Effects of strain and sex on the behaviour of free-range slow-growing chickens raised in a hot environment

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Abstract

Behaviour is a good indicator of the well-being of chickens. The objective of the study was to compare foraging behaviour in males and females of three indigenous chicken strains under generally hot free-range conditions. Behavioural activities were monitored in 21-wk-old Potchefstroom Koekoek (PK), Ovambo (OV) and Naked Neck (NN) chickens. Birds were separated by sex and allocated to four pens of Chloris gayana. Three birds per pen were randomly chosen and marked with paint 20 min before observation. Temperature humidity index (THI) was calculated and main effects analysed using the general linear models procedure. Naked Necks spent more time walking than OV and PK. Strain did not affect other behaviours. Females spent more time foraging, while males dominated standing and walking. There was negative correlation between THI and time spent foraging. There was interaction between strain and sex on time spent standing. Foraging and drinking behaviours were more prominent in the morning (07:00 h) and late afternoon (17:00 h) compared to the 12:00-h period, whereas preening and dust-bathing were dominant around mid-day. Strain, sex and THI influence behaviour in free-range chickens. Breeding programmes should be cognizant of these attributes in order to produce hardier birds in view of worsening climatic uncertainties.

Introduction

Animal welfare activists campaign for the use of natural or near-natural environments for chickens. This has stimulated an increase in the popularity of free-range systems across the world. Free-range chickens have limited access to feed additives and artificial ingredients and are grown in an environmentally friendly manner (ERS 2002). Free-range or organic systems allow birds access to an outside area, promoting foraging, feed selection and activity, thus theoretically improving their welfare (Ponte et al. 2008). These outdoor production systems could decrease stress and allow the selection of strains that may increase comfort and bird welfare (Wang et al. 2009), particularly in the wake of production conditions that are only likely to worsen with predicted trends in climate change. Conventional systems limit the expression of normal behaviour and have become unpopular. Conventional cage systems for laying hens were banned in the European Union (EU) from January 2012 according to the EU Council Directive 1999/74/EC on the welfare of laying hens (CEC 1999). In the developed world, free-range and organic livestock production are well defined with products derived from such systems getting certified (ERS 2002). Free-range products are perceived to be safer and healthier and may carry several health benefits to consumers (Midmore et al. 2005).

Meteorologic elements constitute a major variable for outdoor operations (Sossidou et al. 2011), and the concern and emphasis for such elements in recent years are due to the fact that they are not constant, but change continuously (Ayo et al. 2011). Factors such as temperature (Kristensen et al. 2007) and humidity influence life cycles, reproductive ability, growth rates and thus body weights (BW) of birds. Direct meteorologic factors affecting birds include, especially, high ambient temperature and relative humidity, and may result in severe heat stress (Ayo et al. 2011). High humidity impacts thermoregulation and welfare of chickens (Lin et al. 2005), in that humid conditions reduce the effectiveness of heat dissipation (Warriss et al. 2005). This impairs normal body functions as efficiency is achieved if body temperature is kept constant or maintained within a narrow range (Ayo et al. 2011). The normal body temperature of an adult chicken is 40.6–41.7°C, while the thermo-neutral zone (TNZ) is 18–24°C (Fanatico et al. 2007).

Free-range systems make use of slow-growing strains which are more adapted to these production systems (Castellini et al. 2002; Gordon & Charles 2002). Utilization of the slow-growing indigenous strains enhances the sustainability of chicken production systems. Indigenous strains are preferred to exotic chickens, because of their pigmentation, taste, flavour and leanness (Moreda et al. 2013). Popular strains in Southern Africa include Naked Neck (NN), Ovambo (OV) and Potchefstroom Koekoek (PK) (Nthimo et al. 2004; Grobbelaar et al. 2010) which are dual-purpose strains. The NN and OV are closely
associated with rural livelihoods where they are used to meet the nutritional and economic needs of households (Mapiye et al. 2008). They are considered hardy and adaptable to harsh local climatic conditions, which are important attributes since predominant systems often entail exposing birds to adverse environmental conditions. Such exposure influences the behaviour of birds in various ways and behavioural responses are the most pertinent indicators of the well-being of an animal (Moura et al. 2006). In hot weather, birds thermoregulate behaviourally by exposing a larger body surface area to encourage heat loss and body temperature is elevated (Warriss et al. 2005). Thermal stimulation, among other factors, influences behaviours such as dust-bathing (Orsag et al. 2011).

