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*Full Length Research Paper*

# Characterization of poultry production and management systems in the communal areas of Namibia

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**A survey was conducted on 485 respondents from eight regions of Namibia to characterize their poultry production systems. The overall mean proportions of literacy level were, secondary (33.6%), illiterate (31.5%), primary (27.3%), unspecified (4.0%) and tertiary (2.9%). The estimated chicken population in the whole study area covering 347 510 km$^2$ was about 1.84 million and the estimated chicken density was 14.1 chickens/ km$^2$. Overall, 76.1% of the interviewed households owned chickens with an overall mean of 20 chickens/household. Overall, 20.4% of the chickens were young females, 23.8% adult females, 14.2% young males, 9.7% adult males and 31.9% chicks. Overall, an average of 11 eggs/hen/clutch were laid with 74.3% mean hatchability. These hatched chicks had an average of 56% survival after four weeks. Overall, 33.5% of the chickens were lost due to disease, 27.1% consumed within households, 21.8% killed by predators, 7.9% sold, 6.5% stolen, 2% due to starvation and 1.3% as a result of traumatic injuries. Overall, 60.2% of the sick chickens were treated with local medicinal herbs, 14.3% slaughtered, 3.7% treated by conventional veterinary medicine, whilst 9.5% were vaccinated and 6.2% were treated by local veterinarians. Overall, 53.3% of the households used no housing for chickens, 9.8% used wire mesh housing, 7.0% used corrugated metal sheet housing and 4.9% used thatched brick and mud housing. Overall, 77.7% of the chickens were fed on maize or millet grain, 38.1% on free range forages, 12.5% on household leftovers and 4.1% on commercial feed. In conclusion, based on the survey, chickens in these study areas were reared extensively on raw grains with most owners using traditional methods to treat sick birds and failing to house their flocks to result in high losses to diseases and predators. This study indicated that the education of Namibian communal farmers to improve poultry husbandry would reduce losses and possibly increase profitability of communal poultry enterprise.**

**Key words:** Poultry, literacy, hatchability, predators, feed, housing, disease, theft, Namibia.

## INTRODUCTION

Poultry production is vital to the livelihoods of many vulnerable rural folk in the developing world, especially in Asia and Africa (Melesse, 2014; Padhi, 2016). It is a source of wealth, food security and high quality protein through meat and eggs (Alem et al., 2014; Moreda et al., 2013; Petrus, 2011). Indigenous chickens (*Gallus domesticus*) are the predominant breed raised in the rural areas due to their high adaptability (Goraga et al., 2016; Petrus, 2011). However, the production of indigenous chickens is hamstrung by a number of challenges such as mortalities

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due to predation, regular outbreaks of diseases, notably, Newcastle disease, poor nutrition in terms of both quality and quantity of feed, poor or lack of marketing channels and low performance as a result of poor genetic potential (Melesse, 2014).

In spite of the aforementioned setbacks to the production of indigenous chickens, the same venture presents an opportunity for the provision of quality protein and a sources of income for rural communities. There is a growing demand for scavenging chicken products in urban areas (Melesse, 2014). Indigenous chicken production has been further spurred by recent developments in the identification and promotion of ethno-veterinary medicines, the development of locally constructed and appropriate housing structures, improved genetic selection and breeding among the scavenging chickens, organization among indigenous chicken producers to increase bargaining power and shortening of the marketing chain, among other interventions. Indigenous chickens are preferred over exotic meat breeds due to their higher proportion of lean meat which has a desirable taste and the low inputs required to raise the chickens (Desha et al., 2016; Moreda et al., 2013). It is estimated that village chicken production constitutes 78% of poultry production in sub-Saharan African countries (Tadelle, 2003).

In Namibia, indigenous chickens are raised by most households in the Northern Communal Areas (NCA) (Petrus, 2011). Their distribution range goes beyond that of most other livestock species (Petrus, 2011). Adult females of a high literacy level (primary and secondary education) own and care for the chickens in most village households in South Africa (Yusuf et al., 2014). The improvement of indigenous chicken production has been proposed as one of the ways of reducing rural poverty (Yusuf et al., 2014).

