Journal of Animal & Plant Sciences, 34(1): 2024, Page: 227-241
ISSN (print): 1018-7081; ISSN (online): 2309-8694
https://doi.org/10.36899/JAPS.2024.1.0711

EFFECTS OF SEASON, SEX AND TIME OF DAY ON OSTRICH BREEDER (*Struthio camelus*) BEHAVIOR

B. Yılmaz Dikmen[1]

[1]Department of Animal Science, Faculty of Agriculture, Bursa Uludağ University, Bursa, Türkiye
[*]Corresponding Author's email: bilgehan@uludag.edu.tr

ABSTRACT

Ambient temperature has a crucial effect on livestock production performance, behaviors and welfare. In ostrich, previous research primarily focused on survival and reproductive performance during the climatic shifts. This study was carried out to investigate the effect of seasonal variation on behavioral differences of male and female ostrich (*Struthio camelus*) breeders, reared in farm environment. The individual behaviors related to digestion, locomotor activities, resting, comfort and thermoregulation, reproduction, and aggressive behaviors were recorded. The higher sitting and sleeping behavior were observed in summer season ($P \leq 0.01$ and $P \leq 0.001$, respectively). The thermoregulation behaviors were observed only in summer season ($P \leq 0.0001$). The higher foraging, alertness and spot pecking behaviors were observed in females ($P \leq 0.01$, $P \leq 0.05$, and $P \leq 0.05$, respectively). The boom behavior was only observed in males ($P \leq 0.05$). The higher walking behavior was observed in the afternoon and morning ($P \leq 0.05$). The higher sleeping, dust bathing, grooming and thermoregulation behaviors were observed at noon ($P \leq 0.001$, $P \leq 0.001$, $P \leq 0.0001$ and $P \leq 0.0001$, respectively). There was a significant interaction between season and sex for displace behavior, a sign of aggressive behavior ($P=0.006$). There was a significant interaction between season and time of day for drinking and defecation related to digestive behaviors ($P \leq 0.05$ and $P \leq 0.05$, respectively); sleeping described as a resting behavior ($P=0.0001$); dust bathing and grooming which is related to comfort behaviors ($P \leq 0.0001$ and $P \leq 0.0001$); thermoregulation ($P \leq 0.0001$); copulation described as a reproductive behavior ($P=0.003$); displace and escape behaviors mostly a sign of aggressive behavior ($P \leq 0.05$ and $P \leq 0.05$). Ostriches are diurnal animals with a nomadic lifestyle and have higher activity during the early and late times of the day. Identification of the seasonal, sexual and time of day differences on behavior types of ostriches, provides important information for ostrich management and their welfare.

Keywords: Ostrich (*Struthio camelus*), climate-change, behavior, animal welfare.

Published first online November 15, 2023 Published final January 20, 2024

INTRODUCTION

Ostriches are commercially raised in many countries around the world for their main products, meat, skin, feathers and eggs. While the history of commercial ostrich farming dates to the 1880s in South Africa, it has spread to many parts of the world, especially to the USA, Australia and Europe, since 1980s (Şahan *et al*., 2000; Horbanczuk, 2002). Ostrich breeding started in Türkiye for the first time in 1995 and more than 300 ostrich farms were established in the following years (İpek and Şahan, 2006). Today, ostrich production continues in many countries such as China, Brazil, South Africa, Pakistan, Iran, New Zealand, Australia and more, and also in European countries, mainly in Romania, Poland, Germany, Portugal, Hungary, France and more (Kistner, 2019). And ostrich industry has advanced significantly in higher-production countries, and it has provided some economic stability.

One of the fundamental requirements of good animal welfare is to provide conditions in which animals can express their normal behaviors (Ahmed and Salih, 2012). Behavioral studies, which are indicators of animal welfare, are crucial. Ostriches are exposed to stress in farm conditions and have not been selectively bred to reduce the impact of this stress (Amado *et al*., 2011). Ostrich social behaviors are complex and variable, like that of animals from the most developed and complicated social orders (Cooper *et al*., 2010). In ostriches, general behaviors such as digestion, locomotor and resting are a part of their daily individual behaviors. Social behaviors are described as their interaction among themselves or with other animals. Sexual behaviors have a special place among social behaviors and include behaviors performed for the purpose of reproduction and producing offspring (Stewart, 1994; Brendsen, 1995; Deeming, 1997). There are also some special behaviors unique to ostriches like boom behavior. This behavior is a type of crowing sound made by adult male ostriches. It is usually shown by male

birds standing during the day or at night to indicate who is dominant in their area (Stewart, 1994). Sexual behaviors in ostriches include birds courting each other, kantel and copulation (Şahan *et al*., 2000). Kantel behavior is described as the males wandering around the females which they are going to mate. Females walk by opening their wings, hanging their head down from the shoulders, and flapping their wings slowly, making a clicking sound. Meanwhile, they lower their heads downwards and open and close their beaks rapidly as if they were eating. In this position, they show that they accept the male, and the male responds to the female with similar movements. Courtship behavior is of great importance for successful mating, especially in ostriches raised on commercial farms (Bolwig, 1973; Stewart, 1994; Brendsen 1995). Behaviors such as feather maintenance (grooming) and dust bathing constitute comfort behaviors in ostriches. Grooming by ruffling their feathers is a daily routine behavior in ostriches. Dust bathing behavior is used to control external parasites in wildlife. It is necessary for the welfare of birds to provide an environment where birds can take dust baths, especially in the area allocated to animals on farms (Sambraus, 1994; Stewart, 1994; Deeming, 1998b). Resting and sleeping ostriches occasionally shake their head from side to side to remove excess mucus from their nasal cavities and mouth (Sauer and Sauer, 1967). Ostriches engage in spot-pecking behavior to explore their environment and communicate socially with each other (Stewart, 1994). However, sometimes, as a reaction to negative environmental factors, ostriches may peck each other in a way that injures their feet and heads, and this is defined as aggressive pecking behavior (Lambert *et al.*, 1995). These behaviors are especially important when they are grown in captive systems. The lack of knowledge on breeders' behaviors cause failure in flock management and productivity while rearing under intensive farm conditions (Şahan *et al*., 2000).

Increasing the length of the day is known to stimulate reproduction in a variety of avian species, and ostrich laying season is considered seasonal (Deeming and Ar, 1999; Ball and Ketterson, 2008). The laying season in the Northern Hemisphere begins in March and lasts in September, depending on the annual weather (Ipek and Şahan, 2004), and in Southern Hemisphere it starts in June and lasts in late January (Horbanczuk, 2002; Brassó *et al*., 2022). The seasonal differences in adult ostrich behaviors were reported by (Deeming, 1997; 1998a; Basuony, 2011). Environmental stress is well known to cause immunosuppression in many animal species (Broom and Johnson, 2000). The following factors affect ostrich behaviors: farm design and layout; production system; season; sex; age (young and adult); flock size, male to female ratio, stressors such as; lack of water and feed, heat stress (Cooper *et al*., 2010). Ostriches raised in crowded farms are exposed to stress due to these adverse environmental conditions and begin to show abnormal behaviors. Over time, many of these abnormal behaviors are repeated like daily normal behaviors, and if the problem is not resolved, it can cause low productivity and even sudden death (Brendsen, 1995; Deeming, 1997).

Although ostrich production has decreased significantly in many countries, this specie is still of zootechnical interest. Ostrich meat is a valuable product, especially when compared to red meat. The ostrich meat has desirable chemical composition in terms of its high protein, low fat and cholesterol content. (Paleari *et al*., 1998; Horbanczuk and Sales, 1998; Al-Khalifa and Al-Naser, 2014). Also, ostrich meat is an alternative for consumers who are concerned about their health because it has 60 % lower calories than beef (Akram *et al*., 2019). Besides, today in most countries, customers are increasingly concerned about animal welfare and demand products with appropriate quality labels. Ostrich meat is high quality and produced without any additives. Consumers prefer to buy ostrich meat from extensive production systems and are even willing to pay a higher price for it (Kistner, 2019). Understanding the behavior of ostriches raised in farms or zoos is very important to animal welfare, as both environments are quite different from the birds' natural habitats. There is limited published scientific research about seasonal, sexual and daytime differences in comprehensive behaviors of ostriches. The aim of the study was to investigate the effect of seasonal variation on behavioral differences of male and female ostrich (*Struthio camelus*) breeders, reared in farm environment.