The literature shows that there are strain differences in response to heat stress and that slower growing strains range more widely (Altan et al. 2003; Nielsen et al. 2003) compared to fast-growing birds. Even among slow-growing strains, thermoregulatory capabilities vary. It is thought that the thermoregulatory ability of NN chickens at high temperature is slightly better than that of normally feathered birds (Yahav et al. 1998). Naked Necks are a light-weight multicoloured strain with white, red and black feather combinations. They reach sexual maturity at 155 d of age, with males weighing about 2.0 kg and females 1.4 kg (Chikumba & Chimonyo 2014). The reduced feather cover in the NN strain may be of advantage to the least affected by heat stress, hence more time spent on feeding-related behaviours and consequently higher BW in comparison to other strains. It was rather difficult to predict the relative adaptabilities of the OV and PK strains due to darker plumage colour in one strain and higher BW in the other; thus, this study may allow to disentangle the respective importance of the two factors.

**Materials and methods**

**Animal ethics**

Bird management, care and use were compliant with internationally accepted standards for the welfare and ethics of research animals (Austin et al. 2004) and were specifically approved by the University of KwaZulu-Natal Animal Ethics Research Committee (Reference Number: 039/15/Animal).

**Study site description**

This study was conducted between January and March 2015 at Cedara College of Agriculture in Pietermaritzburg, South Africa (SA). Cedara is located in an upland Savanna zone on latitude 29.53°S and longitude 30.3°E at altitude 613.0 m. The study area has a varied yet verdant climate owing to its diverse and complex topographic characteristics. It is characterized by very warm summers and cold winters. The mean temperature and humidity recorded over the trial period were 25°C (range: 17–40°C) and 61%, respectively. Mean, minimum and maximum humidity recorded were 61%, 35% and 87%, respectively. Ambient humidity was highly variable, particularly in wk 1 (SD = 22.8). The weekly average, minimum and maximum temperature and humidity experienced over the trial period are given in supplementary Table S1. Temperature humidity index (THI) means ranged from 68 to 79.2. The overall mean THI value for the observation period was 73.2.

**Housing, feeding and health management prior to observation**

Day-old chicks of OV, NN and PK strains were obtained from the parent flock kept at the Agricultural Research Council (ARC), Irene, Pretoria, SA. At 1 d old, BW of chicks across the three strains ranged from 39.7 to 49.8 g. From d 1 to d 49 chicks of each strain were reared in 2 × 1.5 m pens in a closed well-ventilated poultry house which was 4 × 10 m. The house floors were...
covered with a 10-cm-thick layer of wood shavings. Heat and light were provided using 75 W infrared lamps. The day-old chicks were maintained at a temperature of 32°C which was gradually reduced to 21°C by 21 d old. A thermometer was kept in the house just above the level of the birds and was used to monitor changes in temperature. A foot bath drenched with a disinfectant (virukill®) was placed at the entrance to the brooding house.

A broiler starter diet was offered ad libitum from standard tube feeders. Potable tap water was offered ad libitum through 4 L plastic fonts. Chicks were vaccinated against Newcastle disease at 10 and 35 d of age. From d 50, birds were given a grower meal. Both feeds were supplied by Meadow feeds, SA. The nutritional composition of the feeds is shown in supplementary Table S2.

At 20 wk of age, selected birds were moved from the poultry house and assigned to four pens under free-range conditions. The pens, where Chloris gayana (Katambora Rhodes grass) was the dominant grass spp, were located side by side and separated by galvanized steel mesh fencing. During establishment, the pens were watered regularly and were rain-fed once established. Weeds and other invader grass spp were hand-picked and eliminated from the pens. Cattle manure was used to fertilize the pens. Wooden cages measuring 2.5 × 2.0 m were placed in one corner of each pen to provide shelter for the birds overnight and shade during the day. The cages, with slatted floors elevated 1.0 m above the ground surface, were fitted with wire mesh doors to deter predators. Doors were left open during the day and closed at night after all birds had voluntarily climbed into the cages. A standard plastic drinker was placed under shade near each cage to provide cool clean water. The drinkers were inspected, washed and replenished at least twice a day to ensure ad libitum access to clean water.