Village poultry production systems vary from the popular scavenging type to the small scale market orientated systems (Desha et al., 2016). Traditional poultry production systems are characterized by poor housing systems, inadequate health care, poor feed quality (Goraga et al., 2016; Moreda et al., 2013), low growth rates, reduced egg production and high mortality rates (Petrus, 2011). Chickens are raised on extensive management systems where they are exposed to extreme weather conditions, predators, thieves, diseases and unmanaged breeding (Goraga et al., 2016; Olwande et al., 2010). Most village chickens roam free and scavenge for food (Gondwe and Wollny, 2007; Melesse, 2014), but supplementary feeds based on cereal grains such as maize and sorghum are often sprinkled on the ground for the chickens to eat. The performance of indigenous chickens can be improved by improving poultry husbandry practices such as housing, feeding, and breeding (Petrus, 2011). Indigenous chicken flock sizes vary. Studies in Malawi (Gondwe and Wollny, 2007) and South Africa (Yusuf et al., 2014) have reported mean flock sizes of 12.9 (1-61) and 29.98 chickens per household, respectively. The major causes of flock losses were identified as disease, predation and theft (Negari et al., 2015; Assefa et al, 2016; ).

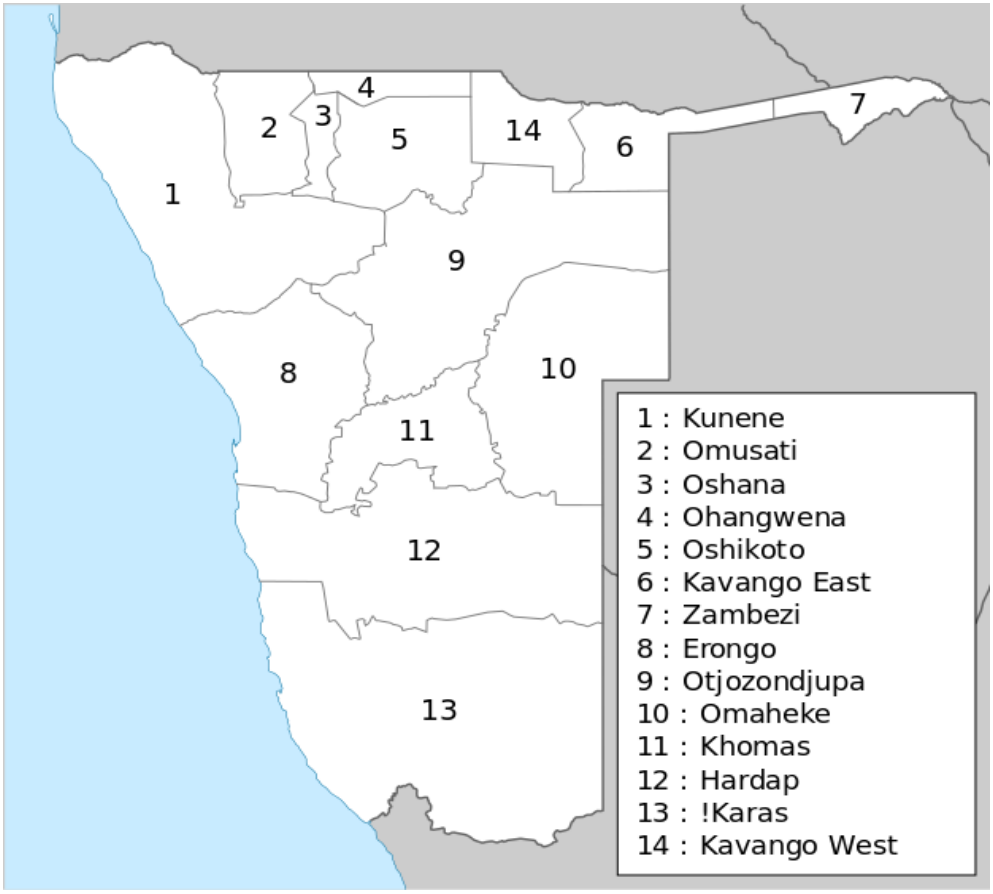
Diseases, notably Newcastle disease, infectious coryza, fowl pox, internal and external parasites have been reported as the major constraints to the production of indigenous chickens in developing countries in the tropics (Goraga et al., 2016). In one study in Namibia, mortalities of up to 42.2% in indigenous birds of eight weeks of age were reported (Petrus, 2011). Other studies in Africa have reported chicken mortalities of 33.6% (Goraga et al., 2016) and 60% (Tadelle, 1996). Other causes of mortality that have been reported include predation, separation of chicks from the hen, trauma and overcrowding (Petrus, 2011).

There is only one study that has been carried out to characterize indigenous chicken production systems in Namibia (Petrus, 2011). Even this study did not dwell to great lengths on the challenges that indigenous chicken farmers face and how indigenous knowledge systems were employed to deal with these challenges. Indigenous knowledge systems associated with indigenous chicken production systems have not been characterized and used and hence there is no basis for improving these systems. In Kenya, 80% of indigenous chicken farmers use indigenous knowledge systems for taking care of their birds' health (Mutombo et al., 2015). This study was carried out to characterize indigenous chicken farmers, their production and management systems and to identify constraints inherent in these systems. To this end, this study aimed to identify priority areas for improving poultry production and for implementing extension services.