MATERIALS AND METHODS

Materials and management: The research was carried on 8 female and 5 male healthy ostrich (*Struthio camelus*) breeder, during August as summer season and end of October as autumn season, at the Research and Application Farm of the Bursa Uludağ University, Bursa, Türkiye (40°14'03.3"N 28°51'31.6"E, and 155 m altitude). Only healthy and not injured female and male ostrich breeders were selected for the study. Routinely, at the end of the laying period, male and female breeder birds are separated from each other. For this reason, the end of October was chosen as the autumn season so that data can be obtained before the birds leave mating groups.

Birds were kept in 1000 m^2 outdoor paddocks with a 5 m^2 of closed shelter area per bird, surrounded by a 3 m high wire fence. The paddocks contained shaded feeders, drinkers and grass feeders. A total four paddocks were used, birds reared in 3 trios (1 male and 2 female) in three paddocks and in quad (2 male and 2 female) reared in one paddock. During the laying season and trial, all birds remained in their own paddocks. All birds had

visual contact with each other. The birds were fed once daily with 2 kg/bird per day of a pellet ostrich breeder feed (18% CP, 2450 kcal ME) and 500 g/bird per day alfalfa were supplied for forage requirement. During the off-season birds were fed once daily with 1.5 kg/bird per day of pellet feed and alfalfa. Drinking water was supplied *ad libitum*.

The ambient temperature and humidity were recorded for every 10-minute interval using HOBO U23 data loggers (Hobo U23–01 Pro V2 temperature/RH data logger, Onset Computer Corporation, Bourne, MA, USA). Data loggers were placed at a height of 3 m inside the paddock. The maximum and minimum ambient temperatures and humidity were determined for a 24-h period during summer and autumn season and were used to calculate temperature-humidity index (THI) values (NRC, 1971). The formula used to calculate THI values given in below;

$$THI = [1.8 \times T + 32] - [(0.55 - 0.0055 \times RH)] \times [1.8 \times T - 26.8)]$$

where T = the dry bulb temperature (°C) and RH = the relative humidity (%).

Table 1. List and description of behavioral data on ostriches

Behavior	Description
Digestive Behaviors	
Eating	Consuming feed from feeder
Drinking	Drinking water from drinker
Foraging	Pecking grass feeder and paddock the ground
Defecation	Excreting urine and feces
Locomotor Behaviors	
Walking	Slow locomotion using feet
Running	Fast locomotion using feet
Spot Pecking	Beak used for environmental exploration or social contact
Alertness	Looking carefully at a point with head raising
Resting Behaviors	
Stand still	Feet in one place with head raise, eyes open
Sitting	Sitting with the head raise, eyes open
Sleeping	Sitting with the head raise or head low, eyes closed Standing with eyes closed
Comfort Behaviors	
Dust Bathing	Sitting and wings are flapped, tails and neck are rubbed the ground
Grooming	Sitting or standing and preening feathers with beak
Head Shake	Quickly turning head left to right several times
Thermoregulation Behavior	In order to dissipate heat from body, birds open-mouth quickly breathe and feathers are erected
Reproduction behaviors	
Boom	Males making a different tone sound with inflated neck while standing or sitting for territorial dominance
Courtship	Male and female are close each other and walking, the wings are extended and vibrated, the neck is lowered, and the beak is rhythmically opened and closed, make a clucking sound
Kantel	Sitting and wings extend and slightly vibrated, neck inflated and S shaped, body rocks from side to side
Copulation	Male mounting the female, phallus intromission by the male, then male get up and retracting the phallus
Laying	Female ostrich sitting and rising after the egg is laid down
Aggressive behaviors	
Threat with Wing Up	Standing on the toe tips, tail erect, neck feathers puffed, wings extended to up and hissing
Displace	Wings open, mouth open, hissing, slowly walking or short running on to other bird
Fight	Wings open, mouth open, hissing, running and kicking to other bird
Escape	Relocation of threatened bird after threat or fight

Behavioral Parameters: Behavior recordings of all birds were taken with binoculars and the naked eye in an empty paddock where the birds could not see the observer. All behaviors were recorded by one person after 30 minutes

of arriving to the paddock and all behaviors were recorded for one hour. A scan sampling technique was used to monitor the behavior of birds as described by Mitlöhner *et al*. (2001). For each bird, behavioral observations were recorded at 10 min intervals for 1 h at 09:00, 13:00 and 17:00. All of the birds were monitored for 4 consecutive days during the summer and autumn season. Each day was assumed as a replicate in the statistical model. The individual behaviors recorded were eating, drinking, foraging, defecation, walking, running, alertness, spot pecking, stand still, sitting, sleeping, dust bathing, grooming, head shake, thermoregulation, boom, courtship, kantel, copulation, laying, threat with wing up, displace, fight, escape. All these behaviors were grouped under 6 main behavioral types such as digestive, locomotor, resting behaviors, comfort and thermoregulation, reproduction, and aggressive behaviors. The list and description of behavioral data on ostriches were given in Table 1 (Adapted from Stewart 1994; Amado *et al*. 2011).

Statistical analysis: The data was analyzed using PROC MIXED procedure of Statistical Analysis System 9.4 (SAS Institute Inc., Cary, NC, USA). This statistical model uses a restricted/residual maximum likelihood (REML) approach. A mixed linear model is a generalization of the standard linear model used in the GLM procedure which is designed to fit the fixed and random effects at the same time (SAS, 2019). The model included sex (male and female), season (summer, autumn), time of day (morning, noon and afternoon), replicate (1-4) as fixed effects and the statistical model also included the interactions of season and sex and season and time of day. To reduce the individual variance, bird number within each replicate was taken into consideration as a random factor in the model. Data were presented as mean ± standard error (SE) in all the tables. Differences were considered significant at $P \leq 0.05$ and the statistical difference at $P \leq 0.10$ was described as a tendency.

The statistical model was as follows:

$Y_{ij} = \mu + a_i + b_j + c_k + d_l + f_m + (ab)_{ij} + (ac)_{ik} + \varepsilon_{ijklm}$,

where $Y_{ij} = \mu^{th}$ observation value, μ = expected mean of the population, a_i = i. seasonal effect (i=summer and autumn), b_j = j. sex effect (j= male and female), c_k = k. time of day effect (k= morning, noon and afternoon), d_l = d. replicate effect (l= replicate 1-4), f_m = individual bird within replicate random effect, $(ab)_{ij}$ = ij. Season and sex interaction effect, $(ac)_{ik}$ = ik. Season and time of day interaction effect, ε_{ijklm} = residual error.

RESULTS

The environmental conditions (temperature, humidity and THI) during the observation days were given Figure 1. In the study, average recorded temperature and humidity were 26.8 ± 1.3°C and 65.6 ± 4.1% RH at 09:00 h; 34.7 ± 0.7°C and 42.0 ± 2.0% RH at 13:00 h; 32.7 ± 1.3°C and 44.6 ± 4.1 % RH at 17:00 h during summer season, respectively, and 11.7 ± 0.8°C and 84.8 ± 2.9% RH at 09:00 h; 19.8 ± 0.7°C and 52.6 ± 2.6% RH at 13:00 h; 18.6 ± 0.8°C and 57.1 ± 2.9 % RH at 17:00 h during autumn season, respectively (Figure 1).

Digestive Behaviors: The effect of season, sex and time of day on digestive behaviors of ostriches were given in Table 2. The drinking and foraging behavior was affected by season, and higher drinking and foraging behavior were found in autumn season ($P \leq 0.01$ and $P \leq 0.05$, respectively). However, the effect of season on eating and defecation behavior was not significant *(*$P > 0.05$). The sex of ostrich was affected foraging behavior, and higher foraging behavior was observed in females ($P \leq 0.01$). The difference in eating, drinking and defecation behavior of male and female ostriches were not significant *(*$P > 0.05$). The eating, drinking and foraging behaviors of ostriches were affected by time of day ($P \leq 0.05$, $P \leq 0.05$ and $P \leq 0.05$, respectively). The lowest eating, drinking and foraging behavior were observed at noon time while they were more actively feeding during the early and late hours of the day. The defecation behavior of ostriches was not changed during the time of day *(*$P > 0.05$). The effect of season and sex interaction, and season and time of day interaction on digestive behaviors of ostriches were not significant *(*$P > 0.05$). But there was a significant interaction between season and time of day for drinking and defecation behavior ($P \leq 0.05$ and $P \leq 0.05$, respectively). The highest drinking behavior was observed in the afternoon hours and highest defecation behavior was observed in the morning hours of autumn season. Our results showed that season and time of day have significant effect on digestive behaviors. Ostrich behaviors significantly change in a hot environment and the welfare compromised.