**Treatments and experimental design**

A total of 144, 20-wk-old PK, OV and NN chickens were used in this study. Birds were separated by sex and allocated to 4 free-range pens such that there were 12 males × 3 strains on each of 2 pens and 12 females × 3 strains on each of 2 separate pens. Strains were mixed to enable comparison of their responses under exactly the same management conditions. The pens, measuring 900 m² each (Figure 1), were demarcated by 2.2 m high wire mesh reinforced by wooden and steel poles. The birds were weighed individually on a digital crane scale, model UME CCS-150 K, S/N: NXC 100020, to determine initial BWs.

**Observations and data collection**

After placement onto the pens, the birds were allowed a 7-d adaptation period before commencement of data collection. For behavioural observations, three birds, one of each strain, in each of the four paddocks were randomly chosen and marked with paint on the tip of the tail 20 min before being let out of the cage at 07:00 h. Paint of a different colour was used each time such that the same bird was not observed more than once. Two trained observers recorded the activities of one bird each, simultaneously, in two pens purposively chosen to represent males and females for each observation session. As a result, two pens of males and females were observed simultaneously for 30 min as a result. Birds in the other two pens were observed immediately after. The observers switched from pens with males to females and vice versa.

Birds in each pen were observed three times a day, once a wk, for a total of 3 wk (Wk 1, 3 and 5) from 07:00 to 08:00 h; 12:00 to 13:00 h and 16:00 to 17:00 h. During behaviour observation, a distance long enough to avoid disrupting the expression of normal behaviour by the birds was maintained. The time spent on each of the following behaviours was recorded:

1. Drinking behaviour (standing over a drinker with the head towards the drinker)
2. Foraging (pecking on vegetation in the paddock or scratching the ground)
3. Preening (cleaning of feathers)
4. Dust-bathing (the act of moving around in dirt)
5. Hunting (chasing after insects)
6. Standing (remaining still in inactivity)
7. Other activities (e.g. lying down and crouching)

Other general behavioural activities such as panting were also noted. A stopwatch, model 870A Century clock-timer, was used to time and record specific time intervals devoted to a particular activity. A thermo hydrometer was used to record ambient temperature, in degree Celsius (°C), and relative humidity as a percentage. Ambient temperature and relative humidity values used were recorded on the same days that behaviour observations were made. As a result, meteorological data reported in the current study correspond to measurements made on the day of observation. The recorded ambient temperature and relative humidity (RH) values were used to estimate...
spent more time foraging than their male counterparts. In addition, birds spent the most time foraging at 07:00 h followed by 16:00 h (Figure 3). There was a significant negative correlation (t (100) = −2.7, P ≤ .01) between time spent foraging and THI. It was estimated that for a unit increase in THI, time spent foraging would decrease by 48 s. Strain did not influence time spent foraging (Table 2). Time of day had an effect (P ≤ .01) on time spent drinking water (Figure 3), while strain, sex, week and THI had no effect (P ≥ .05). Chickens spent more time drinking water in the morning than at mid-day and in the evening (Figures 3; Tables 1 and 2). No interactions were observed between THI and strain in this study.

**Time spent preening and dust-bathing**

Time of day and THI influenced time spent preening, while all other factors had no effect (Table 1). Birds across the three strains were observed preening more at mid-day (12:00 h) than at any other period. Generally, more time was spent preening in the first week relative to wk 3 and 5 (Figure 3). Similarly, the most time spent preening (102 s) coincides with the highest THI recorded. None of the factors studied influenced (Tables 1 and 2) time spent dust-bathing, although time of day approached significance (P = 0.0782). Similar patterns were observed among time spent standing, drinking water, preening and dust-bathing (Figure 4). The chickens dust-bathed mostly during the 12:00 h to mid-afternoon period.

**Time spent standing and walking**

Strain and time of day did not affect time spent standing (Tables 1, 2 and 3). Week, sex of bird and THI influenced (P ≤ .001) time spent standing by the birds. There was a significant positive correlation between THI (t (105) = 3.2, P = .0016) and time spent standing. For every unit increase in THI, time spent standing increased by approximately 39.6 s. The effect of week on time spent standing is shown in Figure 4. There was interaction (P ≤ .001) between strain and sex of bird on time spent standing (Table 3). Strain and sex of bird were the only factors that affected (P ≤ .05) time spent walking. Males of all strains spent more time walking than females, while the NN spent the most time walking relative to the other strains (Table 2).

**Other observations**

It was rather interesting to note that male OV and PK dominated in standing, while males of all three strains spent more time walking than females (Figure 3). A lot of time was also spent lying down in inactivity, particularly during the hottest times of the day. Four PK females and two NN males were attacked by a hawk; as a result six birds were lost over the observation period.

