EFFECT OF CLIMATIC CONDITIONS ON THE BEHAVIOUR OF ADULT OSTRICHES (*STRUTHIO CAMELUS*) IN BRITAIN

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Abstract *Animal Welfare 1997, 6:* 349-356

Welfare is being promoted as a reason why ostriches should not be kept on farms in Europe. It is reasoned that the climate, particularly during winter, is unsuitable for these birds despite there being little scientific evidence to support this claim. This study recorded the frequency of behaviours of male and female adult ostriches kept on a farm in Britain during the spring of 1996. 'Rainy', 'dull and dry', 'bright and dry', and 'sunny' weather categories were used to assess the influence of climate on behaviour. Six main behaviours (sitting, standing, pacing, walking, foraging and feeding) were observed together with a variety of low frequency 'other' behaviours which were combined for analysis. Gender had no significant effect on any of the behaviour frequencies. During 'rainy' periods both males and females showed sitting behaviour five times more than during 'dull' and 'bright' weather and two and a half times more than during 'sunny' weather. Increased sitting behaviour during rainy periods was due to a significant reduction in pacing and 'other' behaviours with no significant effect on feeding and foraging behaviours. Sitting during sunny weather also occurred more often than during dull and bright weather but not at the expense of any other particular behaviour. Adult ostriches in Britain alter their behaviour in response to prevailing weather conditions, particularly rain.

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

Introduction

Ostriches (*Struthio camelus*) have been farmed in South Africa for well over a century but are a recent addition to agriculture in other parts of the world including the United States of America, Australia and Europe. Many new areas where ostriches are being farmed have climates which differ greatly from the prevailing climate in southern Africa. In particular, temperate and continental climates in the northern hemisphere are characterized by long winters of cold temperatures and persistent rain and often relatively cool summers.

Concern has been raised against the keeping of ostriches in Europe. The colder, wetter climate is considered to be inappropriate for ostriches and could be deleterious to their welfare unless proper management of the birds is practised (Bertram 1993). Indeed climatic conditions to which other farm animals, eg outdoor reared pigs, are exposed are considered

to be significant welfare issues (Farm Animal Welfare Council 1996). There is, unfortunately, little information about the behavioural response of ostriches to different weather conditions. For example, the reaction of wild ostriches to rain is not documented. Panting in response to hot temperatures has been reported, although juveniles and adult birds did not seek shade during the hottest part of the day (Sauer & Sauer 1967). In a survey of ostrich farms in Germany, captive ostriches were reported to sit close together facing the prevailing wind but only a fifth of the birds in the survey chose to enter stables to seek shelter from winter conditions (Reiner *et al* 1996). Berendsen (1995) reported that during periods of rain adult ostriches preferred to sit in the open rather than seek shelter.

Such a paucity of data is hampering development of husbandry systems which minimize the impact of adverse weather conditions and maximize the welfare of ostriches in Europe. In order to begin to redress this problem the behaviour of ostriches under different weather conditions was recorded during the spring of 1996.

Methods

The study was carried out at Hangland Farm, a commercial ostrich farm in Oxfordshire, UK (51°16'W, 52°6'N). Adult ostriches came from farmed flocks (originally from Namibia, Zimbabwe and Israel), were older than 3 years of age, in breeding condition and producing eggs. The birds were maintained as trios, consisting of one male and two females, in enclosures with areas ranging from 1200 to 1900m^2. Each enclosure was of permanent pasture, with some bare earth patches. Wire and wooden fencing and hedges were used as boundaries (McKeegan & Deeming 1997). All birds had visual contact with other adult ostriches in adjacent pens. Small, three-sided huts (measuring 2.5x3.7m with a 2.5m opening to the eaves and 3.7m rise to the top of the pitch), hedges and trees were available as shelter in all of the enclosures. In addition to forage from grass and hedges, each bird was provided with approximately 2kg of supplementary food delivered daily. This consisted 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) mixed with one type of pellet derived wholly either from grass, maize or lucerne (as available), and whole barley, in a 1:1:1 ratio. Drinking water was available at all times in the enclosures.

Weather conditions were recorded at the time of observations and included an estimated percentage cloud cover and two readings of temperature (°C) and relative humidity (%RH) taken, to obtain an average value, during the middle and at the end of observations. Relative humidity was recorded at 1m from the ground using an electronic probe (Soar, Brinsea Products Ltd, Sandford, Somerset). A light meter reading of a standard view of some of the enclosures was taken using a single lens reflex camera (Pentax KX) with a centre weighted, through the lens exposure meter (lens of focal length 50mm, aperture at F16 and film speed set at 200 ISO). Shutter speed readings were 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: 1) overcast and raining; 2) overcast but dull and dry; 3) overcast but bright and dry; and 4) sunny, bright and dry.