## MATERIALS AND METHODS

A survey was conducted on 485 households distributed across seven of the 8 regions in the Northern Communal Area (NCA) of Namibia and one of the 6 regions in the southern regions of Namibia. The eight regions under study covered a total area of 347 510 $km^2$ with a total of 257 798 households and an estimated chicken population of almost 1.84 million. The overall objective of the survey was to characterize poultry production systems and constraints within the communal farming system in Namibia. The spatial distribution of the regions of Namibia (as from 2013) is shown in Figure 1 below. The figure shows the Zambezi region (7) (formerly known as the Caprivi region) and the Kavango region, which has been split into Kavango East (6) and Kavango West (14) regions. Structured questionnaires were used to characterize selected farmers, their poultry production systems and their management of these systems. Regional total number of households and regional total

**Fig. 1.** The regions of Namibia.




surface areas of the eight regions understudy was retrieved from the Namibia 2011 Population and Housing Census report (Namibia Statistics Agency, 2011).

The statistically valid sample size for the chickens were determined by using Poisson distribution and calculated as follows:

$P(x) = \frac{e^{-\lambda}\lambda^{x}}{x!}$ where x = 0, 1, 2....., λ is the mean flock size of 140 chickens for each household

These samples were calculated within 95% confidence interval, with accuracy bound of 5. The samples were also based on an expected range of chickens (0 to 80) per household (adapted from, Mendelssohn et al, 2006). Data was first recorded on tally sheets and then summarized in Microsoft Excel spreadsheets for determination of descriptive statistics. Pivot tables were used to detect salient associations between variables which were then statistically analyzed using cross tabulations in the Statistical Package for Social Sciences (SPSS version 16). The Z test was used for comparison of proportions whereby p values ≤ 0.05 were considered significant (Stangroom, 2017).

## RESULTS

### Land size and household populations

The total surface area of the eight regions under study was 347 510 km$^2$ with Kunene as the largest region and Oshana the smallest region. The total number of households in the eight regions was 257 798 (Namibia Statistics Agency, 2011). Omusati had the highest number of household whilst Caprivi had the lowest.

### Mean size of household and gender of head of household of respondents

Overall, the proportions of households headed by males (61.5±11.6) was significantly higher to those headed by females (38.5±11.6) (P<0.01). The proportion of households headed by females in Omusati, however, was significantly higher than those headed by males (P<0.05). Oshikoto region had the highest proportion of household headed by males though this was only significantly higher than those in Omusati (P<0.01) and

**Table 1.** Regional land size and number of households (HH) per region.

| Region | Total Area ($km^2$) | Total number of HH |
|---|---|---|
| Caprivi | 14 528 | 21 283 |
| Kavango | 48 463 | 36 741 |
| Kunene | 115 293 | 18 495 |
| Ohangwena | 10 703 | 43 723 |
| Omaheke | 84 612 | 16 174 |
| Oshana | 8 653 | 37 284 |
| Omusati | 26 573 | 46 698 |
| Oshikoto | 38 685 | 37 400 |
| **Overall** | **347 510** | **257 798** |

**Table 2.** The male/female proportions as household heads and the mean size of households according to region.

| Region | Number of Female-headed households | Proportion of Female-headed household (%) | Number of Male-headed households | Proportion of male-headed households (%) | Total number of Households | Mean size of household |
|---|---|---|---|---|---|---|
| Caprivi * | 29 | 35.4 | 53 | 64.6 | 82 | 5.7 |
| Kavango | 41 | 46.1 | 48 | 53.9[a] | 89 | 10 |
| Kunene | 23 | 34.3 | 44 | 65.7 | 67 | 10.9 |
| Ohangwena | 17 | 41.5 | 24 | 58.5 | 42 | 7.5 |
| Omaheke | 21 | 30.0 | 49 | 70.0[b] | 70 | 8.3 |
| Omusati | 33 | 56.9 | 25 | 43.1[ab] | 58 | 6.9 |
| Oshana | 21 | 35 | 39 | 65 | 60 | 6.9 |
| Oshikoto | 3 | 17.6 | 14 | 82.4[a] | 17 | 8.7 |
| **Overall** | **188** | **38.5±11.6** | **296** | **61.5±11.6** | **485** | **8.1±1.7** |

*Renamed Zambezi region as from 2013. [a,b]Proportions sharing the same superscript are significantly different at P<0.05.

those in Kavango (P<0.05). According to the population census of 2011, the overall household size in the targeted 8 regions was 8.1±1.7. Kunene region had the highest mean household size (10.9) and Caprivi region had the lowest household size (5.7).

