



Effects of Water Restriction on the Growth Performance, Carcass Characteristics and Organ Weights of Naked Neck and Ovambo Chickens of Southern Africa

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ABSTRACT: In semi-arid areas of Southern Africa, dehydration can compromise the performance and welfare of local chickens, particularly during the growing period when confinement is curtailed and birds are left to scavenge for feed and water. The effect of water restriction on the growth performance was compared in Naked Neck (NNK) and Ovambo (OVB) chickens that are predominant in Southern Africa. A total of 54 eight-wk-old pullets each of NNK and OVB chickens with an initial average weight of 641 ± 10 g/bird were randomly assigned to three water intake treatments, each having six birds for 8 wk. The water restriction treatments were *ad libitum*, 70% of *ad libitum* and 40% of *ad libitum* intake. Nine experimental pens with a floor space of 3.3 m^2 per strain were used. The pens were housed in an open-sided house with cement floor deep littered with a 20 cm layer of untreated wood shavings. Feed was provided *ad libitum*. Average daily water intake (ADWI), BW at 16 weeks of age (FBW), ADG, ADFI, feed conversion ratio (FCR) and water to feed ratios (WFR) were determined. Ovambo chickens had superior ($p < 0.05$) FBW, ADG and ADWI than NNK chickens. Body weight of birds at 16 weeks of age, ADG, ADFI, ADWI, and WFR declined progressively ($p < 0.05$) with increasing severity of water restriction while FCR values increased ($p < 0.05$) as the severity of water restriction increased. Naked Neck chickens had better FCR at the 40% of *ad libitum* water intake level than Ovambo chickens. The dressing percentage per bird was higher in water restricted birds than those on *ad libitum* water consumption, irrespective of strain. Heart weight was significantly lower in birds on 40% of *ad libitum* water intake than those on *ad libitum* and 70% of *ad libitum* water intake, respectively. In conclusion, NNK chickens performed better than OVB chickens under conditions of water restriction and would be ideal to raise for meat and egg production in locations where water shortages are a major challenge. (**Key Words:** Chickens, Ovambo, Feed Intake, Growth Performance, Water Restriction, Semi-arid Areas)

INTRODUCTION

The Ovambo (OVB) and Naked Neck (NNK) chickens are closely associated with rural livelihoods in Southern Africa where they are used to meet nutritional (meat and eggs) and economic needs of households (Mapiye et al., 2008). The chickens also have social, cultural and symbolic roles that transcend their practical use as food or commodities. Birds are often given away as gifts, sacrificed to ancestors and divinities, or consumed as part of ritual and

secular celebrations, thereby strengthening important social bonds (Aklilu et al., 2007).

Ovambo chickens are a small but aggressive, dual-purpose, agile dark coloured breed, thought to have originated from the northern part of Namibia and Ovamboland (van Marle-Koster and Nel, 2000). Sexual maturity is attained at 143 d with males weighing about 2.16 kg and females 1.54 kg. The NNK chickens are a widely distributed, multi-coloured, relatively light-weight breed kept for meat and eggs for home consumption. Naked Neck chickens reach sexual maturity at 155 d of age, with males weighing about 1.95 kg and females 1.4 kg. Naked Neck chickens possess better post weaning (>12 weeks of age) heat tolerance than OVB chickens due to the presence

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of a major gene that causes reduced plumage cover (Cahaner et al., 1993). Reduced plumage is effective when temperatures are high and birds have to dissipate excess heat (Deeb and Cahaner, 2001). Adaptation of NNK chickens to water restriction has, however, not been established. Haematological and serum biochemical responses of these strains to water restriction have been reported earlier (Chikumba et al., 2013).

Approximately 80% indigenous chicken producers in Southern Africa live in fragile and marginal environments where there is lack of adequate potable water for both human and livestock consumption (Swatson, 2003). The situation is worsened in the hot dry periods of the year when availability of water and succulent scavenging resources is low. In addition, Mwale and Masika (2009) showed that about 60% of indigenous chicken producers in rural areas do not offer water to recently weaned free-ranging chickens, trusting their ability to scavenge for water. The chickens usually subsist on unpalatable, detergent tainted waste-water from bathrooms and kitchens. It is crucial to evaluate the effect of restricted water intake during the growing period of local chickens as it is likely to reduce subsequent hen-day egg production and egg (Saengchan et al., 2008). Understanding the effects of restricted water intake on the growth performance of chicken strains kept by smallholder poultry producers is not only crucial in elucidating the mechanisms of adaptation to water stress but in identifying drought-tolerant strains for use in the future and enhancement of food security in drought prone areas.