Locomotor Behaviors: The effect of season, sex and time of day on the locomotor behaviors of ostriches were given in Table 3. The spot pecking behavior was affected by season, and higher spot pecking behavior was detected during the autumn season ($P \leq 0.05$). However, there was no seasonal variation observed for walking, running and alertness behaviors *(*$P > 0.05$). The sex of ostrich was affected alertness behavior and spot pecking behavior, and higher alertness behavior and spot pecking behavior were observed in females ($P \leq 0.05$ and $P \leq 0.05$, respectively). Walking and running behavior of male and female ostriches were similar *(*$P > 0.05$). On the other hand, higher walking behavior was recorded in the morning and afternoon ($P \leq 0.05$). The running behavior tends to be observed only in the morning while they were more active (P=0.075). Alertness and spot pecking behavior of ostriches were similar throughout the day *(*$P > 0.05$). The effect of season and sex interaction, and

season and time of day interaction on locomotor behaviors of ostriches were found not significant *(P*>0.05). Spot pecking behavior significantly reduced during the summer. On the other hand, walking behavior was reduced at noon.

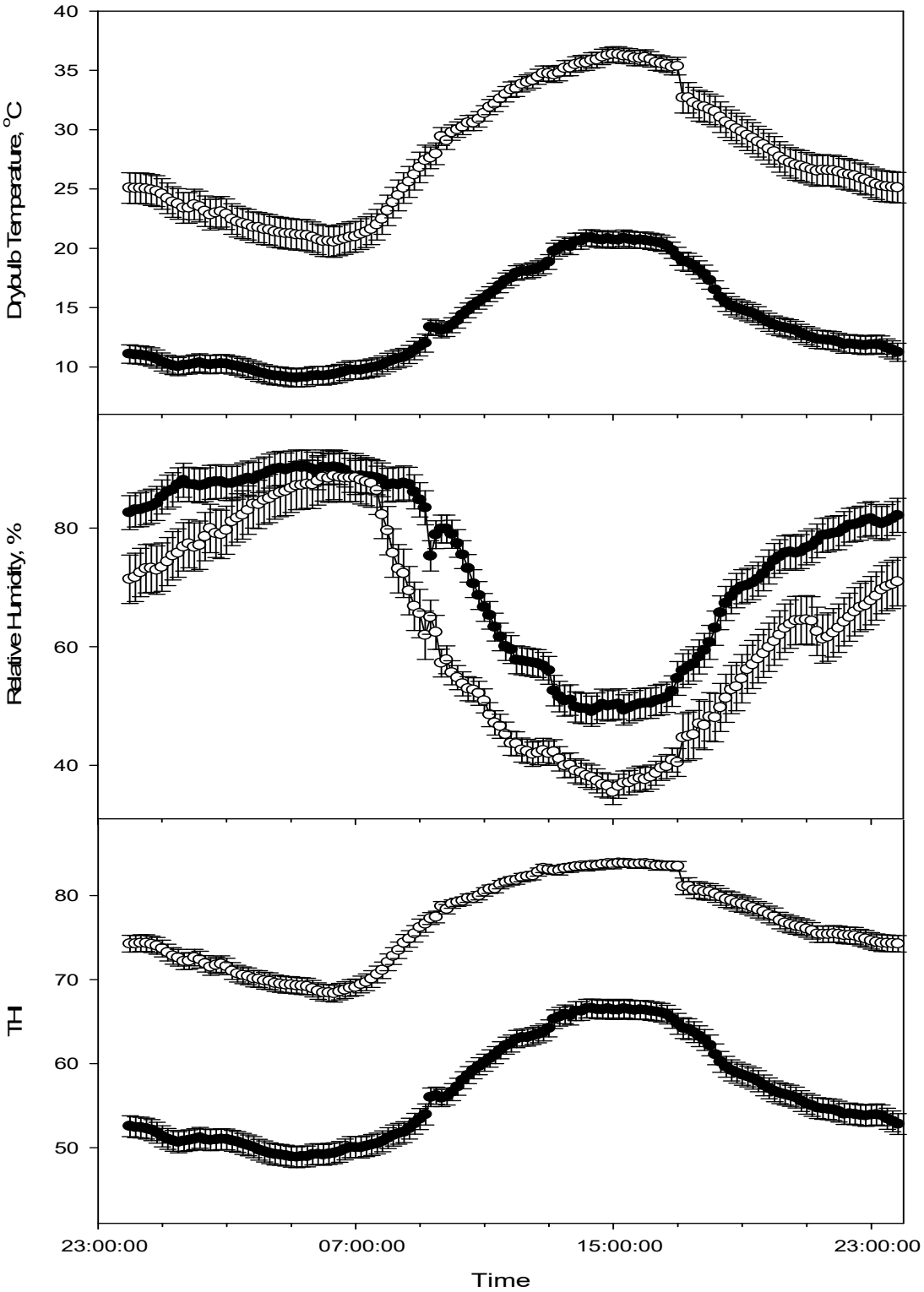

Figure 1. Average values of dry bulb temperature (ºC), relative humidity (%) and THI during the summer (open circles) and autumn (closed circles) season

Table 2. The digestive behaviors of ostriches according to season, sex and time of day (%) (mean ± SE)

		Digestive Behaviors			
		Eating	**Drinking**	**Foraging**	**Defecation**
Season	Summer	0.13 ± 0.02	0.02 ± 0.01^{b}	0.07 ± 0.02^{b}	0.02 ± 0.01
	Autumn	0.13 ± 0.02	0.06 ± 0.01^{a}	0.12 ± 0.02^{a}	0.03 ± 0.01
P		*0.872*	*≤0.01*	*≤0.05*	*0.264*
Sex	Male	0.12 ± 0.02	0.04 ± 0.01	0.06 ± 0.02^{b}	0.02 ± 0.01
	Female	0.13 ± 0.02	0.04 ± 0.01	0.13 ± 0.02^{a}	0.03 ± 0.01
P		*0.703*	*0.514*	*≤0.01*	*0.657*
Time	Morning	0.17 ± 0.02^{a}	0.05 ± 0.01^{a}	0.14 ± 0.02^{a}	0.04 ± 0.01
	Noon	0.07 ± 0.02^{b}	0.02 ± 0.01^{b}	0.05 ± 0.02^{b}	0.02 ± 0.01
	Afternoon	0.14 ± 0.02^{a}	0.05 ± 0.01^{a}	0.09 ± 0.02^{ab}	0.02 ± 0.01
P		*≤0.05*	*≤0.05*	*≤0.05*	*0.245*
Season × Sex					
S × M		0.14 ± 0.03	0.01 ± 0.01	0.04 ± 0.02	0.01 ± 0.01
S × F		0.13 ± 0.03	0.03 ± 0.01	0.09 ± 0.02	0.02 ± 0.01
A × M		0.11 ± 0.03	0.06 ± 0.01	0.07 ± 0.02	0.03 ± 0.01
A × F		0.14 ± 0.03	0.05 ± 0.01	0.17 ± 0.02	0.03 ± 0.01
P		*0.461*	*0.184*	*0.435*	*0.804*
Season × Time					
S × MO		0.15 ± 0.03	0.05 ± 0.01^{b}	0.09 ± 0.03	0.02 ± 0.01^{bc}
S × NO		0.07 ± 0.03	0.01 ± 0.01^{c}	0.04 ± 0.03	-
S × AF		0.17 ± 0.03	0.01 ± 0.01^{c}	0.01 ± 0.03	0.04 ± 0.01^{ab}
A × MO		0.19 ± 0.03	0.05 ± 0.01^{b}	0.19 ± 0.03	0.06 ± 0.01^{a}
A × NO		0.08 ± 0.03	0.03 ± 0.01^{cb}	0.06 ± 0.03	0.03 ± 0.01^{abc}
A × AF		0.11 ± 0.03	0.09 ± 0.01^{a}	0.12 ± 0.03	-
P		*0.322*	*≤0.05*	*0.379*	*≤0.05*

$^{a,b,c:}$ Values with different superscripts in the same column differ statistically ($P \leq 0.05$).
S: summer, A: autumn, MO: morning, NO: noon, AF: Afternoon, M: Male, F: Female
- : No behavior was observed.