### Respondents' literacy levels

Overall, the greatest proportion of respondents (33.6%) had secondary level of education followed by the proportion of illiterate respondents (31.5%) and primary educated respondents (27.3%). Respondents with tertiary level education formed the lowest proportion (2.9%). The rest of the respondents (4.0%) did not specify their level of education. Respondents from Caprivi region had the highest proportion of secondary (54.8%) and tertiary level (7.1%) education. Respondents from Caprivi also had the lowest proportion of illiteracy (14.3%). Respondents from Ohangwena and Oshikoto had lowest proportion of secondary level education (23.8% and 23.5%, respectively) and no tertiary level education. Respondents from Oshikoto had the highest proportion of illiteracy (58.8%).

### Proportions of households owning chickens, chicken density and chickens/household according to region

The estimated total population of chickens for the eight regions under study was 1 835 760. The highest proportion of chickens was in Oshikoto (33.7%) which, however, had the third highest chicken density (16 chickens/$km^2$) after Oshana (48 chickens/$km^2$) and Caprivi (18 chickens/$km^2$). Kunene and Omaheke, the smallest regions studied, had the lowest proportions of chickens (4.7% and 4.6%, respectively) and the lowest chicken density (0.7 and 1.0 chickens/$km^2$, respectively). The average density of chickens in the eight regions was 14.1±15.6 chickens per $km^2$. The overall proportion of

**Table 3.** Proportional (%) literacy levels of respondents by region.

| Region | Illiterate | Primary | Secondary | Tertiary | Unspecified |
|---|---|---|---|---|---|
| Caprivi | 14.3 | 15.5 | 54.8 | 7.1 | 8.3 |
| Kavango | 20.2 | 34.8 | 38.2 | 3.4 | 3.4 |
| Kunene | 49.3 | 16.4 | 18.0 | 4.5 | 6.0 |
| Ohangwena | 35.7 | 40.5 | 23.8 | 0.0 | 0.0 |
| Omaheke | 24.3 | 34.3 | 34.3 | 1.4 | 5.7 |
| Omusati | 31.0 | 32.8 | 31.0 | 5.2 | 0.0 |
| Oshana | 18.3 | 26.7 | 45.0 | 1.7 | 8.3 |
| Oshikoto | 58.8 | 17.6 | 23.5 | 0.0 | 0.0 |
| **Overall** | **31.5** | **27.3** | **33.6** | **2.9** | **4.0** |

**Table 4.** Chicken distribution according to household (HH) and region.

| Region | Estimated* chicken population | Estimated chickens/km$^2$ | % HH owning chicken | Chickens/region (%) | Chickens/HH** |
|---|---|---|---|---|---|
| Caprivi | 266 442 | 18.3 | 73.2 | 14.5 | 22 |
| Kavango | 196 384 | 4.1 | 61.8 | 10.7 | 19 |
| Kunene | 85 372 | 0.7 | 76.1 | 4.7 | 15 |
| Ohangwena | 155 958 | 14.6 | 81.0 | 8.5 | 17 |
| Omaheke | 84 945 | 1.0 | 67.1 | 4.6 | 15 |
| Omusati | 255 696 | 9.6 | 81.7 | 13.9 | 21 |
| Oshana | 422 172 | 48.8 | 96.6 | 23.0 | 27 |
| Oshikoto | 617 820 | 16.0 | 100.0 | 33.7 | 30 |
| **Overall** | **1 835 760** | **14.1±15.6** | **76.1±13.3** | **100.0** | **20** |

*Total chicken population was estimated through extrapolation of survey findings; **Values calculated from data obtained during survey that also included even households without chickens.

respondents' households owning chickens across the eight regions was 76.1±13.3 and Oshikoto had the highest proportion of ownership (100%) whilst Kavango had the lowest (61.8%). Statistical analysis showed that the proportion of households owning chickens in Kavango where significantly lower than those from all the other regions except for Kunene and Omaheke. The proportion of ownership in Oshikoto was significantly higher than those in each of the other regions except those in Ohangwena, Omusati and Oshana.

The overall mean number of chickens/household was 20. The average number of chickens/household in Oshikoto was significantly higher than the averages from each of the other regions ($P<0.05$). The average number of chickens/household in Omaheke was significantly lower than those from Caprivi and Kavango ($P<0.05$). There was no significant difference in the average number of chickens/household in the rest of the other regions.