**Discussion**

Bird behaviour frequently switched among the major activity categories, namely foraging, drinking, preening, dust-bathing, standing, walking and lying down. Similar observations were
made in broilers (Merlet et al. 2005). The literature reports strain differences in response to free-ranging behaviour (Nielsen et al. 2003), heat stress (Altan et al. 2003) and BW (Nthimo et al. 2004) in chickens. In this study, we anticipated strain differences in foraging behaviour under heat stress conditions. Our expectation was that the NN would forage for longer than the other strains. The NN chickens possess better post-weaning heat tolerance than OV and PK due to the reduced plumage cover which is effective in minimizing heat stress where birds have to dissipate excess heat (Cahaner et al. 1993; Deeb & Cahaner 2001; Raju et al. 2004; Fathi et al. 2013). The NN carry an autosomal incompletely dominant gene (Na) which results in a 30% reduction in overall plumage cover for heterozygotes, which are associated with increased thermal tolerance (Raju et al. 2004; Rajkumar et al. 2010; Fathi et al. 2013). In the current study, one behaviour that perhaps demonstrates the marginal advantage of the NN, over other strains, is the more time spent walking by chickens in this group, perhaps suggesting greater adaptability. This presumably shows greater thermal tolerance, thus flexibility in terms of time spent on otherwise heat-intensive activities by the strain. OV chickens, which were the heaviest in the study, an observation consistent with earlier studies (Nthimo et al. 2004; Chikumba & Chimonyo 2014) but not Grobbelaar et al. (2010), are predominantly dark coloured. As such, it was anticipated that OV would be most affected by high THI. Strain differences observed in BW in this study are consistent with previous observations (Chikumba & Chimonyo 2014) where differences were recorded in 16-wk BW of OV and NN chickens. Similar BW observations were made by Nthimo et al. (2004).

Generally, females dominated most activities in terms of the time dedicated to a particular behaviour. They spent more time on most activities with the exception of standing and walking. Less time spent walking by females is probably an effort to reduce energy expenditure, particularly because birds were at point of lay. Time spent lying down in inactivity is perhaps yet another energy-conserving effort shown by birds. The fact that this coincided with high THI values shows that birds

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**Table 1.** Significance levels for fixed effects tested for statistical models used to estimate the effect of strain, sex, week, time of day and THI on time spent foraging, drinking water, preening, dust-bathing, walking and standing by free-range indigenous chickens.

| Effect         | F value | P value | F value | P value | F value | P value | F value | P value | F value | P value | F value | P value |
|----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Foraging       | 0.57    | NS      | 1.31    | NS      | 1.77    | NS      | 0.07    | NS      | 3.87    | *       | 0.19    | NS      |
| Drinking water | 6.50    | **      | 1.85    | NS      | 1.60    | NS      | 0.23    | NS      | 13.28   | ***     | 10.52   | **      |
| Preening       | 9.67    | ***     | 0.72    | NS      | 1.49    | NS      | 0.12    | NS      | 0.64    | NS      | 15.71   | ***     |
| Dust-bathing   | 5.57    | **      | 5.23    | **      | 8.00    | ***     | 2.48    | NS      | 1.37    | NS      | 2.27    | NS      |
| Walking        | 5.43    | **      | 2.76    | NS      | 4.20    | *       | 0.55    | NS      | 0.69    | NS      | 8.23    | ***     |
| Standing       | 1.08    | NS      | 0.81    | NS      | 1.14    | NS      | 0.71    | NS      | 1.54    | NS      | 11.69   | ***     |
| Strain × Sex   | 0.85    | NS      | 1.17    | NS      | 0.77    | NS      | 0.34    | NS      | 2.25    | NS      | 3.20    | NS      |
| Strain × THI   | 4.53    | NS      | 2.76    | NS      | 4.20    | *       | 0.55    | NS      | 0.69    | NS      | 8.23    | ***     |

Note: NS: not significant.
*P < .05.
**P < .01.
***P < .001.

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**Figure 2.** Effects of strain and sex of bird on final BWs of NN, OV and PK chickens.
refrain from feeding as a means of minimizing the heat burden. Feeding generates heat and, during hot times, would result in increased heat loads, therefore exposing birds to thermal stress. The observation on females spending more time foraging than males is not consistent with previous research (Nthimo et al. 2004). The females, which were at point of lay, probably had greater nutrient demands to meet egg production requirements. The males were expected to forage for a longer time to meet greater nutrient requirements; conversely, they have higher BW which might mean potential susceptibility to heat stress. Sexual dimorphism observed in the BW of NN and OV strains is in agreement with Nthimo et al. (2004) who noted differences in 26-wk BW of OV, PK and NN chickens.