The objective of the study was, therefore, to compare the effects of water restriction on BW gains, feed intake, feed conversion ratio and water to feed ratios of NNK and OVB chickens. It was hypothesized that NNK chickens have a greater ability to withstand higher levels of water restriction than OVB chickens.

MATERIALS AND METHODS

Study site and ethical aspects of the study

The study was conducted between January and March 2012 at Cedara College of Agriculture, which is located in the upland savanna zone on latitude 29.53°S and longitude 30.27°E at altitude 613 m. The minimum, maximum and average temperature and relative humidity during the experimental weeks are summarized in Table 1. The average environmental temperature was 22.3°C and relative humidity was moderate at an average of 65.8%. Care and use of chicks were compliant with internationally accepted standards for welfare and ethics of research animals (Austin et al., 2004) and were specifically approved by the University of KwaZulu-Natal Animal Ethics Research

Table 1. Average minimum and maximum temperature and average relative humidity from 9 to 16 weeks of age of the trial

Week	Temperature (°C)			Relative humidity (%)
	Mean	Min.	Max.	
9	22.4	16.4	28.3	76.6
10	23.5	18.0	29.0	71.8
11	22.9	18.6	27.1	75.6
12	24.4	19.3	29.4	61.3
13	25.4	18.1	32.6	61.8
14	21.8	16.1	27.4	60.5
15	20.5	14.3	26.7	63.0
16	17.9	12.1	23.7	56.3

Committee (Reference number: 048/12/Animal).

Birds, treatments and management

A total of 250 day-old chicks each of Ovambo and Naked Neck strains, hatched from parent stock of a conserved population kept at the Agricultural Research Council, Irene, Pretoria, were used in the experiment.

From d 1 to d 49 chicks of each strain were reared in separate (2×1.5 m) pens in a closed well ventilated poultry house which was 2 m wide and 3 m long. Floors were covered with a 15 cm thick layer of wood shavings. Infrared lamps (75 watt) were used as a source of heat and light. Room temperature was gradually decreased from 32°C when the birds were 1 d old to 21°C when 21 d old by raising the infrared lamps and extending the surrounds of the pens. On account of cold weather, light was provided continuously from infrared lamps because it was necessary to heat the room. A proprietary broiler starter diet (Table 2) was offered *ad libitum* from tube feeders made of standard gutter materials. Potable tap water was offered *ad libitum* in 4 L plastic founts. Birds were vaccinated against Newcastle disease at 10 and 35 d of age. A foot bath drenched with virucidal chemical was placed at the entrance to the brooding house.

At d 49 of age, the birds were weighed, and 54 females of each strain with bodyweight of 641±10 g/bird were

Table 2. Chemical composition (label values) of commercial broiler starter and grower feeds used in the study¹

Composition	Starter	Grower
Crude protein (g/kg)	200.00	180.00
Metabolisable energy (MJ/g)	12.76	13.00
ME/CP ratio (MJ/g)	0.06	0.07
Fat (g/kg)	25.00	25.00
Fibre (g/kg)	50.00	60.00
Moisture (g/kg)	120.00	120.00
Calcium (g/kg)	12.00	12.00
Phosphorus (g/kg)	6.00	5.50
Lysine (g/kg)	12.00	10.00

¹ Supplied by Meadow Feeds, Pietermaritzburg, South Africa.