**Proportional distribution of the chicken age categories according to region**

The overall distribution of chickens in the regions under study showed that the most abundant age group were the chicks (31.9%), followed by the adult females (23.8%), young females (20.4%), young males (14.2%) and the adult males (9.7%). Oshikoto had the highest proportion of young females (30.9%), Omusati had the highest proportion of adult females (30.8%), Oshana had the highest proportion of young males (20.0%) and Kunene

**Table 5.** The proportional distribution of the chicken age categories according to region.

| Region | % young females | % adult females | % young males | % adult males | % chicks |
|---|---|---|---|---|---|
| Caprivi | 16.2 | 26.8 | 16.5 | 11.5 | 29.0 |
| Kavango | 25.9 | 18.1 | 16.9 | 7.4 | 31.8 |
| Kunene | 15.2 | 22.0 | 12.7 | 16.4* | 33.7 |
| Ohangwena | 28.6 | 18.4 | 10.5 | 8.3 | 34.2 |
| Omaheke | 13.7 | 28.4 | 8.4 | 8.1 | 41.4* |
| Omusati | 17.8 | 30.8 | 10.3 | 11.0 | 30.1 |
| Oshana | 23.0 | 20.3 | 20.0* | 7.0 | 29.7 |
| Oshikoto | 30.9 | 21.3 | 14.2 | 6.9 | 26.8 |
| **Overall** | **20.4** | **23.8** | **14.2** | **9.7** | **31.9** |

**Table 6.** Reproductive capacity of chickens according to region.

| Region | Ratio of eggs/hen/clutch | Hatchability (%) | Chick survival up to 4 weeks (%) |
|---|---|---|---|
| Caprivi | 11.0 | 79.9 | 57.0 |
| Kavango | 13.0 | 76.8 | 55.3 |
| Kunene | 9.0 | 68.7 | 68.5 |
| Ohangwena | 11.0 | 63.3 | 42.4 |
| Omaheke | 12.0 | 78.5 | 55.8 |
| Omusati | 11.0 | 78.3 | 56.9 |
| Oshana | 11.0 | 70.5 | 46.1 |
| Oshikoto | 10.0 | 78.6 | 69.1 |
| **Overall** | **11.0** | **74.3** | **56.4** |

**Table 7.** Proportional (%) causes of off-take of chickens according to region.

| Region | Diseases | Theft | Predation | Starvation | Consumption | Sale | Trauma |
|---|---|---|---|---|---|---|---|
| Caprivi | 20.7 | 8.8 | 11.8 | 0.7 | 32.6 | 24.0 | 1.3 |
| Kavango | 28.6 | 10.4 | 33.0 | 0.6 | 20.4 | 5.6 | 1.5 |
| Kunene | 28.6 | 14.1 | 22.6 | 7.1 | 18.7 | 8.0 | 0.9 |
| Ohangwena | 38.3 | 1.2 | 26.1 | 0.7 | 27.6 | 4.5 | 1.5 |
| Omaheke | 38.9 | 10.8 | 16.0 | 6.2 | 15.1 | 13.0 | 0.0 |
| Omusati | 27.9 | 2.4 | 29.8 | 0.0 | 35.1 | 2.1 | 2.7 |
| Oshana | 38.5 | 4.1 | 17.3 | 1.0 | 34.2 | 2.5 | 2.4 |
| Oshikoto | 46.3 | 0.0 | 17.4 | 0.0 | 32.9 | 3.3 | 0.0 |
| **Overall** | **33.5** | **6.5** | **21.8** | **2.0** | **27.1** | **7.9** | **1.3** |

had the highest proportions of adult males (16.4%) and and Omaheke had the highest proportion of chicks (41.4%). Omaheke had the lowest proportions of young females (13.7%) and young males (8.4%), Kavango had

**Table 8.** Proportional (%) management of sick chickens according to region.

| Region | Consultation of Veterinarians | Conventional veterinary medicine | Local medicinal herbs | Slaughter | Vaccination |
|---|---|---|---|---|---|
| Caprivi | 9.0 | 7.7 | 34.6 | 38.4 | 10.3 |
| Kavango | 0.0 | 4.1 | 79.6 | 16.3 | 0.0 |
| Kunene | 10.5 | 12.3 | 22.8 | 21.1 | 33.4 |
| Ohangwena | 8.3 | 5.6 | 80.5 | 2.8 | 2.8 |
| Omaheke | 8.0 | 4.0 | 50.0 | 26.0 | 12.0 |
| Omusati | 4.6 | 15.2 | 65.1 | 4.6 | 10.6 |
| Oshana | 3.6 | 23.2 | 60.7 | 5.4 | 7.1 |
| Oshikoto | 5.9 | 5.9 | 88.2 | 0.0 | 0.0 |
| **Overall** | **6.2** | **9.7** | **60.2** | **14.3** | **9.5** |