Resting Behaviors: The effect of season, sex and time of day on resting behaviors of ostriches were given in Table 4. There was a seasonal variation in sitting and sleeping behaviors, and higher sitting and sleeping behaviors were observed during the summer season when the ambient temperature was high (P≤0.01 and P=0.0001, respectively). However, the effect of season on stand still behavior was not significant (P>0.05). The sex of ostrich affected sitting behavior, and higher sitting behavior was detected in males (P≤0.01). Male and female ostriches showed similar stand still and sleeping behavior (P>0.05). The time of day significantly changed the sitting and sleeping behaviors of ostriches (P≤0.01 and P=0.0001, respectively). The lower sitting behavior was observed in the morning and higher sleeping behavior was observed at noon. Stand still behavior of ostriches was not affected by time of day (P>0.05). The effect of season and sex interaction, and season and time of day interaction on resting behaviors of ostriches were found not significant (P>0.05), except for sleeping behavior (P=0.0001). The effect of season and time of day interaction on sleeping behavior of ostriches was found significant, and higher sleeping behavior was observed at noon in summer season (P=0.0001). Ostriches showed more resting behavior during the summer and reduced their activity at noon.

Comfort and Thermoregulation Behaviors: The effect of season, sex and time of day on comfort and thermoregulation behaviors of ostriches were given in Table 5. The dust bathing, grooming and thermoregulation behaviors were affected by season, and higher dust bathing and grooming behaviors were found during the autumn season (P≤0.01, and P≤0.0001, respectively). The thermoregulation behavior was observed only in summer season (P≤0.0001). The effect of season on head shake behavior was not significant (P>0.05). The sex of ostrich significantly changed the head shake behavior, and higher head shake behavior was observed in males (P≤0.05). The sex of ostrich was not affected dust bathing, grooming and thermoregulation behaviors (P>0.05). It has been detected that dust bathing, grooming and thermoregulation behaviors of ostriches significantly changed during the day (P=0.0001, P≤0.0001, and P≤0.0001, respectively). The higher dust bathing, grooming and thermoregulation behavior were observed at noon. Head shake behavior of ostriches was similar during the day (P>0.05). The effect of season and sex interaction on head shake behavior of ostriches tends to be significant, and lower head shake behavior was observed during the autumn season in female ostriches (P=0.070). The effect of season and sex interaction on dust bathing, grooming and thermoregulation behaviors

of ostriches were not significant *(P*>0.05). There was a significant effect of season and time of day interaction on dust bathing, grooming and thermoregulation behaviors of ostriches (*P*=0.0001, *P*≤0.0001, and *P*≤0.0001, respectively). The highest dust bathing and grooming behavior were found at noon during the autumn season, and highest thermoregulation behavior was observed at noon during the summer season when the ambient temperature was high. Ostriches, showed less comfort behaviors and tried to regulate their body temperature when the ambient temperature is high. This behavioral change shows that their welfare is significantly affected by heat stress.

Reproduction Behaviors: The effect of season, sex and time of day on reproduction behaviors of ostriches were given in Table 6. The copulation behavior was affected by season, and higher copulation behavior was detected in autumn (*P*≤0.05). However, the effect of season on boom, courtship, kantel and laying behavior was not significant *(P*>0.05). Only male ostriches showed boom behavior (*P*≤0.05). Sex of ostrich did not change the courtship, kantel and copulation behaviors *(P*>0.05). The time of day tends to be affected copulation and laying behaviors of ostriches (*P*= 0.053 and *P*= 0.078, respectively). The lowest copulation behavior was observed during the morning and laying behavior was detected during the afternoon. Ostriches showed similar boom, courtship and kantel behaviors throughout the day *(P*>0.05). The effect of season and sex interaction on reproduction behaviors of ostriches was not significant *(P*>0.05). The copulation behavior of ostriches was significantly affected by season and time of day interaction (*P*≤0.01). The highest copulation behavior was observed in the afternoon during the summer, and at noon during the autumn season. The effect of season and time of day interaction on boom, courtship and kantel behavior of ostriches were not significant *(P*>0.05). The laying behavior tends to be more observed in the afternoon during the summer season (*P*= 0.078). Ostriches showed less reproductive behaviors at hot hours during the summer season.

Aggressive Behaviors: The effect of season, sex and time of day on aggressive behaviors of ostriches were given in Table 7. The effect of season, sex and time of day on threat with wing up, displace, fight and escape behaviors of ostriches were similar (*P*>0.05). There was a significant season and sex interaction for displace behavior and lower displace behavior was observed in males during the autumn season (*P*≤0.01). Other aggressive behaviors were similar in both season and sex *(P*>0.05). Season and time of day interaction changed the escape and displace behaviors of ostriches, and higher escape and displace behaviors were observed during the afternoon in summer season (*P*≤0.05 and *P*≤0.05, respectively). Ostriches' aggressive behaviors were similar in both seasons.

Table 3. The locomotor behaviors of ostriches according to season, sex and time of day (%) (mean ± SE)

		Locomotor Behaviors			
		Walking	**Running**	**Alertness**	**Spot Pecking**
Season	Summer	0.13 ± 0.02	0.002 ± 0.003	0.04 ± 0.01	0.05 ± 0.02[b]
	Autumn	0.14 ± 0.02	0.007 ± 0.003	0.03 ± 0.01	0.11 ± 0.02[a]
P		0.579	0.279	0.393	≤0.05
Sex	Male	0.13 ± 0.02	0.002 ± 0.003	0.05 ± 0.02[b]	0.05 ± 0.02[b]
	Female	0.15 ± 0.02	0.006 ± 0.003	0.12 ± 0.02[a]	0.12 ± 0.02[a]
P		0.433	0.453	0.037	0.015
Time	Morning	0.13 ± 0.02[ab]	0.012 ± 0.004	0.05 ± 0.01	0.12 ± 0.02
	Noon	0.09 ± 0.02[b]	-	0.02 ± 0.01	0.07 ± 0.02
	Afternoon	0.19 ± 0.02[a]	-	0.03 ± 0.01	0.07 ± 0.02
P		≤0.05	0.075	0.223	0.151
Season × Sex					
S × M		0.10 ± 0.03	-	0.07 ± 0.02	0.04 ± 0.02
S × F		0.16 ± 0.03	0.003 ± 0.010	0.02 ± 0.02	0.07 ± 0.02
A × M		0.15 ± 0.03	0.005 ± 0.010	0.04 ± 0.02	0.07± 0.02
A × F		0.14 ± 0.03	0.009 ± 0.010	0.02 ± 0.02	0.16 ± 0.02
P		0.287	0.891	0.393	0.115
Season × Time					
S × MO		0.14 ± 0.03	0.005 ± 0.010	0.06 ± 0.02	0.10 ± 0.03
S × NO		0.01 ± 0.03	-	0.04 ± 0.02	0.03 ± 0.03
S × AF		0.17 ± 0.03	-	0.02 ± 0.02	0.04 ± 0.03
A × MO		0.12 ± 0.03	0.020 ± 0.010	0.04 ± 0.02	0.14 ± 0.03
A × NO		0.11 ± 0.03	-	-	0.11 ± 0.03
A × AF		0.20 ± 0.03	-	0.03 ± 0.02	0.10 ± 0.03
P		0.685	0.312	0.379	0.774

[a,b:] Values with different superscripts in the same column differ statistically (*P* ≤ 0.05).
S: summer, A: autumn, MO: morning, NO: noon, AF: Afternoon, M: Male, F: Female
- : No behavior was observed.

Table 4. The resting behaviors of ostriches according to season, sex and time of day (%) (mean ± SE)

		Resting Behaviors		
		Stand Still	**Sitting**	**Sleeping**
Season	Summer	0.10 ± 0.01	0.10 ± 0.01[a]	0.042 ± 0.010
	Autumn	0.10 ± 0.01	0.02 ± 0.01[b]	-
P		*0.740*	*≤0.01*	*≤0.0001*
Sex	Male	0.11 ± 0.01	0.09 ± 0.01[a]	0.019 ± 0.010
	Female	0.09 ± 0.01	0.03 ± 0.01[b]	0.024 ± 0.010
P		*0.154*	*≤0.01*	*0.554*
Time	Morning	0.11 ± 0.02	0.01 ± 0.02[b]	0.006 ± 0.010[b]
	Noon	0.10 ± 0.02	0.09 ± 0.02[a]	0.054 ± 0.010[a]
	Afternoon	0.19 ± 0.02	0.07 ± 0.02[a]	0.004 ± 0.010[b]
P		*0.500*	*≤0.01*	*≤0.0001*
Season × Sex				
S × M		0.11 ± 0.02	0.13 ± 0.02	0.037 ± 0.010
S × F		0.10 ± 0.02	0.06 ± 0.02	0.048 ± 0.010
A × M		0.12 ± 0.02	0.05 ± 0.02	-
A × F		0.07 ± 0.02	-	-
P		*0.303*	*0.469*	*0.554*
Season × Time				
S × MO		0.14 ± 0.02	0.03 ± 0.02	0.011 ± 0.010[b]
S × NO		0.10 ± 0.02	0.15 ± 0.02	0.109 ± 0.010[a]
S × AF		0.07 ± 0.02	0.12 ± 0.02	0.007 ± 0.010[b]
A × MO		0.09 ± 0.02	-	-
A × NO		0.10 ± 0.02	0.04 ± 0.02	-
A × AF		0.10 ± 0.02	0.03 ± 0.02	-
P		*0.290*	*0.224*	*≤0.0001*

[a,b:] Values with different superscripts in the same column differ statistically ($P \leq 0.05$). S: summer, A: autumn, MO: morning, NO: noon, AF: Afternoon, M: Male, F: Female; - : No behavior was observed.