Birds did not seem to forage much in the first week probably as a result of the dramatic change in conditions including the transition from indoor to an outdoor environment. The first week of observation had the highest average maximum temperature (35°C) and humidity (87%), hence a high THI. It was shown in this study that increases in THI lead to a reduction in time spent foraging. Time spent standing, however, increased with increasing THI. The time spent standing in the current study is higher than 20 ± 30.8 s reported by Spencer (2013). The discrepancy could be a reflection of the differences in strains and rearing conditions. Regression analyses showed that there was no relationship between THI and time spent on all other activities. The observation that birds foraged and drank water more in the cooler hours of the day agrees with previous reports (Dawkins et al. 2003; Horsted et al. 2007; Spencer 2013). Contrary to the same researchers, birds foraged much longer in the morning than other periods in our study. Dawkins et al. (2003) observed chickens to be most active right before sunset. Chickens forage more during the cooler hours of the day as they are less likely to struggle with thermoregulation. Higher temperatures that are commonly experienced around mid-day to early afternoon also depress appetite, thus compromising feed intake (Dawkins et al. 2003).

### Table 2. LsM for time spent on different activities by PK, OV and NN chickens.

| Effects     | n | Foraging     | Standing       | Drinking water | Preening | Dust-bathing | Walking |
|-------------|---|--------------|----------------|----------------|----------|--------------|---------|
| Strain      |   |              |                |                |          |              |         |
| NN          | 36 | 265.4 ± 28.00 | 136.9 ± 19.37  | 25.6 ± 8.88    | 74.4 ± 17.83 | 42.5 ± 21.77 | 77.1 ± 8.29 |
| OV          | 36 | 297.1 ± 28.91 | 140.8 ± 19.37  | 43.7 ± 10.27   | 41.6 ± 18.10 | 54.6 ± 26.06 | 46.1 ± 8.29 |
| PK          | 36 | 252.9 ± 28.91 | 152.9 ± 19.66  | 35.8 ± 10.27   | 88.0 ± 18.70 | 42.6 ± 29.17 | 69.6 ± 8.41 |
| P value     |   | .3314         | .8821          | .4083          | .1459     | .9241        | .0255   |
| Sex         |   |              |                |                |          |              |         |
| Male        | 36 | 230.4 ± 23.95 | 176.2 ± 15.81  | 28.3 ± 8.09    | 54.9 ± 14.71 | 53.8 ± 21.44 | 81.7 ± 6.77 |
| Female      | 36 | 313.3 ± 22.86 | 110.7 ± 15.97  | 41.8 ± 7.96    | 81.1 ± 15.03 | 39.3 ± 20.90 | 46.7 ± 6.83 |
| P value     |   | .0197         | .0052          | .1673          | .2096     | .5977        | .0004   |
| Week        |   |              |                |                |          |              |         |
| 1           | 36 | 187.8 ± 29.98 | 207.0 ± 19.66  | 48.7 ± 12.38   | 101.3 ± 19.0 | 54.4 ± 38.14 | 69.9 ± 8.41 |
| 3           | 36 | 364.7 ± 28.00 | 67.7 ± 19.37   | 20.6 ± 8.75    | 45.5 ± 17.83 | 36.1 ± 21.05 | 65.8 ± 8.29 |
| 5           | 36 | 263.0 ± 28.00 | 155.8 ± 19.37  | 35.8 ± 8.75    | 57.2 ± 17.83 | 49.2 ± 21.05 | 57.0 ± 8.29 |
| P value     |   | .0002         | .0001          | .1642          | .0866     | .8725        | .5369   |

*Number of observations.

**Naked Neck.**

**Ovambo.**

**Potchefstroom Koeokek.**

### Figure 3. Time spent foraging, drinking water and preening at different observation periods by NN, OV and PK chickens.