Nine trios 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 (Bubier *et al* 1996; McKeegan & Deeming 1997). Observations were made at 1000, 1300 and 1600h on 25 days during a 6-week period in late April and May

1996. The positioning of the enclosures on the farm meant that observation of all nine trios took around 10 minutes to complete. The order in which trios were observed was randomized from one period of time to another. 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. It was difficult to identify individual females reliably from a distance and so records were made of the behaviour of the first female observed in each enclosure.

The frequency of each behaviour was calculated as a proportion of all the behaviours observed for each male and female bird during the four climate types. Two-way analysis of variance (ANOVA) tests were carried out on data for each behaviour to examine the effect of gender, climatic conditions and their interaction. Wilcoxon signed-rank tests were carried out on frequency data for male and female ostriches (paired by enclosure) to compare gender differences in time budgets and to compare behaviours of each gender under the differing climatic conditions. Although all comparisons were made only those which proved significant are described.

Results

The climatic conditions varied over the observation period and the temperature, humidity, cloud cover and light readings are shown for each climatic condition in Table 1. The highest temperatures, lowest humidities, smallest cloud cover and highest light intensities were recorded during sunny periods. With the exception of precipitation there was no difference between climatic parameters measured during rainy, and dull and overcast weather.

Table 1 Summary of climatic conditions in each weather category.

Variable	Climate			
	Raining	Dull and overcast	Bright and overcast	Sunny
No of observations	12	17	19	27
Temperature (°C)				
Mean	13.6	13.5	18.2	22.5
SD	3.2	2.2	4.4	5.0
Range	9.9–21.5	10.7–18.7	9.8–27.1	10.0–33.0
Humidity (%RH)				
Mean	59.3	51.7	41.2	34.5
SD	13.1	11.1	5.6	3.7
Range	35.4–81.2	38.2–70.6	32.1–51.8	28.4–46.1
Cloud cover (%)				
Mean	97.9	100	89.0	24.6
SD	5.8	0	13.2	19.6
Range	80–100	–	60–100	0–60
Light intensity (foot lumen)				
Mode	336	336	1340	1340
Range	336–1340	167-1340	336-1340	668-2680

SD – standard deviation

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Six behaviours were commonly recorded: sitting (head up or down), standing, pacing a boundary, walking across the enclosure, foraging from the pasture, feeding on concentrate ration (defined by McKeegan & Deeming 1997). Several other behaviours, including searching, search pacing, preening and eliciting at a nest site (defined by McKeegan & Deeming 1997), were seen but because of their low frequency for analysis these behaviours were combined in a single 'other' category. The frequencies of the six major and 'other' behaviours are shown for male and female ostriches during each climatic condition (see Table 2). During the course of the study, ostriches were observed exhibiting courtship behaviours and mating in all weather conditions with the exception of rain.

Table 2 **Frequency (mean % ± SD) of behaviour type for male and female ostriches during four climatic conditions.**

Behaviour	Sex	Climate			
		Raining	Dull and overcast	Bright and overcast	Sunny
Sit	M	52.8 ± 20.4	13.1 ± 15.5	10.5 ± 10.2	21.8 ± 16.6
	F	50.0 ± 13.2	12.4 ± 11.6	14.6 ± 13.6	19.3 ± 9.8
Stand	M	19.4 ± 13.8	21.6 ± 8.8	22.2 ± 13.4	23.5 ± 11.6
	F	13.9 ± 10.2	20.3 ± 11.1	26.3 ± 7.0	20.2 ± 12.7
Pace	M	2.8 ± 4.2	22.9 ± 15.4	15.8 ± 7.0	21.4 ± 8.4
	F	8.3 ± 8.3	17.7 ± 11.0	14.0 ± 12.1	18.9 ± 14.5
Walk	M	6.5 ± 6.9	7.8 ± 9.8	5.9 ± 3.2	5.8 ± 7.2
	F	5.6 ± 7.2	3.9 ± 2.9	5.9 ± 7.2	7.4 ± 8.1
Forage	M	12.0 ± 10.3	19.0 ± 13.4	25.7 ± 14.8	14.4 ± 9.0
	F	16.7 ± 11.8	27.5 ± 11.4	25.2 ± 14.4	20.2 ± 6.2
Feed	M	3.7 ± 6.1	6.5 ± 6.2	5.9 ± 6.1	3.7 ± 4.1
	F	0.9 ± 2.8	4.6 ± 5.7	4.7 ± 6.1	1.6 ± 2.0
Other	M	2.8 ± 4.2	9.2 ± 9.4	14.0 ± 8.3	9.5 ± 8.7
	F	4.6 ± 4.4	12.4 ± 6.9	9.4 ± 10.5	12.4 ± 5.2

Two-way ANOVA tests showed that gender had no significant effect on the frequency of each behaviour (Table 3). This was confirmed by Wilcoxon signed-rank tests for paired male and female ostriches which showed that there were no significant differences between the genders for any behaviour during any of the four climatic conditions. The two-way ANOVA tests showed that climatic conditions significantly affected the frequency of sitting, pacing, foraging and 'other' behaviours. The remaining behaviours were not significantly affected (Table 3). There was no significant interaction between gender and climatic conditions for any behaviour (Table 3).