randomly selected and placed in nine experimental pens. The pens were 230 cm long, 143 cm wide and 120 cm high corresponding to three water restriction treatments replicated three times. Each replicate, represented by a pen, had six birds. The water restriction treatments were *ad libitum*, 70% and 40% of *ad libitum* intake. Birds were acclimated to the pen environment for 7 d prior to the experiment. During this period, all birds were allowed water *ad libitum* and a proprietary grower diet (Table 2) was gradually introduced. Thereafter, and depending on the restriction treatment, water was supplied in one instalment daily at 0900 h for 8 wk until the birds were 16 wk old. Water restricted birds were given 70% and 40% of the amount that the *ad libitum* group consumed the previous day. When water was offered, water restricted birds drank it all in less than 5 min. Water levels were chosen to represent optimum, moderate and severe water restriction, respectively, which the birds usually encounter under natural conditions (Mupeta et al., 2000). The experimental pens were housed in an open-sided house with cement floor, deep littered with wood shavings. The resulting stocking density was 3.5 birds/m². All the birds were fed on the same proprietary finisher pellets until they were 16 wk old. Feed was provided *ad libitum* and given from tube feeders made of standard gutter materials measuring 30 cm long×12 cm wide×9 cm deep. Wood shavings were changed on a weekly basis and water founts cleaned daily.

Data collection

Average daily water intake (ADWI) was determined as the difference between water supplied and water refused after 24 h. Daily water intake was corrected for evaporative loss, which was determined using two founts of similar design and capacity placed at random points within the experimental facility. Body weight changes were determined by measuring BW for each bird on a weekly basis starting from wk zero of the experiment. Data of weekly body weights were used to calculate ADG g/bird/d. Feed consumption was measured every wk to establish the ADFI g/bird/d. Feed conversion ratio (FCRg/g) was calculated as the amount of feed consumed per unit of live weight gain. Water to feed ratio (WFR mL/g) was calculated as the proportion of water to feed consumed daily during the experimental period. Mortality was recorded as and when it occurred. At the end of the trial 12 birds from each water restriction treatment i.e 4 birds from each replication, were randomly selected for evaluation of carcass characteristics and internal organ weights. The birds were slaughtered in the early morning (0800 h). After bleeding, the carcasses were scalded in water at temperatures ranging between 70°C and 90°C. Feathers were plucked manually. The carcasses were then eviscerated and weighed using a digital electronic scale

(Jadever JPS-1050, Micro Precision Calibration Inc, USA). The liver, lungs, heart, kidneys and the gizzard were also collected and weighed. The length of the gastro-intestinal tract from the gizzard was also measured using a flexible tape.

Statistical analysis

The data were analysed using a mixed model with repeated measurements in time (age) by the MIXED procedure of the SAS (2010). The covariance matrix was chosen using the Akaike information criterion to detect the effects of the main causes of variation (strain, water restriction level and age), as well as their interactions. The model used was:

$$Y_{ijkl} = \mu + B_i + T_j + A_k + (B \times T)_{ij} + (B \times A)_{ik} + (T \times A)_{jk} + (B \times T \times A)_{ijk} + \epsilon_{ijkl}$$

Where:

Y_{ijkl} = response variable (ADWI, ADFI, ADG, FCR, WFR, carcass characteristics and organ weights)

μ = overall mean

B_i = effect of the *i*th strain, with *i* = NNK and OVB;

T_j = effect of *j*th water restriction level, with *j* = *ad libitum*, 70% and 40% of *ad libitum*;

A_k = age with *k* = 9, 10 ... 16 weeks;

$(B \times T)_{ij}$ = interaction of the *i*th strain and *j*th level of water restriction;

$(B \times A)_{ik}$ = interaction of *i*th strain and *k*th age of bird;

$(T \times A)_{jk}$ = interaction of *j*th treatment and *k*th age of bird;

$(B \times T \times A)_{ijk}$ = interaction of the *i*th strain, *j*th level of water restriction and *k*th age of bird; and

ϵ_{ijkl} = random error term assumed to be normally and independently distributed with mean 0 and variance equal to δ^2 .

Least square means were compared using the PDIF procedure of SAS (2010). Statistical significance was considered at the 5% level of probability.

RESULTS

No chick deaths were recorded during the entire experimental period among the different combinations of strains and water restriction levels.

Water intake

Strain had a significant effect on water intake such that OVB chickens with an ADWI of 113.6±6.08 mL/d drank more ($p < 0.05$) than NNK chickens with 91.1±6.08 mL/d. No significant interaction was observed between strain and water restriction level on this parameter (Table 3).

