmental temperatures and to more severe conditions such as snow or prolonged frost. It will be very important to also carry out similar research on ostrich chicks and juveniles, since environmental temperature is very important to rearing success (Deeming *et al* 1996).

During the spring, the observed frequency of feeding behaviour (on concentrate food) was less than 5 per cent for both genders (Deeming 1997) but during the winter this activity accounted for 20-30 per cent of all observations. Foraging was a significant behaviour during the spring (a frequency of 15-30%) and was even more important during dry weather in the winter (occurring at a frequency of 20-42%). Females foraged more than males during both seasons. It is interesting that winter rain caused a significant reduction in foraging but not in feeding, despite the fact that the concentrate ration was provided in troughs exposed to the elements so that the ostriches had to tolerate rain if they wished to continue feeding. During the spring, neither activity was significantly affected by rain (Deeming 1997).

The results reported here are similar to the time-activity budgets of the ostriches recorded during the winter where climatic conditions were averaged over 10min observation periods (Deeming in press). In winter, consumption of food was a priority for the birds (taking over 50% of the budget) with feeding taking precedence during the morning period (1000-1300h) and foraging being more important during the afternoon (1300-1600h). This difference was attributed to the consumption of all the concentrate by midday, which forced the ostriches to forage from pasture if they wished to maintain their calorific intake (Deeming in press). As in the present study, the ostriches largely avoided unnecessary activity, such as pacing, during winter conditions with movement around the enclosure usually being achieved while foraging. Gender differences reported for the time-activity budgets of ostriches during the summer (McKeegan & Deeming 1997; Ross & Deeming 1998) were absent during the winter (Deeming in press). The higher frequency of standing by males in the present study may reflect greater vigilance by these birds but the significance of this, in terms of starting to establish or maintain a territory, remains unclear.

The importance of food consumption probably reflects the higher energy requirements of ostriches during the colder conditions of winter. Furthermore, the reduction (of roughly 50%) in the frequency of pacing in males and females during the winter compared with the spring suggests that pacing and walking behaviours (which consume energy without leading directly to food intake) have a lower priority than behaviours like foraging which involve both locomotion and eating. The behavioural differences observed for adult ostriches which are actively breeding and laying eggs have been attributed to the differing energy demands of reproduction in males and females (McKeegan & Deeming 1997; Ross & Deeming 1998). Low egg production was suggested as an explanation for the lack of gender differences in behaviours

observed during the spring months (Deeming 1997). In the present study, the lack of gender differences between the frequency of behaviours probably reflects the similar energy demands of non-breeding males and females where the maintenance of body temperature is paramount. Future work could aim to monitor body temperature and behaviour during various environmental conditions.

The provision of concentrate ration is very important in the husbandry of ostriches in Britain. Although the amount of concentrate food provided for each bird was greater during the winter (4kg compared with 2kg in the spring; Deeming 1997) it remains unclear what is the appropriate feed ration for ostriches of any age at any time of the year. The foraging activity of the ostriches in this study, and that reported by Deeming (in press), strongly suggest that additional supplies of ration may be needed during the afternoon in the winter. This is certainly going to be the case if ostriches are denied access to grazing, whether by being housed during bad weather or because the pasture is covered with snow or frozen. Feeding opportunities for any individual could also be influenced by group size and their position in the dominance hierarchy (Deeming in press). Furthermore, location of food troughs under shelter would mean that the ostriches would not have to endure wet weather in order to ingest concentrate ration.

Animal welfare implications

This study shows that, while adult ostriches can modify their behaviour patterns between different climatic conditions and seasons, there is a need to ensure that ostrich husbandry is matched with bird welfare during winters in northern Europe. Proper husbandry should include: i) provision of shelters of a sufficient size to accommodate all birds in an enclosure ($10m^2$ $bird^{-1}$ is currently recommended by Anon 1997); ii) provision of a concentrate ration under shelter; and iii) provision of concentrate ration *ad libitum* until appropriate food levels have been determined. Without such considerations, the welfare of adult ostriches kept in outside enclosures with little access to shelter will be compromised. To ensure that this does not happen additional research is required to clarify these aspects of husbandry.

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