Table 3 **Results of two-way ANOVA for each behaviour examining the effect of gender (male or female), climate (rain, dull, bright or sunny) and the interaction between these variables.**

Behaviour	Gender	Climate	Interaction
	$F_{1,64}$	$F_{3,64}$	$F_{3,64}$
Sit	0.02	30.10***	0.22
Stand	0.33	1.42	0.60
Pace	0.15	7.47***	0.83
Walk	0.24	0.04	0.51
Forage	2.75	3.46*	0.47
Feed	2.70	1.95	0.07
Other	0.22	4.43**	1.10

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

When it rained, sitting was the behaviour most frequently observed in both males and females averaging half of the observations. Standing and foraging were also frequently observed (Table 2). During a heavy shower most of the birds were observed sitting, usually at the location they had been at when the rain had started; almost no ostriches sought shelter despite it being available. In light rain or if it had been raining for some hours the birds were much more active.

Male ostriches exhibited different time budgets depending on the weather conditions. Compared to the other three climatic conditions, sitting increased during rainy periods (Z = 45.0, $P = 0.009$ in all cases) with an associated significant reduction in pacing compared with dull, bright and sunny conditions (Z = 0.0, 2.0 & 1.0 and P = 0.009, 0.018 & 0.013 respectively). Compared to bright conditions, both foraging and 'other' behaviours were also reduced when it was raining (Z = 5.0 and 1.0, P = 0.044 and 0.021 respectively). There was also a significant reduction in 'other' behaviours during rainy periods compared to sunny periods (Z = 1.0, P = 0.035). There was no significant difference in the frequency of standing and feeding between the four weather conditions. Likewise no significant differences were observed between the frequencies of the various behaviours during dull, bright or sunny weather. An exception to this was a significantly higher frequency in sitting during sunny weather compared to dull and bright conditions (Z = 0.0 and 2.0, P = 0.009 and 0.018 respectively) but without any significant decrease in the frequency of any other behaviours.

The time budget of female ostriches showed a significant increase in sitting during rain compared to the three dry weather conditions (Z = 45.0, P = 0.009 in all cases). Frequency of sitting was apparently due to a decrease in the frequency of pacing during rain compared to dull and sunny weather (Z = 1.0 and 0.0, P = 0.013 and 0.014 respectively) and of standing during bright weather (Z = 2.0, P = 0.018). There was also a reduction in the frequency of 'other' behaviours during rainy periods compared to dull and sunny periods (Z = 4.0 and 3.0, P = 0.0033 and 0.024 respectively). There was no significant difference in the frequency of foraging and feeding between the four weather conditions. As with males there was no significant difference between the frequency of any other behaviours during dull, bright or sunny weather.

The influence of precipitation on sitting behaviour was investigated further by re-analysis of the data. The number of males and females sitting during each observation period was recorded for the rainy and dull weather categories (which showed near identical parameters). Analysis of co-variance showed that there was a significant effect of climate on sitting (rain versus dull: $F_{1,57} = 36.24$, $P = 0.001$) but neither gender nor environmental temperature (co-variates: $F_{2,57} = 0.03$, $P = 0.968$; Figure 1) had any significant effect. Similar results were obtained for humidity and light intensity.

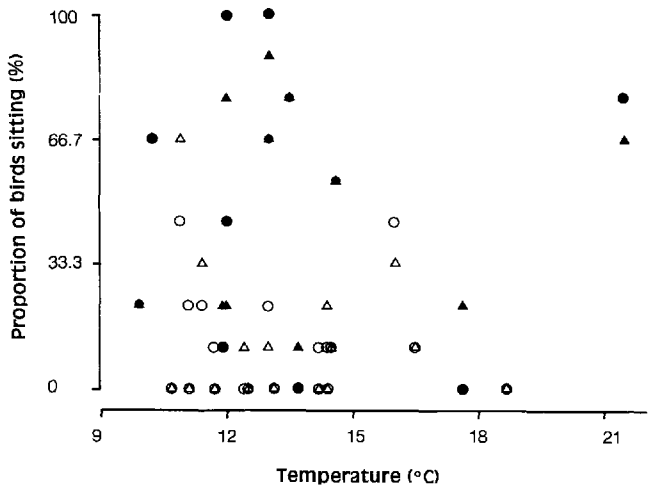

Figure 1 **The relationship between ambient temperature and the proportion of male or female (circles and triangles respectively) ostriches sitting during 1) rainy weather (closed symbols) and 2) dull but dry weather (open symbols).**