Table 3. Performance parameters of Naked Neck and Ovambo chickens raised with or without water restriction

Performance parameter (per bird basis)	Strain						SE ¹	Anova (p-value)		
	Naked neck			Ovambo				Strain	WRL ²	Strain ×WRL
	<i>Ad lib</i>	70% of <i>ad lib</i>	40% of <i>ad lib</i>	<i>Ad lib</i>	70% of <i>ad lib</i>	40% of <i>ad lib</i>				
Birds (n)	18	18	18	18	18	18				
Weight at 16 weeks (g)	1,595.8	1,334.4	1,037.3	1,278.6	1,528.1	1,824.4	45.39	0.001	0.001	0.86
Average daily gain (g/d)	17.3	12.5	7.7	20.6	15.1	11.6	0.77	0.002	0.001	0.69
Average daily feed intake (g/d)	82.1	63.9	39.3	81.7	77.6	70.3	4.30	0.06	0.008	0.29
Feed conversion ratio	4.7	5.2	5.1	4.0	5.2	6.2	0.59	0.09	0.001	0.30
Average daily water intake (mL/d)	129.9	91.2	52.0	162.5	113.5	64.9	10.5	0.02	0.001	0.66
Water:feed ratio (mL:g)	1.6	1.4	0.9	2.0	1.5	0.9	0.15	0.18	0.002	0.45

Means within a row followed by different superscript are significantly different ($p < 0.05$).

¹ SE = Standard error. ² WRL = Water restriction level.

Body weight at 16 weeks of age

There were significant differences between strains in the weight of birds at 16 wk of age. Ovambo chickens with average live weight of $1,544 \pm 26.2$ g/bird were heavier ($p < 0.05$) than Naked Neck chickens with $1,323 \pm 26.2$ g/bird. Water restriction also affected the weight of birds at 16 wk of age. The BW of the birds at 16 wk of age declined proportionally as the magnitude of water restriction increased. Body weights were $1,710 \pm 32.1$, $1,431 \pm 32.1$ and $1,158 \pm 32.1$ g/bird, for birds on *ad libitum*, 70% and 40% of *ad libitum* water intake, respectively. Although, no interaction between strain and water restriction level was observed, body weights of NNK chickens on 70% and 40% of *ad libitum* water intake were 16.6% and 34.1% lower ($p < 0.05$) than that of those on *ad libitum* water intake, respectively. Similarly, the BW of OVB chickens on 70% and 40% of *ad libitum* water intake were 16.8% and 28.7% lower ($p < 0.05$) than those of birds on *ad libitum* water intake, respectively (Table 3).

Average daily gain

There was a significant effect of strain on ADG during the study period. The OVB chickens had higher ($p < 0.05$) ADG (15.8 ± 0.45 g/bird/d) than NNK chickens (12.5 ± 0.45 g/bird/d). The ADG was also influenced ($p < 0.05$) by water restriction level such that birds on 40% of *ad libitum* water intake had the lowest ($p < 0.05$) gains (9.6 ± 0.55 g/bird/d) followed ($p < 0.05$) by those that received 70% of *ad libitum* (13.8 ± 0.55 g/bird/d) while those on *ad libitum* (19.0 ± 0.55 g/bird/d) water intake had the highest ($p < 0.05$) ADG. No significant interaction between strain and water restriction level was observed for ADG (Table 3).

Average daily feed intake

No significant effect of strain was observed on ADFI. Water restriction level, however, affected ADFI. Birds subjected to *ad libitum* water intake had the highest ($p < 0.05$) ADFI (81.9 ± 3.04 g/bird/d), followed by those on 70% of *ad libitum* (70.7 ± 3.04 g/bird/d) and 40% of *ad libitum*

(65.9 ± 3.04 g/bird/d) water intake, which were not significantly different ($p > 0.05$). Even though no significant interaction was observed between strain and water restriction level on feed intake, feed consumption of NNK chickens on *ad libitum* water consumption was 52% and 8% higher than that of birds given water at 40% and 70% of *ad libitum*, respectively, while for OVB it was 23% and 8% higher, respectively (Table 3).