### Figure 4. Time spent on various activities by NN, OV and PK chickens by week (Wk) of observation.

### Table 3. LsM on the interaction effects of strain and sex of bird on time spent standing by birds.

| Sex       | Strain, time (s)          | Naked Neck | Ovambo | Potchefstroom Koeokek |
|-----------|---------------------------|------------|--------|-----------------------|
| Male      | 100.6 ± 24.84<sup>a</sup> | 212.1 ± 24.84<sup>a</sup> | 215.9 ± 24.84<sup>a</sup> |
| P value   | .0001                     | <.0001      | <.0001 |
| Female    | 173.2 ± 24.84<sup>b</sup> | 69.4 ± 24.84<sup>b</sup>  | 87.6 ± 23.59<sup>b</sup> |
| P value   | <.0001                     | .0063       | .0009  |

<sup>a</sup> Values in the same row with different superscripts differ significantly (P < .05).
The THI range of 68–79.2 shows that, at some point, birds were exposed to some degree of heat stress. At THI values of 72–79, mild heat stress occurs, while THI values of 80–89 indicate heat stress (Pennington & Van Devender 2004). The current findings suggest that foraging, hence dry matter intake (DMI), is perhaps more important in influencing drinking behaviour than other factors since invariably more time was spent drinking water during periods when birds foraged more actively. The literature shows that chickens go off-feed if water intake is restricted (Chikumba & Chimnyo 2014) perhaps agreeing with our view, although the direct effect of DMI on drinking behaviour should be tested. Feed consumption in NN chickens given ad libitum water access was 52% and 8% higher than that of birds given water at 40% and 70% of ad libitum, respectively (Chikumba & Chimnyo 2014). The mean time spent drinking water is similar to that reported by Murphy and Preston (1988). The strains used in the two studies differ, perhaps suggesting that the important factor driving drinking behaviour is DMI. The weight loss experienced by the birds in this study is probably a consequence of the change in rearing conditions. The same might have been worsened by the high THI which discouraged foraging. Literature reports reduced feed intakes at high temperatures so as to preserve body water by reducing faecal water loss and body heat increment (Mashaly et al. 2004; Chikumba & Chimnyo 2014). Reduced feed intake by birds is an adaptive strategy to survive under hot environmental conditions. Reduced BW was recorded in broilers exposed to high temperatures and humidity, perhaps indicating depressed feed intake (Lin et al. 2005).

Spending the most time preening during the 12:00 h period perhaps indicates more than just a simple trade-off between preening and foraging by birds. It is during the hottest period that birds clean their feathers and ward external parasites (Clayton et al. 2010). A previous study noted that the preferred time of dust-bathing, a similar behaviour driven by thermal stimulation, is the middle of the day (Wichman & Keeling 2009; Orsag et al. 2011). Our observation on dust-bathing contradicts the report by Murphy and Preston (1988) where absence of dust-bathing was noted in broilers. Preening and dust-bathing are important parts of normal bird behaviour (Orsag et al. 2011). These behaviours help to remove stale oil from feathers and are particularly important in free-range chickens which are often exposed to various edaphic and biotic factors, hence parasite infestation. The maximum environmental temperature recorded in the current study was much higher than 18–24°C, which is the TNZ for chickens (Fanatico et al. 2007). At ambient temperatures within the TNZ, chickens are able to maintain their body temperature. Any increase in temperature above this zone initiates heat dissipation mechanisms. At high THI values, heat production decreases while heat dissipation increases (Lin et al. 2005). High THI values experienced in the current study discouraged foraging due to increased heat load (Lin et al. 2005). The high THI positively influenced standing and preening behaviours as birds normally thermoregulate by behavioural changes. High ambient humidity exacerbates the effects of high temperatures by reducing the effectiveness of panting to induce evaporative cooling from the respiratory tract (Warriss et al. 2005). This largely agrees with behavioural trends observed in this study.

It can be concluded that strain and sex influenced the foraging behaviour, and NN chickens and females, in general, spent more time foraging. Sex of bird influenced walking and standing behaviours. There was a negative correlation between THI and time spent foraging, while time spent standing and preening increased with increasing THI. Foraging and drinking behaviours were more prominent in cooler hours of day (morning), while preening and dust-bathing occurred mostly when THI was high (mid-day to afternoon). Ambient temperature and relative humidity are important factors influencing free-ranging behaviour and hence overall performance of slow-growing chickens. Breeding programmes should be cognizant of these attributes in order to produce hardier birds in view of the worsening climatic uncertainties.

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Disclosure statement

No potential conflict of interest was reported by the authors.

References

Altan O, Pabuçcuoğlu A, Awtan A, Konyalioğlu S, Bayraktar H. 2003. Effect of heat stress on oxidative stress, lipid peroxidation and some stress parameters in broilers. Bri Poult Sci. 44:545–550.