Table 5. The comfort and thermoregulation behaviors of ostriches according to season, sex and time of day (%) (mean ± SE)

		Comfort Behaviors			Thermoregulation
		Dust Bathing	**Grooming**	**Head Shake**	**Behavior**
Season	Summer	0.006 ± 0.004[b]	0.03 ± 0.01[b]	0.014 ± 0.005	0.14 ± 0.008
	Autumn	0.027 ± 0.004[a]	0.11 ± 0.01[a]	0.008 ± 0.005	-
P		*≤0.01*	*≤ 0.0001*	*0.333*	*≤0.0001*
Sex	Male	0.012 ± 0.004	0.08 ± 0.01	0.019 ± 0.005[a]	0.067 ± 0.008
	Female	0.021 ± 0.004	0.07 ± 0.01	0.003 ± 0.005[b]	0.074 ± 0.008
P		*0.148*	*0.435*	*≤0.05*	*0.534*
Time	Morning	-	0.04 ± 0.01[b]	0.016 ± 0.006	0.020 ± 0.010[b]
	Noon	0.038 ± 0.005[a]	0.14 ± 0.01[a]	0.004 ± 0.006	0.144 ± 0.010[a]
	Afternoon	0.010 ± 0.005[b]	0.04 ± 0.01[b]	0.013 ± 0.006	0.048 ± 0.010[b]
P		*≤0.0001*	*≤0.0001*	*0.267*	*≤0.0001*
Season × Sex					
S × M		-	0.03 ± 0.02	0.028 ± 0.006[a]	0.134 ± 0.012
S × F		0.012 ± 0.006	0.04 ± 0.02	-	0.149 ± 0.012
A × M		0.023 ± 0.006	0.13 ± 0.02	0.009 ± 0.006[a]	-
A × F		0.030 ± 0.006	0.10 ± 0.02	0.006 ± 0.006[b]	-
P		*0.669*	*0.142*	*0.070*	*0.534*
Season × Time					
S × MO		-	0.05 ± 0.02[bc]	0.021 ± 0.008	0.041 ± 0.014[c]
S × NO		0.005 ± 0.008[b]	0.04 ± 0.02[bc]	0.007 ± 0.008	0.288 ± 0.014[a]
S × AF		0.013 ± 0.008[b]	0.01 ± 0.02[c]	0.014 ± 0.008	0.096 ± 0.014[b]
A × MO		-	0.03 ± 0.02[bc]	0.011 ± 0.008	-
A × NO		0.072 ± 0.008[a]	0.24 ± 0.02[a]	-	-
A × AF		0.007 ± 0.008[b]	0.08 ± 0.02[b]	0.011 ± 0.008	-
P		*≤0.0001*	*≤0.0001*	*0.902*	*≤0.0001*

[a,b,c:] Values with different superscripts in the same column differ statistically ($P \leq 0.05$).
S: summer, A: autumn, MO: morning, NO: noon, AF: Afternoon, M: Male, F: Female
- : No behavior was observed.

Table 6. The reproduction behaviors of ostriches according to season, sex and time of day (%) (mean ± SE)

		Reproduction Behaviors				
		Boom	**Courtship**	**Kantel**	**Copulation**	**Laying**
Season	Summer	0.002 ± 0.003	0.04 ± 0.01	0.007 ± 0.003	0.008 ± 0.003[b]	0.005 ± 0.002
	Autumn	0.007 ± 0.003	0.06 ± 0.01	-	0.015 ± 0.003[a]	-
P		*0.224*	*0.244*	*0.177*	*≤0.05*	*0.103*
Sex	Male	0.010 ± 0.003	0.05 ± 0.01	0.007 ± 0.004	0.014 ± 0.003	-
	Female	-	0.05 ± 0.01	-	0.009 ± 0.003	0.005 ± 0.002
P		*≤0.05*	*0.981*	*0.177*	*0.175*	*0.103*
Time	Morning	0.007 ± 0.003	0.04 ± 0.01	0.004 ± 0.004	0.006 ± 0.003[b]	-
	Noon	0.007 ± 0.003	0.04 ± 0.01	0.007 ± 0.004	0.011 ± 0.003[ab]	-
	Afternoon	-	0.07 ± 0.01	-	0.017 ± 0.003[a]	0.007 ± 0.002
P		*0.233*	*0.154*	*0.527*	*0.053*	*0.078*
Season × Sex						
S × M		0.005 ± 0.004	0.05 ± 0.01	0.014 ± 0.005	0.009 ± 0.004	-
S × F		-	0.04 ± 0.01	-	0.006 ± 0.004	0.009 ± 0.003
A × M		0.014 ± 0.004	0.06 ± 0.01	-	0.019 ± 0.004	-
A × F		-	0.06 ± 0.01	-	0.012 ± 0.004	-
P		*0.224*	*0.602*	*0.177*	*0.643*	*0.103*
Season × Time						
S × MO		0.007 ± 0.005	0.05 ± 0.02	0.007 ± 0.006	-	-
S × NO		-	0.02 ± 0.02	0.014 ± 0.006	-	-
S × AF		-	0.06 ± 0.02	-	0.023 ± 0.004[a]	0.013 ± 0.003
A × MO		0.007 ± 0.005	0.03 ± 0.02	-	0.011 ± 0.004[b]	-
A × NO		0.014 ± 0.005	0.06 ± 0.02	-	0.023 ± 0.004[a]	-
A × AF		-	0.09 ± 0.02	-	0.011 ± 0.004[b]	-
P		*0.233*	*0.154*	*0.527*	≤0.01	*0.078*

[a,b:] Values with different superscripts in the same column differ statistically ($P \leq 0.05$).
S: summer, A: autumn, MO: morning, NO: noon, AF: Afternoon, M: Male, F: Female
- : No behavior was observed.

Table 7. The aggressive behaviors of ostriches according to season, sex and time of day (%) (mean ± SE)

		Aggressive Behaviors			
		Threat with wing up	**Displace**	**Fight**	**Escape**
Season	Summer	0.005 ± 0.005	0.009 ± 0.003	0.005 ± 0.003	0.008 ± 0.004
	Autumn	0.008 ± 0.005	0.005 ± 0.003	-	0.005 ± 0.004
P		*0.590*	*0.334*	*0.332*	*0.587*
Sex	Male	0.012 ± 0.005	0.005 ± 0.003	0.005 ± 0.003	0.009 ± 0.004
	Female	0.002 ± 0.005	0.009 ± 0.003	-	0.003 ± 0.004
P		*0.164*	*0.334*	*0.332*	*0.259*
Time	Morning	0.014 ± 0.006	0.005 ± 0.004	0.007 ± 0.004	-
	Noon	-	0.007 ± 0.004	-	0.007 ± 0.005
	Afternoon	0.006 ± 0.006	0.009 ± 0.004	-	0.011 ± 0.005
P		*0.285*	*0.705*	*0.390*	*0.246*
Season × Sex					
S × M		0.009 ± 0.007	-	0.009 ± 0.005	0.009 ± 0.005
S × F		-	0.018 ± 0.004[a]	-	0.006 ± 0.005
A × M		0.014 ± 0.007	0.009 ± 0.004[ab]	-	0.009 ± 0.005
A × F		0.003 ± 0.007	-	-	-
P		*0.906*	*≤0.01*	*0.332*	*0.587*
Season × Time					
S × MO		0.014 ± 0.009	0.009 ± 0.005[b]	0.014 ± 0.006	-
S × NO		-	-	-	-
S × AF		-	0.018 ± 0.005[a]	-	0.023 ± 0.007[a]
A × MO		0.014 ± 0.009	-	-	-
A × NO		-	0.014 ± 0.005[ab]	-	0.014 ± 0.007[b]
A × AF		0.012 ± 0.009	-	-	-
P		*0.743*	*≤0.05*	*0.390*	*≤0.05*

[a,b,c:] Values with different superscripts in the same column differ statistically ($P \leq 0.05$).
S: summer, A: autumn, MO: morning, NO: noon, AF: Afternoon, M: Male, F: Female
- : No behavior was observed.