Feed conversion ratio

Water restriction level had a significant effect ($p < 0.05$) on the FCR. Birds on 40% of *ad libitum* water intake had the highest ($p < 0.05$) FCR of 7.2 ± 0.41 g/g, followed by those on 70% of *ad libitum* water intake with 5.2 ± 0.41 g/g, while those on *ad libitum* water intake with 4.4 ± 0.41 g/g had the lowest. Strain of chicken had no effect on FCR. Although the interaction between strain and water restriction level was not significant, NNK chickens subjected to 40% of *ad libitum* water intake had a lower FCR compared to OVB chickens (Table 3).

Water:feed ratio

Strain of chicken did not affect the average WFR, but there was a progressive decline due to water restriction. The highest ($p < 0.05$) WFR was observed in birds on *ad libitum* (1.8 ± 0.11 mL/g) water followed by those on 70% of *ad libitum* (1.5 ± 0.11 mL/g) while those on the 40% of *ad libitum* (0.9 ± 0.11 mL/g) water intake had the lowest. There was no interaction between strain and water restriction level on WFR (Table 3).

Carcass characteristics and organ weights

Strain of chicken had no effect on the weight of organs. However, there was a significant reduction in the dressed weight and liver, lung and heart weights due to water restriction. Birds on the 40% of *ad libitum* water intake had the lowest (824 ± 47.7 g/bird) dressed weights compared to those on 70% of *ad libitum* (991 ± 47.7 g/bird) and *ad libitum* water intake ($1,017 \pm 47.7$ g/bird), which were not

significantly different. Heart weight was significantly lower in birds on the 40% of *ad libitum* water intake (8 ± 0.4 g/bird) than those on the 70% of *ad libitum* (10 ± 0.4 g/bird) and *ad libitum* water intake (10 ± 0.4 g/bird), which were also similar. The highest liver weights were recorded in birds on *ad libitum* (35 ± 1.9 g/bird) followed by those on 70% of *ad libitum* (30 ± 1.9 g/bird) and 40% of *ad libitum* (27 ± 1.9 g/bird), in that order. A similar trend was observed for lung weight where birds on the 40% of *ad libitum* had the lowest (9 ± 0.8 g/bird) followed by 70% of *ad libitum* and *ad libitum* water intake each with 11 ± 0.8 g/bird. There was no significant interaction between strain and water restriction level for all the carcass and internal organ parameters measured (Table 4).

DISCUSSION

In the present study, the lower water intake of NNK chickens on *ad libitum* water intake could be a reflection of either lower water requirements, a greater dependence on metabolic water to maintain hydrational homeostasis or a higher capability of budgeting body water more economically than OVB chickens. Similar differences in efficiency of water utilization among chicken strains were reported by Ahmed and Alamer (2011), who reported that Saudi local chickens had lower water requirements than fast growing Hisex commercial layers.

At 40% water restriction, the decline in body weight reflected a superiority of NNK over OVB chickens in water expenditure and utilization, since water consumption of the former was lower than that of the latter. It could be postulated that NNK chickens were able to budget their water balance efficiently than OVB chickens. Strain differences in body weight loss were previously reported by Arad (1982) who noted significantly higher rates of weight

loss in commercial Leghorns compared to native chickens during water deprivation under hot conditions. The decline in body weight of birds fed at 70% of *ad libitum* was comparable with results of Abdelsamie and Yadiwilo (1981) who reported a drop of 18% in body weight in broilers maintained on a 25% water restriction under hot conditions.

The finding that there was a progressive decline in ADFI with increasing severity of water restriction concurs with previous studies that showed that birds reduce their feed intake as an important adaptive strategy to preserve body water by reducing faecal water loss together with reducing body heat increment (Pires et al., 2007; Viola et al., 2009). Our results, however, contradict findings of Ahmed and Alamer (2011), who reported no significant effect of water restriction on feed intake in local Saudi breed layers subjected to 40% water restriction. Kellerup et al. (1965) also noted no significant decrease in food consumption when water was restricted in broilers. The high feed intake observed by these authors during water deficiency could also be an important adaptive mechanism employed by these chickens to reduce the adverse impact of water scarcity.

The high FCR of OVB chickens subjected to water restriction compared to NNK chickens has important economic implications as the feed consumed reduced ADG significantly compared to birds that drank water *ad libitum*. The better FCR of NNK than OVB chickens under water restriction is consistent with findings of van Marle-Köster and Casey (2001), who found that the former had better FCR and higher growth rates than most indigenous chicken strains found in South Africa under extensive production conditions that characterise most communal areas where they are normally kept.