Austin JC, du Toit DN, Fraser PL, Mansfield D, Macleod A, Odendaal JSJ, Seier J. 2004. Guidelines on ethics for medical research: Use of animals in research and training. SAMRC. 1–53. Available from: http://www.kznhealth.gov.za/research/ethics3.pdf

Ayo JO, Obidi JA, Rekwot PI. 2011. Effects of heat stress on the well-being, fertility, and hatchability of chickens in the Northern Guinea Savannah zone of Nigeria: a review. ISRN Vet Sci. 2011:1–10.

Bertin A, Chanson M, Delaveau J, Mercerand F, Mostl E, Calandreau L, Arnould C, Letterric C, Collin A. 2013. Moderate heat challenge increased yolk steroid hormones and shaped offspring growth and behavior in chickens. PLoS ONE. 8:e5767.

Cahaner A, Deeb N, Gutman N. 1993. Effect of the plumage-reducing Naked-neck (Na) gene on the performance of fast growing broilers at normal and high ambient temperatures. Poult Sci. 72:767–775.

Castellini C, Mugnai C, Dal Bosco A. 2002. Meat quality of three chicken genotypes reared according to the organic system. Ital J Food Sci. 14:401–412.

CEC. 1999. Laying down minimum standards for protection of laying hens. OJEC. 203:53–57.

Chikumba N, Chimnyo M. 2014. Effects of water restriction on the growth performance, carcass characteristics and organ weights of naked neck and ovambo chickens of Southern Africa. Asian Australas J Anim Sci. 27:974–980.

Clayton DH, Koop JAH, Harbison CW, Moyer BR, Bush SE. 2010. How birds combat ectoparasites. Open Ornithol J. 3:41–71.

Dawkins M, Cook P, Whittingham M, Mansell K, Harper A. 2003. What makes free-range chickens range? In situ measurement of habitat preference. Anim Behav. 66:151–160.

Deeb N, Cahaner A. 2001. Genotype-by-environment interaction with broiler genotypes differing in growth rate 1. The effects of high ambient temperatures and naked neck genotype on lines differing in genetic background. Poult Sci. 80:695–702.
Eberhart DE, Washburn KW. 1993. Variation in body temperature response of naked neck and normally feathered chickens to heat stress. Poult Sci. 72:1385–1390.

[ERS] Economic Research Service, USDA. 2002. Recent growth patterns in the U.S. organic foods market. AIB-777. Washington (DC): US Government Printing Service.

Fanatico AC, Pillai PB, Emmert J, Owens CM. 2007. Meat quality of slow- and fast-growing chicken lines fed low-nutrient or standard diets and raised indoors or with outdoor access. Poult Sci. 86:2245–2255.

Fathi MM, Galal A, El-Safty S, Mahrous M. 2013. Naked neck and frizzle genes for improving chickens raised under high ambient temperature: growth performance and egg production. World Poultry Sci. J. 69:813–832.

Gordon SH, Charles DR. 2002. Niche and organic chicken products. Nottingham: Nottingham University Press.

Grobbelaar JAN, Sutherland B, Molalakgotla NM. 2010. Egg production potentials of four indigenous chicken breeds in South Africa. Anim Genet Resour. 46:25–32.

Horsted K, Hermansen J, Ranvig H. 2007. Crop content in nutrient-restricted versus non-restricted organic laying hens with access to different forage vegetations. Bri Poult Sci. 48:177–184.

Joubert JJ. 1996. The story of the indigenous domestic animals in South Africa. Agricultural Research Centre, Private Bag X2, Irene, 0062. South Africa (unpublished).

Kristensen HH, Prescott NB, Perry GC, Ladewig J, Erbsoll AK, Overad KC, Watthes CM. 2007. The behaviour of broiler chickens in different light sources and illuminances. Appl Anim Behav Sci. 103:75–89.

Lin H, Zhang HF, Du R, Gu XX, Zhang ZY, Busye J, Decuyper E. 2005. Thermoregulation responses of broiler chickens to humidity at different ambient temperatures at four weeks of age. Poult Sci. 84:1173–1178.

Mapije C, Mwale M, Mupangwa JF, Chimonyo M, Fotti R, Mutenje MJ. 2008. A research review of village chicken production constraints and opportunities in Zimbabwe. Asian-Aust J Anim Sci. 21:1680–1688.