**Table 9.** Proportional (%) household feeding management according to region.

| Region | Free range | Millet/maize | Left overs | Commercial feed |
|---|---|---|---|---|
| Caprivi | 61.0 | 54.2 | 22.0 | 11.9 |
| Kavango | 18.0 | 80.0 | 4.0 | 0.0 |
| Kunene | 28.6 | 69.4 | 46.9 | 14.3 |
| Ohangwena | 44.4 | 83.3 | 2.8 | 0.0 |
| Omaheke | 2.3 | 86.4 | 20.5 | 2.3 |
| Omusati | 51.8 | 66.1 | 0.0 | 0.0 |
| Oshana | 40.0 | 88.0 | 4.0 | 4.0 |
| Oshikoto | 58.8 | 94.1 | 0.0 | 0.0 |
| **Overall** | **38.1** | **77.7** | **12.5** | **4.1** |

the lowest proportion of adult females (18.4%), and Oshikoto had the lowest proportion of adult males (6.9%) and chicks (26.8%).

**Reproductive capacity of chickens according to region**

The overall mean number of eggs/hen/clutch was 11 and Kavango had the highest number of eggs/hen/clutch (13) whilst Kunene had the lowest (9). The overall mean hatchability of eggs was 74.3% and Caprivi had the highest hatchability (79.9%) whilst Ohangwena had the lowest (63.3%). The overall mean survival of chicks up to four weeks was 56.4% and Oshikoto had the highest level of chick survival (69.1%) whilst Ohangwena had the lowest (42.4%).

**Proportional causes of off-take of chickens according to region**

The overall mean proportions of chicken losses were diseases (33.5%), followed by consumption within the household (27.1%), predation (21.8%), sales (7.9%), theft (6.5%), starvation (2.0%) and trauma (1.3%). Oshikoto had the highest proportion of chickens dying from diseases (46.3%) and this proportion was significantly higher than those from each of the other regions ($P<0.05$). Caprivi had the lowest proportion of chickens dying from diseases (20.7%) and this proportion was significantly lower than those from each of the other regions ($P<0.05$). Kunene had the highest proportion of chicken thefts (14.1%) and this proportion was significantly higher than those from each of the other regions ($P<0.05$). Oshikoto had the lowest proportion of chicken thefts (0.0%) and this proportion was significantly lower than those from each of the other regions ($P<0.05$). Kavango had the highest proportion of chickens lost to predators (33.0%) and this proportion was significantly higher than those from each of the other regions ($P<0.05$). Caprivi had the lowest proportion of chickens lost to predators (11.8%) and this proportion was significantly lower than those from each of the other regions ($P<0.05$). Kunene region had the highest proportion of chickens dying from starvation (7.1%) and this proportion was significantly

higher than those of the other regions (P<0.05). Oshikoto (32.9%) and Omusati (had the lowest proportion of chickens dying of starvation (0.0%) and this proportion was significantly lower than those of the other regions (P<0.05). Omusati had the highest proportion of chicken consumption (35.1%) and this proportion was not significantly higher than those of Oshana (34.2%), Oshikoto (32.6%) and Caprivi but was significantly higher than those from the rest of the regions (P<0.05). Caprivi had the highest proportion of chicken sales (24.0%) and this proportion was significantly greater than those from the other regions (P<0.05). Omusati had the lowest proportion of chicken sales (2.1%) and this proportion was not significantly lower than those from Oshana (2.5%), Oshikoto (3.3%) and Ohangwena (4.5%) but was significantly lower than those from the rest of the regions (P<0.05%).

**Proportional management of sick chickens according to region**

Overall, the highest mean proportion of respondents used local medicinal herbs (60.2%) to manage sick chickens, followed by slaughter of sick chickens (14.3%), standard veterinary medicine (9.7%), vaccination (9.5%) and the veterinary service (6.2%). Kunene had the highest proportion of respondents using veterinary services to manage sick chickens (10.5%) though this proportion was not significantly higher than those from Caprivi (9.0%), Ohangwena (8.3%) and Omaheke (8.0%). These proportions, however were significantly higher than those of the rest of the regions (P<0.05). Kavango had the lowest proportion of respondents using veterinary service (0.0%) and this proportion was significantly lower than those from each of the other regions (P<0.05). Oshana had the highest proportion of respondents that used standard veterinary medicine in the management of sick chickens (23.2%) and this proportion was significantly higher than those from each of the other regions (P<0.05). Omaheke and Kavango had the lowest proportion of respondents using standard veterinary medicine in the treatment of sick chickens (4.0% and 4.1%, respectively) and these proportions were significantly lower than those from each of the other regions (P<0.05). Oshikoto had the highest proportion of respondents using local medicinal herbs for treatment of sick chickens (88.2%) and this proportion was significantly higher than those from each of the other regions (P<0.05). Kunene had the lowest proportion of respondents using local medicinal herbs for treatment of sick chickens (22.8%) and this proportion was significantly lower than those from each of the other regions (P<0.05). Caprivi had the highest proportion of respondents that slaughtered sick chickens (38.4%) and this proportion was significantly higher than those from each of the other regions (P<0.05). Oshikoto had the lowest proportion of respondents that slaughtered sick chickens (0.0%) and this proportion was significantly lower than those from each of the other regions (P<0.05). Kunene had the highest proportion of respondents that vaccinated sick chickens (33.4%) and this proportion was significantly higher than those from each of the other regions (P<0.05). Kavango and Oshikoto had the lowest proportion of respondents that vaccinated sick chickens (0.0%) and this proportion was significantly lower than those from each of the other regions (P<0.05).