The WFR of OVB chickens on *ad libitum* intake were within the normal reference range of 2:1 (NRC, 1994),

Table 4. Carcass and internal organ weights of 16 week old female Naked Neck and Ovambo chickens raised with or without water restriction

Carcass and viscera parameter (per bird)	Strain						\pm SE ¹	Anova (p-value)		
	Naked neck			Ovambo				Strain	WRL ²	Strain \times WRL
	<i>Ad lib</i>	70% of <i>ad lib</i>	40% of <i>ad lib</i>	<i>Ad lib</i>	70% of <i>ad lib</i>	40% of <i>ad lib</i>				
Birds (n)	12	12	12	12	12	12				
Cold dressed mass (g)	1,050.1	994.0	827.3	965.9	940.8	886.4	67.48	0.66	0.10	0.49
Dressing percentage	65.2	74.6	76.9	53.8	63.6	68.8	5.50	0.05	0.06	0.94
Liver (g)	34.4	31.8	28.8	34.5	27.5	26.7	2.97	0.42	0.08	0.72
Lung (g)	9.3	11.7	9.0	11.4	10.3	9.3	1.22	0.79	0.34	0.32
Heart (g)	10.0	10.1	8.7	10.0	9.4	8.2	0.56	0.40	0.04	0.73
Kidney (g)	10.5	10.1	8.8	10.2	10.1	8.4	0.96	0.78	0.19	0.98
Gizzard (g)	41.7	40.1	33.3	39.8	35.8	33.7	3.26	0.50	0.11	0.74
GIT (cm)	127.8	127.9	129.5	121.0	120.9	132.0	6.19	0.49	0.51	0.64

Means within a row followed by different superscript are significantly different ($p < 0.05$).

¹ SE = Standard error. ² WRL = Water restriction level.

while those of NNK chickens were lower than the normal reference range. Naked Neck chickens appear to have lower water requirements than OVB chickens for the same amount of feed consumed. In agreement with the present study, Ahmed and Alamer (2011) determined that the WFR of Saudi local chicken was lower than those of a commercial layer strain. The observed WFR, however, contradicts with Miller et al. (1988). Birds are expected to voluntarily reduce their feed intake when the quantity of water is restricted in order to conserve body water. It is, however, worth noting that water consumption by birds is influenced by many factors, including, the age (Leeson and Summers, 2008), genotype (Ahmed and Alamer, 2011), sex (Ziaei et al., 2007), stocking density (Feddes et al., 2002), health and welfare (Manning et al., 2007), ambient temperature (Belay et al., 1993), quality of feed and behavioural patterns such as polydipsia (Proudman and Opel, 1981).

The significant effect of water restriction on dressing percentage could be attributed to differences in live-weight among the different water restriction levels. Saleh (1992) reported a strong relationship between body weight and carcass weight ($r = 0.98$) and between carcass weight and dressing percentage ($r = 0.33$). The high dressing percent of water restricted birds could also be attributed to the fact that water restriction elicited a stronger water saving response that led to attenuation of body water losses, resulting in higher dressing percentage compared to birds on *ad libitum* water intake. Similar observations were made in Saudi local chickens (Ahmed and Alamer, 2011). The low heart weight of birds fed water at 40% of *ad libitum* is consistent with results reported by Burh et al. (1998) in chicks submitted to food and water deprivation, according to which heart weight decreased with increasing water deprivation. In contrast, Viola et al. (2009) observed an increase in relative heart weight in broilers restricted of water for three weeks. The increase in heart weight was attributed to higher blood viscosity caused by water restriction.

CONCLUSIONS

It can be concluded that under thermoneutral conditions and up to 16 wk of age, Naked Neck chickens consume less water than Ovambo chickens, which could be a reflection of their lower water requirements, greater dependence on metabolic water or unusual capability to budget water more economically. The Ovambo had higher weight gain, feed intake and FCR at moderate levels of water restriction, but NNK performed better at the most severe water restriction level. The low water requirements coupled with high FCR of Naked Neck chickens at the most severe water restriction level makes them ideal to keep for meat production in locations where access to water is limited.

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