Mashaly MM, Hendricks GL, Kalama MA, Gehad AE, Abbas AO, Patterson PH. 2004. Effect of heat stress on production parameters and immune responses of commercial laying hens. Poult Sci. 83:889–894.

Merlet F, Puterflam J, Faure JM, Hocking PM, Magnusson MS, Picard M. 2005. Detection and comparison of time patterns of behaviours of two broiler breeder genotypes fed ad libitum and two levels of feed restriction. Appl Anim Behav Sci. 94:255–271.

Midmore P, Naspetti S, Sherwood AM, Daniela V, Wier M, Zanoli R. 2005. Consumer attitudes to quality and safety of organic and low input foods: A review. Quality low input food [online]; [cited 2015 Jun 20]. Available from: http://t0.unracted.org/trade_env/tlf-organic/meetings/misc/QLIF_Review_Reanalysis200509.pdf

Moreda E, Hareppal S, Johansson A, Sisaye T, Sahile Z. 2013. Characteristics of indigenous chicken production system in South West and South part of Ethiopia. Bri Poult Sci. 2(3):25–32.

Moura DJ, Nääs IA, Pereira DF, Silva RBTR, Camargo GA. 2006. Animal welfare concepts and strategy for poultry production: A review. Braz J Poult Sci. 8:137–148.

Murphy LB, Preston AP. 1988. Time-budgeting in meat chickens grown commercially. Bri Poult Sci. 29:571–580.

Nielsen BL, Thomsen MG, Sørensen P, Young JF. 2003. Feed and strain effects on the use of outdoor areas by broilers. Bri Poult Sci. 44:161–169.

Nthimo AM, Nesper FWC, du Toit JEJ, Fair MD, Odenya W. 2004. Phenotypic characterization of indigenous chickens in Lesotho in the pre-laying phase. S Afr J Anim Sci. 34 (supplement 2):125–127.

Orság J, Brouček J, Mačúrová L, Knížatová M, Flak P, Hanus A. 2011. Behaviour of hens deprived of dust-bathing. Slovak J Anim Sci. 44:65–71.

Pennington JA, Van Devender K. 2004. Heat stress in dairy cattle. Fayetteville: UACES Publications.

Ponte PIP, Rosado CMC, Crespo JP, Crespo DG, Mourão JL, Chaveiro-Soares MA, Brás JLA, Mendes I, Gama LT, Prates JAM, et al. 2008. Pasture intake improves the performance and meat sensory attributes of free-range broilers. Poult Sci. 87:71–79.

Rajkumar U, Reddy BLN, Rajaravindra KS, Niranjhan M, Bhattacharya TK, Chatterjee RN, Panda AK, Reddy MR, Sharma RP. 2010. Effect of naked neck gene on immune competence, serum biochemical and carcass traits in chickens under a tropical climate. Asian-Aust J Anim Sci. 23:867–872.

Raju MVLN, Shyam Sunder G, Chawak MM, Rama Rao SV, Sadagopan VR. 2004. Response of naked neck (nana) and normal (nana) broiler chickens to dietary energy levels in a subtropical climate. Bri Poult Sci. 45:186–193.

[SAS] Statistical Analysis System. 2010. SAS/ STAT user’s guide, Release 9.1. Cary (NC): SAS Institute.

Sossidou EN, Dal Bosco A, Elson HA, Fontes CMGA. 2011. Pasture-based systems for poultry production: implications and perspectives. World Poult Sci J. 67:47–58.

Spencer DVM. 1995. Heat abatement programmes for midwest dairies. Agr Pract. 14(5).

Spencer T. 2013. Pastured poultry nutrition and forages. National sustainable agriculture information service. NCAT. www.attra.ncat.org.

Wang KH, Shi SR, Dou TC, Sun HJ. 2009. Effect of a free-range raising system on growth performance, carcass yield, and meat quality of slow-growing chicken. Poult Sci. 88:2219–2223.

Warriss PD, Pagazaurntundua A, Brown SN. 2005. Relationship between maximum daily temperature and mortality of broiler chickens during transport and lairage. Bri Poult Sci. 46:647–651.

Wichman A, Keeling LJ. 2009. The influence of losing or gaining access to peat on the dust-bathing behaviour of laying hens. Anim Welfare. 18:149–157.

Yahav S, Lugher D, Cahaner A, Dotan M, Rusai M, Hurwitz S. 1998. Thermoregulation in naked neck chickens subjected to different ambient temperatures. Bri Poult Sci. 39:133–138.