DISCUSSION

The lifestyle of ostriches in their natural habitat is nomadic and they are mostly diurnal animals with a high activity during the early and late hours of the day. Understanding the behavior of ostriches is a useful tool for improving production, welfare and health, as has been reported in other poultry species. Previous studies reported observations of ostrich behaviors in the wild (Mutiga *et al*., 2016) or in captivity (Kennou Sebei and Bergaoui, 2009; Amado *et al*., 2011; Ahmed and Salih 2012). In our study ostriches spent more time with digestive and locomotor behaviors in all investigated behaviors. These results are supported by previous studies in Sauer and Sauer (1966) for South African ostriches, in Mutiga *et al*. (2016) for wild Somali ostriches in their natural environment and in Ahmed and Salih (2012) for red neck ostriches under captive conditions.

Digestive Behaviors: Birds are resorted to some behavioral changes such as consuming less feed, seeking for shade, and accelerated respiration for thermoregulation during hot summer days (Ruuskanen *et al*., 2021). Also, Mutiga *et al*. (2016) reported high feeding behavior in dry season for wild Somali ostriches. In the current study, there was no seasonal effect on eating and defecation behavior, but higher foraging behavior was observed in autumn season. The ostriches are omnivore animals and their foraging behavior in summer season is expected to be lower than in autumn season due to dry grazing land. Also in our study, lower drinking behavior observed in summer season and ostriches tend to drink more in the morning hours during the summer. It can be thought that this situation is caused by the increase water temperature in the drinkers during the hot summer days.

Ostriches often perform pecking activity while eating feed. Females generally perform higher pecking behavior than males (Cooper *et al*., 2010) and females show higher foraging behavior than males (Deeming, 1998b). Supported to previous studies, in the current study pecking grass feeder and paddock ground accepted as a foraging behavior, and higher foraging behavior was observed in females when compared to males. However, there was no sexual difference on eating, drinking and defecation behavior of male and female ostriches. Similar to our results, Bertram (1992) and Mutiga *et al*. (2016) reported that there was no time budget difference between male and females for feeding behavior.

Higher eating and foraging behavior were observed in the morning and afternoon. This result is supported by Amado *et al*. (2011) and Ahmed and Salih (2012), who reported that feed consumption was higher in the morning and in the afternoon, when the ambient temperature was low. Also, higher feed consumption during the morning was reported by Sambraus (1994), Deeming (1998a) and Mutiga *et al*. (2016). As a matter of fact, birds may tend to reduce their feed consumption in order to prevent the internal heat increase that will occur due to digestion during the hot hours of the day. Lower frequencies of drinking behavior were observed at noon time. In according to our findings, Amado *et al*. (2011) and Ahmed and Salih (2012) reported that higher drinking behavior were observed in the afternoon, in young and adult ostriches, respectively.

In our study there was no interaction between season and sex on digestive behaviors of ostriches. Like our findings Mutiga *et al*. (2016) reported that in wild Somali ostriches both males and females spend more time to feeding during dry season when compared to wet season, but difference between male and females for feeding behavior was not significant.

Locomotor Behaviors: There was no seasonal variation detected on walking, running and alertness behavior of ostriches in the current study. Similar to our findings, Mutiga *et al*. (2016) reported that in wild Somali ostriches there was no seasonal difference for walking and vigilance (alertness) behavior. It is known that adult ostriches spend most of their daily time on the move in search of food in nature. In our study, higher spot pecking behavior was found in autumn season. It could be a result of more alertness to their surroundings while foraging in the field.

As a defense against the threat of predation, vigilance or alertness is known to increase with predation risk (Edmunds, 1974). Thus, Ross and Deeming (1998) reported that males were more vigilant and fed for shorter periods than females, also Mutiga *et al*. (2016) reported that males had higher percentage time with vigilant state than females but found not statistically significant. However, in the study, higher alertness behavior was observed in females than males. This may be because females were constantly active while performed behaviors such as foraging and or spot pecking. Thus, in the study, higher spot pecking behavior was observed in females than males. In accordance with our results Ahmed and Salih (2012) reported that female ostriches showed numerically higher environment pecking behavior than males.

In the study, higher walking behavior was observed in the afternoon and morning, in addition running behavior tends to be observed only in the morning. A similar result to our findings was also reported by Ahmed and Salih (2012) in which they found that ostriches walking less in the middle of the day and running more in the afternoon. But Mutiga *et al*. (2016) reported that in wild Somali ostriches' greater movement behavior was observed in the evening. It could be inferred that such locomotor behaviors of ostriches were affected by the daytime temperature differences (shown

in Figure 1). In the current study, there was no difference for time of the day on stand still, alertness and spot pecking behavior of ostriches. However, Ahmed and Salih (2012) reported that adult ostriches stand still more in the morning. And Amado *et al*. (2011) reported that young ostriches stand still more in the morning, walk less at the noon and run more in the afternoon. In accordance with our findings Mutiga *et al*. (2016) reported that time of the day did not affect vigilance (alertness) behavior in wild Somali ostriches.

While male ostriches spend most of their time for standing and walking, females spend more of their time for standing, foraging and feeding during summer (Ross and Deeming, 1998), this gender differences not observed during the winter season (Deeming, 1998b). In our study, there was no interaction between season and sex on locomotor behaviors of ostriches. These findings are in agreement with Mutiga *et al*. (2016) who reported that in wild Somali ostriches' males spent similar time to movement during wet and dry season, but females spent numerically higher time to movement during the wet season when compared to dry season, but this difference found not significant.

Resting Behaviors: The high temperatures during summer may have caused a reduction in bird activity (Ahmed and Salih, 2012; Fericean *et al*., 2022). Thus, our results showed higher sitting and sleeping behavior during the summer season, and there was no seasonal effect on stand-still behavior. However, Mutiga *et al*. (2016) reported that wild Somali ostriches resting time allocation was higher in wet season than dry season.

In the study, higher sitting behavior was observed in males. But there was no sexual difference for standstill and sleeping behaviors of male and female ostriches. Like our results Mutiga *et al*. (2016) reported that males spent more time with resting than females. Also Deeming (1998b) reported that males spent more time for standing than females during winter climatic conditions in British ostrich farm.

Our results showed less sitting behavior was observed in the morning and higher sleeping behavior was observed at noon. There was no difference in standstill behavior of ostriches during the day. Thus, Fericean *et al*. (2022) observed that standing was the most commonly observed resting behavior, followed by sitting during the day, also sleeping were observed in the afternoon and at night. However, Ahmed and Salih (2012) reported that ostriches showed more stand still behavior in the morning than in the middle of the day. Also, higher sleeping behavior was observed at noon during the summer season. Especially in summer, the activities of birds were affected by the temperature, so it could be inferred that birds had more resting behavior to cope with the heat.

The results showed that season and time of day interaction for stand still behavior was not significant, so there was no difference for stand still behavior during the in both seasons. Similar to our findings Deeming (1998a) reported that there was no difference in the frequency of daily variation of standing behavior during the winter. Similar results were also reported by Ross and Deeming (1998) for the same behavior during to summer.

Comfort and Thermoregulation Behaviors: Since ostriches do not have preen glands, dust bathing is more common than grooming (Samson, 1996). According to Deeming (1998b) preening (grooming) was observed very little, but dust bathing behavior was not observed during winter. Also, McKeegan and Deeming (1997) reported that preening and dust bathing behaviors were observed very little in time activity of ostriches during summer in England. However, Mutiga *et al*. (2016) reported that wild Somali ostriches spent more time with preening in wet season when compared to dry season. Thus, in the current study, higher dust bathing and grooming behavior was observed during the autumn.

The ostrich lacks sweat glands (Aravinth and Selman, 2015b). However, with extended exposure to a range of ambient temperatures between 15 and 50 ^{o}C, the ostrich was able to keep their body temperature at a constant level (Basuony, 2011). Ostriches regulate their body temperature in a variety of ways, including controlling heat loss during cold weather by covering their thighs with their wings and creating a gentle breeze during hot weather by lifting and moving their wings (Cooper *et al*., 2010; Aravinth and Selvan, 2015b). Thus, ostriches use increased evaporative water loss via respiration during the hot summer season (Maloney, 2008). Yawning, stretching, and panting behavior are all used to maintain physiological balance in ostriches during hot weather (Cooper *et al*., 2010). In the study thermoregulation behavior was observed only in summer season and the frequency of this behavior increased from morning to afternoon hours of the day. It could be concluded that these findings suggest that birds tend to breathe frequently (panting) for thermoregulation to cope with the heat during the summer season. On the other hand, they tend to show more comfort behaviors such as dust bathing and grooming during the cool weather. In addition, thermoregulation behavior was similar for both male and female ostriches.