**Proportional (%) household feeding management according to region**

Overall, the highest mean proportion of feed type used by the respondents from the eight regions under study was millet or maize (77.7%) followed by free range (38.1%), leftovers (12.5%) and commercial chicken feed (4.1%). Caprivi had the highest proportion of respondents using free range methods to rear their chickens (61.0%) and this proportion was not significantly higher than that from Oshikoto (58.8%) but was significantly higher than those from each of the other regions (P<0.05). Omaheke had the lowest proportion of respondents using free range methods to rear their chickens (2.3%) and this proportion was significantly lower than those from each of the other regions (P<0.05). Oshikoto had the highest proportion of respondents using maize or millet to feed their chickens (94.1%) and this proportion was significantly higher than those from each of the other regions (P<0.05). Caprivi had the lowest proportion of respondents using maize or millet to feed their chickens (54.2%) and this proportion was significantly lower than those from each of the other regions (P<0.05). Kunene had the highest proportion of respondents using leftovers to feed their chickens (46.9%) and this proportion was significantly higher than those from each of the other regions (P<0.05). Omusati and Oshikoto had the lowest proportion of respondents using leftovers to feed their chickens (0.0%) and this proportion was significantly lower than those from each of the other regions (P<0.05). Kunene had the highest proportion of respondents using commercial feed to rear their chickens (14.3%) and this proportion was significantly higher than those from each of the other regions (P<0.05). Omusati and Oshikoto had the lowest proportion of respondents using commercial feed to rear their chickens (0.0%) and this proportion was significantly lower than those from each of the other regions (P<0.05).

**Proportional of chicken housing by type according to region**

Overall the highest mean proportion of respondents built no housing for their chickens (53.3%) followed by those that used wire mesh chicken housing (9.8%), corrugated metal sheet housing (7.0%) and thatched brick and mud housing (4.9%). Oshikoto had the highest proportion of respondents using no built structures to house their

chickens (100.0%) and this proportion was significantly higher than those from each of the other regions (P<0.05). Omaheke had the lowest proportion of respondents using no built structures to house their chickens (7.1%) and this proportion was significantly lower than those from each of the other regions (P<0.05). Caprivi had the highest proportion respondents using thatched brick and mud housing for their chickens (15.9%) and this proportion was not significantly higher than that from Omaheke (14.3%) but was significantly higher than the those from each of the other regions (P<0.05). Ohangwena, Omusati, Oshana and Oshikoto had the lowest proportion of respondents using thatched brick and mud housing for chickens (0.0%) and these were significantly lower than those from Kavango, Kunene, Omaheke and Caprivi (P<0.05). Caprivi had the highest proportion of respondents using wire mesh housing (15.9%) and this proportion was significantly higher than those from each of the other regions (P<0.05). Kavango had the lowest proportion of respondents using wire mesh housing and this proportion was significantly lower than those from each of the other regions (P<0.05). Omaheke, Kunene and Oshana had the highest proportions of respondents using metal sheet housing for chickens (14.3%, 13.4% and 13.3%, respectively) and these proportions were significantly higher than those from the other regions. Oshikoto had the lowest proportion of respondents using metal sheet housing for chickens and this was significantly lower than those from each of the other regions (P<0.05).

## DISCUSSION

This cross-sectional study was carried out in seven of the 8 regions of the Northern Communal Areas (NCA) and one of the 6 regions located south of the Veterinary Cordon Fence of Namibia in 485 households. The results showed that more households were headed by males (61.5%) than females (38.5%). This finding is in agreement with other studies in Africa (Goraga et al., 2016; Mohammad and Hussein, 2017; Muhiye, 2007; Mwale and Masika, 2009; Tarekegn et al., 2015), but contrast the findings of other studies (Blackie, 2014; Mlambo et al., 2011; Muchadeyi et al., 2009) and even a study that was conducted in the same vicinity (Petrus, 2011). However, it is well known that females are responsible for taking care of village chickens, because they spend more time at home than males. Of the eight regions studied, Oshikoto region had the highest proportion of male headed households. This region had the greatest proportion of village chickens (33.7%); all households owned chickens and had the greatest number of chickens per household. These findings give an indication of the role of males in rural village economies. In the Omusati region, the proportion of female-headed households was significantly higher (p<0.05) than that for male-headed households. Each household had on average 7-10 members, which is higher than those reported elsewhere (Goraga et al., 2016; Moreda et al., 2013). The majority of respondents (67.8%) were literate, that is, they had primary, secondary or tertiary education. The level of literacy reported by this study is higher than the level of 64.9% reported in Ethiopia (Goraga et al., 2016). Kunene and Oshikoto regions had the lowest levels of literacy among the eight regions. Kunene is known to be the region with one of the lowest levels of literacy in Namibia.