Discussion

In Europe adult ostriches are kept outside and are exposed to the prevailing climate which can be cold and wet for prolonged periods. Unfortunately the paucity of data on ostrich behaviour under captive conditions in Europe is hampering development of appropriate husbandry systems which maximize welfare. McKeegan and Deeming (1997) recorded a time budget of adult ostriches in Britain during July and August when there was very little variation in the warm, dry weather. One advantage of the present study was that it recorded the effects of climate during spring in the UK when the climate is changeable. Therefore, the behaviour of birds exposed to different conditions could be recorded during a short period of time.

It was found that the variability of ostrich behaviours was similar to that reported for birds observed in the wild (Sauer & Sauer 1966; Bertram 1980; Burger & Gochfeld 1988). Furthermore, during dry weather conditions, the time budget of both genders was similar to that described for adult birds during the summer months in the UK (McKeegan & Deeming 1997), although rates of foraging were higher in the present study.

Berendsen (1995) reported that rain prompted ostriches to sit down and not necessarily seek shelter. The present study confirms these observations with a high incidence of sitting during rainy periods in both males and females, with sitting occurring where the birds had been when the rain started. It was precipitation, rather than temperature, humidity or cloud cover, which induced the high incidence of sitting. Increased sitting behaviour during rainy periods was at the expense of activity behaviours, such as pacing. Frequencies of maintenance behaviours, such as foraging and feeding, were not significantly different to those recorded during dry periods. Furthermore, comparisons between the time budgets of behaviours during other climatic types showed that there were no significant differences in behaviour despite differences in average temperature, humidity, cloud cover or light intensity.

It was interesting that, relative to dull or bright conditions, sunny weather increased sitting behaviour in both genders although significant differences were only observed in males. Increased sitting in sunny weather did not appear to be at the expense of any other one behaviour. Although this may indicate that the birds could absorb radiant heat by sitting and did not need to carry out maintenance behaviours to keep warm, the true motivation behind this behaviour is unclear and requires further investigation.

A time budget for breeding ostriches recorded during the summer of 1995 showed that males spent significantly more time pacing and walking than females but that females spent significantly more time foraging and feeding than males (McKeegan & Deeming 1997). By contrast, in the present study, although females always foraged more than they paced the differences were not significant and in males time spent pacing was not consistently greater than that spent foraging. This difference in observations may reflect the methodology used to measure behaviour, or the effects of climate on thermoregulation or reproduction. McKeegan and Deeming (1997) recorded all behaviours throughout an 18-hour day whereas in the present study an instantaneous sample was recorded three times a day. Alternatively, although the summer of 1995 was consistently warm (a mean of 25°C), the spring of 1995 was consistently cool (Table 1) and male birds may have needed to forage more for food in order to meet energy requirements leaving less time for territorial behaviour such as pacing. Lastly, in the present study the laying season had just started whereas during the summer of 1995 it was at its peak. Compared to the present study, data for egg production of ostriches in pairs and trios in the study by McKeegan and Deeming (1997) showed that females in the former study were producing almost twice the number of eggs (1.75 ± 0.80 versus 0.97 ± 0.28 eggs bird^{-1} week^{-1}, t test, $t_{4,6}$ = -1.87, P = 0.16). It is possible that the cool weather recorded during this study was adversely affecting the reproductive capability of the females as ingested energy may have been needed more for body maintenance rather than for egg production. It is difficult to determine which is the best explanation for these differences and the influence of climate on the energy metabolism and reproductive performance of ostriches requires further investigation.

Animal welfare implications

In the early stages of the development of ostrich farming consideration of welfare should be of paramount importance since experience of this type of animal husbandry is minimal in Europe. This report is the first to clearly indicate that adult ostriches modify their behaviour according to the prevailing climate and that rain has the greatest influence on behaviour. The

fact that rain had the only significant effect on ostrich behaviour is very important given their propensity to sit out in such weather rather than seek shelter. During winter months it may be appropriate to bring ostriches into shelter during prolonged periods of rain. It is important that this study is repeated for all seasons of the year, particularly during a cold winter in Europe, to ensure that appropriate husbandry systems are developed which maximize ostrich welfare in a farming environment.

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