Resting and sleeping ostriches from time to time shake their heads from side to side to remove excess mucus from their nasal cavity and mouth. They usually yawned after this behavior (Sauer and Sauer, 1967). Our results showed that there was no seasonal effect on head shake behavior of ostriches, however, males showed more head shaking than females. It might be result of more resting behavior in males than in females.

In the study, there was no sexual difference for dust bathing and grooming behavior for male and female ostriches. But Mutiga *et al*. (2016) reported that males spent more time with preening (grooming) than females. Thus, care of the plumage is an important behavior for maintaining good feather condition in ostriches. The preening frequency was higher during the morning than afternoon hours; however, dust bathing was higher during afternoon than morning in ostriches (Deeming and Bubier, 1999). Also, Ahmed and Salih (2012) reported that dust bath behavior was observed mostly in the afternoon. But our results showed higher dust bathing and grooming behavior were observed at noon. In addition, the highest grooming behavior was detected at noon during the autumn season.

Previous studies reported that dust bathing behavior of ostriches was observed mostly in the afternoon during summer season (Amado *et al*., 2011; Ahmed and Salih, 2012). However, in our study the highest dust bathing behavior was found at noon in the autumn season. It can be a result of high temperatures at noon during to summer season might have caused a reduction in activity of birds.

Reproduction Behaviors: Seasonal photoperiod variation in poultry affects reproductive activities. Thus, the secretion of the gonadotropin releasing hormone, which affects the development of the gonads and sexual behavior, is affected by photoperiod (Johnson 2015; Vizcarra *et al*. 2015). However, according to Cooper *et al*. (2010) ecological studies demonstrate that ostriches are opportunistic breeders whose reproduction is dependent on the quality and amount of forage. The duration of the breeding season also depends on the condition of the birds and climatic conditions. As a matter of fact, ostriches react immediately to climatic changes (Fericean and Rada, 2013). In the study, there was no seasonal effect on boom, courtship, kantel and laying behavior of ostriches. But the highest copulation behavior was observed in the afternoon during the summer season, and at noon during autumn season. It might be a result of temperature differences in season and time of day affected these behaviors.

In the study, there was no sexual difference for courtship, kantel and copulation behavior of male and female ostriches. The monotonous booming sound is the start of mating in the male and helps to attract the attention of the females for courtship (Aravinth and Selvan, 2015a; Mukhtar *et al*., 2017). But, in the study, boom behavior was only observed in one male and no other mating behavior was observed before or after booming. Also, there was no difference in boom behavior throughout the day in both seasons.

During to breeding season breeder males show breeding dance “kantel” in order to attract females for reproduction (Aravinth and Selvan, 2015a; Fericean *et al*., 2022). Thus, in the study, kantel behavior was only observed in males during the summer season in the morning and at noon, but this difference was not statistically significant. Sambraus (1994) reported that mating activity in ostriches showed a diurnal pattern and seen during morning hours, and ostriches lay eggs mostly in the afternoon or early evening (Brassó *et al*., 2020). Thus, laying behavior tends to be observed in the afternoon during the summer season.

Aggressive Behaviors: Animal territorial behavior refers to techniques such as vocalization, posing, and physical aggression to protect their territory from attacks by members of the same species. There is little known about agonistic behaviors in captive ostriches (Deeming and Bubier, 1999). A more confident and aggressive bird will raise its head and neck, with its anterior torso tilted upwards and tail elevated, whereas a submissive bird will lower its head and tail (Bertram, 1992). The results of our study showed that there was no statistical difference in both seasons among male and female ostriches during the day.

Aggression towards the caretaker or other males was very common in ostriches during the breeding period. It was reported that ostriches display aggressive behavior while feeding and or collecting eggs during the breeding period, and even show aggression towards males in the neighboring paddock (Fericean *et al*., 2022). The results of our study showed higher displace behavior was observed in females during the summer season, also higher escape and displace behaviors were observed in the afternoon during the summer season. In contrast to our results Fericean *et al*. (2022) reported that aggressive behavior was higher in the morning than in the afternoon and night.

The ostriches pecking the air, feed and water troughs, feathers and fences are accepted as behavioral indicators of stress or boredom. Also, feather pecking is a behavioral disorder in ostriches, it is reported that they did this behavior due to lack of nutrients (Stewart 1994, Huchzermeyer, 1997; Lambrechts *et al*., 1998). Fericean *et al*. (2022) reported that pecking behavior was lower in family (trio) type breeding system but was higher in colony breeding system. However, in our study there was no aggressive feather pecking or stereotypic behaviors were observed. This might be because of the family (trios and pairs) rearing system was applied in the study, also birds were feed with standard commercial ostrich ration.

In our study there was no lithophaga and coprophagia behavior was observed. However, Ahmed and Salih (2012) reported that the lowest frequency of lithophagia and coprophagia were found at noon. Ostriches can run in circles in a waltz-like motion, seemingly on tiptoe, with their wings raised and spread, Stewart (1994) claims that the dancing behavior can be seen in both wild ostriches and animals raised in

captivity. However, in our study there was no frequency of dancing (waltz) behavior was observed. In accordance to our study, Amado *et al*. (2011) reported that dancing was only observed in young ostrich chicks, but dust bathing was not observed in this group.

Conclusion: Understanding the emotions of animals through behavioral studies is essential to determine their stressful conditions and helpful in improving their welfare. In the study, it was determined that there were seasonal variations in drinking, foraging, sitting, sleeping, dust bathing, grooming, thermoregulation, spot pecking and copulation behaviors of ostriches. Female ostriches were showed more foraging, alertness and spot-pecking behavior than males, while they were showed less sitting and head shake behavior. During the summer season, ostriches showed less foraging, drinking and more sitting behavior may be a result of heat stress. On the other hand, they showed less comfort and reproduction behaviors which compromise their welfare significantly in a hot environment. Knowing the normal behaviors of ostriches helps producers better to understand their needs. Management practices such as providing suitable shaded areas, systems that provide cool water, and areas where they can easily demonstrate comfort behaviors during hot seasons, can contribute to the welfare of ostriches in a captive environment.

REFERENCES

Ahmed, F.A.M. and R.R.M. Salih (2012). Some behavioral traits of red neck ostrich under captive conditions. J. Vet. Sci. Technol. 3(2):117. https://doi.org/10.4172/2157-7579.1000117.

Akram, M. B., M. I. Khan, S. Khalid, M. Shoaib and S. Azeema (2019). Quality and sensory comparison of ostrich and goat meat. Int. J. Life Sci. 5(1):2168-2175. https://doi.org/10.21276/SSRIIJLS.2019.5.1.9.

Al-Khalifa, H. and A. Al-Naser (2014). Ostrich meat: production, quality parameters, and nutritional comparison to other types of meats. J. Appl. Poult. Res. 23(4): 784-790. https://doi.org/10.3382/japr.2014-00962.

Amado, M.F., D.B. Xavier, V. Boere, C. Torres-Pereira, C. McManus and F.E.M. Bernal (2011). Behaviour of captive ostrich chicks from 10 days to 5 months of age. Rev. Bras. Zootec. 40(7):1613-1618. https://doi.org/10.1590/S1516-35982011000700029.

Aravinth, A. and S.T. Selvan (2015a). Breeding behavioural pattern in ostrich a key for better management for its reproductive life. Indian J. Appl. Res. 5(12):289-291.

Aravinth, A. and S.T. Selvan (2015b). General behavioural pattern in ostrich a key for better management. Int. J. Sci. Res.4(11):672-674.

Ball, G.F. and E.D. Ketterson (2008). Sex differences in the response to environmental cues regulating seasonal reproduction in birds. Philos. Trans. R. Soc. Lond., B, Biol. Sci. 363:231–246. http://doi.org/10.1098/rstb.2007.2137.

Basuony, H.A.A.M. (2011). Effects of seasonal variations on thermoregulation of ostrich. Doctor of philosophy thesis, Al-Azhar University, Cairo, Egypt.

Bertram, B.C.R. (1992). The ostrich communal nesting system. Princeton University Press, Princeton, New Jersey.

Bolwig, N. (1973). Agonistic and sexual behaviour of the African ostrich (*Struthio camelus*). Condor. 75(1):100-105. https://doi.org/10.2307/1366538.

Brassó, L.D., B. Béri and I. Komlósi (2020). Studies on ostrich (*Struthio camelus*) – review. Acta agrar. Debr. 2020-1:15-22. https://doi.org/10.34101/actaagrar/1/3772.

Brassó, L.D., E. Török, I. Komlósi and J. Posta (2022). Factors affecting the survival of ostrich from hatching until the age of 48 weeks. J. Agric. 12:1591. https://doi.org/10.3390/agriculture12101591.

Brendsen, K.D. (1995). Behaviour. In: Krebich, A., Sommer, M. (Eds) Ostrich farm management, Landwirtschafttsverlag Gmbh, Münster-Hiltrup, Germany, pp.25-32.

Broom, D.M. and K.G. Johnson (2000). Stress and animal welfare. Chapman and Hall, London, 211p.

Cooper, R.G., J.O. Horbanzuk, R. Villegas-Vizcaino, S. Kennoui Sebai, A.E.F. Mohammed and K.M.A. Mahrose (2010). Wild ostrich (*Struthio camelus*) ecology and physiology. Trop. Anim. Health Prod. 42:363–373. https://doi.org/10.1007/s11250-009-9428-2.

Deeming, D.C. (1997). Effect of climatic conditions on the behaviour of adult ostriches (*Struthio camelus*) in Britain. Anim Welf. 6(4):349–356. https://doi.org/10.1017/S0962728600020054.

Deeming, D.C. (1998a). Effect of winter climatic conditions on the behaviour of adult ostriches (*Struthio camelus*) on a British farm. Anim. Welf. 7(3):307–315. https://doi.org/10.1017/S096272860002073X.

Deeming, D.C. (1998b). A note on effects of gender and time of day on the winter time-activity budget of adult ostriches (*Struthio camelus*) in a farming environment. Appl. Anim. Behav. Sci. 59(4):363-371. https://doi.org/10.1016/S0168-1591(98)00090-2.

Deeming, D.C. and N.E. Bubier (1999). Behaviour in natural and captive environments. In: Deeming, D.C. (Ed) The ostrich: biology, production and health. CABI Publishing, Wallingford, Oxon, UK, pp.83-104.

Deeming, D.C. and A. Ar (1999). Factors affecting the success of commercial incubation. In: Deeming, D.C. (Ed) The ostrich: biology, production and health. CABI Publishing, Wallingford, Oxon, UK, pp. 159-190.

Edmunds, M. (1974). Defense in animals: a survey of anti-predator defenses. Longman, New York, USA. 357 p.

Fericean, L.M. and O.A. Rada (2013). The behavior of ostriches in captivity, Res. J. Agric. Sci. 45(1):165-171.

Fericean, L.M., M. Ostan, O.A. Rada M. Ivan, S. Prunar, F. Prunar and I. Bănăţean-Dunea (2022). Observation on social behaviour of ostrich (*Struthio camelus*) in captivity. Sci. Papers Ser. D, Anim. Sci. LXV(2):473-478.

Horbanczuk, J.O. (2002). Egg production. In: The ostrich. Warsaw, pp. 77-82.

Horbanczuk, J.O. and J. Sales (1998). Lipid and cholesterol content and fatty acid composition of meat obtained from ostriches reared on a commercial farm. Anim. Sci. Pap. Rep. 16(1):51-55.

Huchzermeyer, F.W. (1997). Behaviour problems in farmed birds. The British Domesticated Ostrich Association, Ostrich News 6:17–21.

İpek, A. and Ü. Şahan (2006). Egg production and incubation results of ostrich farms in the Marmara region of Turkey. Arch. Geflugelkd. 70(2):69- 73.

Johnson, A.L. (2015). Chapter -28, Reproduction in the female. (Ed) Scanes, C.G., Sturkie's Avian Physiology (Sixth Edition), Academic Press, pp. 635–665. https://doi.org/10.1016/B978-0-12-407160-5.00028-2.

Kennou Sebei, S. and R. Bergaoui (2009). Ostriches' reproduction behaviour and mastery of natural incubation under farming conditions. Trop. Anim. Health Prod. 41:353–361. https://doi.org/10.1007/s11250-008-9196-4.

Kistner, C. (2019). Ostrich production today: the (eco)logical way to economic success. Lohmann Inform. 53(1):16-22.

Lambert, M.S., Deeming, D.C., Sibly, R.M. and L.L. Ayres (1995). The relationship between pecking behaviour and growth rate of ostrich (*Struthio camelus*) chicks in captivity. Appl. Anim. Behav. Sci. 46(1-2): 93-101. https://doi.org/10.1016/0168-1591(95)00640-0.

Lambrechts, H., F.W. Huchzermeyer and D. Swart (1998). Integrating ostrich behaviour in commercial farming systems. In: Huchzermeyer, F.W. (ed.) Ratites in a Competitive World. Proceedings of the 2nd International Ratite Congress, September 1998, Oudtshoorn, South Africa, pp. 167–169.

Maloney, S.K. (2008). Thermoregulation in ratites: A review. Aust. J. Exp. Agric. 48(10):1293-1301. https://doi.org/10.1071/EA08142.

McKeegan, D.E.F. and D.C. Deeming (1997). Effects of gender and group size on the time-activity budgets of adult breeding ostriches (*Struthio camelus*) in a farming environment. Appl. Anim. Behav. 51(1-2):159-177. https://doi.org/10.1016/S0168-1591(96)01096-9.

Mitlöhner F.M., J.L. Morrow-Tesch, S.C. Wilson, J.W. Dailey and J.J. McGlone (2001). Behavioral sampling techniques for feedlot cattle. J. Anim. Sci. 79(5):1189-1193. https://doi.org/10.2527/2001.7951189x.

Mukhtar, N., Gazala and M. Waseem Mirza (2017) Understanding of social and mating behaviour of ostrich (*Struthio camelus*). J. World's Poult. Res. 7(2):72-78.

Mutiga, M., P.K. Muoria, K. Kotut and H.W. Karuri (2016). Behavioural patterns and responses to human disturbances of wild somali ostriches (*Struthio molybdophanes*) in Samburu, Kenya. Int. J. Adv. Res. 4(8):495-502. http://dx.doi.org/10.21474/IJAR01/1239.

NRC (1971). A guide to environmental research on animals. Natl Acad Sci, Washington, DC.

Paleari, M.A., Camisasca, S., Beretta, G., Renon, P., Corsico, P., Bertolo, G. and G. Grivelli (1998). Ostrich meat: physico-chemical characteristics and comporison with turkey and bovine meat. Meat Sci. 48(3/4): 205-210. https://doi.org/10.1016/S0309-1740(97)00091-0.

Ross, E.J. and D.C. Deeming (1998). Feeding and vigilance behaviour of breeding ostriches (*Struthio camelus*) in a farming environment in Britain. Brit. Poult. Sci. 39(2):173-177. https://doi.org/10.1080/00071669889088.

Ruuskanen, S., B.Y. Hsu and A. Nord (2021). Endocrinology of thermoregulation in birds in a changing climate. Mol. Cell. Endocrinol. 519(1): 111088.https://doi.org/10.1016/j.mce.2020.111088.

Sambraus, H.H. (1994). Das sexualverhalten des Afrikanischen Staußes (*Struthio camelus*). The sexual behavior of the African ostrich (*Struthio camelus*). Tierärztliche Prax. 22(6):538–541.

Samson, J. (1996). Behavioral problems of farmed ostriches in Canada. Can. Vet. J. 37(7):412–414.

SAS (2019). A User's Guide to SAS V9.4.M6. SAS Institute, Inc., Cary, N.C., USA.

Sauer, E.G.F. and E.M. Sauer (1966). Social behaviour of the South African Ostrich (*Struthio camelus australis*). Ostrich. 37(1):183–191. https://doi.org/10.1080/00306525.1966.9639797

Sauer, E.G.F. and E.M. Sauer (1967). Yawning and other maintenance activities in the South African Ostrich. Auk. 84(4):571-587. https://doi.org/10.2307/4083337.

Stewart, J.S. (1994). Ostrich behaviour and behavioural problems. Proc. Ann. Conf. Avian Veterinarians, 28–30 September, Reno, Denver, USA, pp. 104–109.

Şahan, Ü., A. İpek and B. Yılmaz (2000). Devekuşlarında genel, sosyal ve cinsel davranışlar ve davranış problemleri. (General, social and reproductive behaviours and behavioural problems in ostriches). Tav. Araş. Derg. 2(2):48-54.

Vizcarra, J., R. Alan and J. Kirby (2015). Chapter-29, Reproduction in male birds. (Ed) Scanes, C.G., Sturkie's Avian Physiology (Sixth Edition), Academic Press, pp. 667–693. https://doi.org/10.1016/B978-0-12-407160-5.00029-4.