Survey data was extrapolated to estimate the chicken population in the eight regions. It was estimated that a total of 1 835 760 chickens were kept in the regions studied. Although the majority of indigenous chickens occurred in the Oshikoto region (33.7%), chicken density in this region (16% chickens/ $km^2$) was lower than those for Oshana (48.8 chickens/$km^2$) and Caprivi (18.3 chickens/$km^2$) regions.

About 53.3% of the respondents had no designated structures for housing chickens. Therefore about 50% of the chickens and eggs in all the regions were at risk of predation by various predatory animals such as birds of prey, wild and domestic carnivores and were exposed to extreme weather elements. In Oshikoto region, most respondents did not have structures for housing chicken with only 5.9% having wire mesh housing structures. These findings indicate that the respondents' awareness regarding chicken housing was low. The proportion of farmers providing chickens with housing in this study was greater than the 35.8% reported in Botswana (Badubi et al., 2006). Wire mesh housing was common in all the regions, perhaps indicating the availability, affordability and security offered by wire mesh structures.

Each household kept an average of 20 (15-30) chickens. This figure is higher than the 2.9-5 chickens per household reported in Ethiopia (Moreda et al., 2013; Negari et al., 2015; Assefa, et al., 2016) but comparable to 16 and 18.8 birds per household reported in Kenya (Onono, et al., 2018) and parts of Ethiopia (Tarekegn et al., 2015). The flock size was, however, much smaller than the 450 birds reported in another study in the United Arab Emirates (Mohammad and Hussein, 2017).

An analysis of chickens surveyed revealed that about a third (31.9%) of the chickens were chicks and 23.8% were hens as has been reported in studies in Ethiopia and Zimbabwe (Moreda et al., 2013). Hens and chicks are essential for the production of replacement chickens and sustainability of the flocks. As expected cocks (9.7%) constituted the least proportion of village chickens. A cock to hen ratio of 1:5 was similar to the results of Blackie et al, (2010) but higher than a ratio of 1:2.58 reported from South Africa (Yusuf et al., 2014) and a ratio of 1:2 reported from Chad (Issa et al., 2013) and Ethiopia (Assefa et al., 2016). However, this ratio remains too high when compared to the recommended ratio of up to 1:10

in commercial exotic breeds (Yusuf et al., 2014) and predisposes cocks to fights and injuries. The high cock to hen ratio may be an indication of a lack of breeding knowledge among rural households. Therefore, the culling of extra cocks is recommended as they are an unnecessary burden on the already stretched feed resources.

Feeding management of the chickens was based on scavenging for feed/free range (38.1%) or household left overs (12.5%), scavenging and supplementation with millet/maize (77.7%) or on commercial feed (4.1%). In this study, there was an overlap of feeding systems. Caprivi and Oshikoto regions had the highest proportions of households using the free range scavenging system, whilst Omaheke had the least number of households using this system. This can be attributed to the fact that this region had the least number of households and the lowest chicken population compared to other regions as confirmed in Table 1 and Table 4. Maize or millet supplementation in Oshikoto was significantly higher ($p<0.05$) than in any other region. The Caprivi region had the lowest proportion of households providing supplementary feed to chickens. In Zimbabwe and Ethiopia, the proportions of households that provided supplementary feed were 90% (Mlambo et al., 2011) and 96.3% (Moreda et al., 2013) respectively and these proportions were higher than those reported in this study. The differences in supplementation levels between regions and countries may be a reflection of the variation in production levels and competition for cereals for human food. In Kunene region, the use of household left overs and commercial feed was very popular than in other regions. This region experiences frequent drought periods and households are unlikely to have cereal grain stocks to feed chickens. Nevertheless, scavenging was reportedly the most common and typical production system for managing village chickens in rural areas of most African countries (Moreda et al., 2013). Although scavenging systems have low input costs, chickens are exposed to diseases, parasites, predators and harsh weather elements. Even under the scavenging system, however, these village chickens were still able to produce eggs and chicks to sustain families and chicken numbers. There is therefore potential to increase production in this system and improve the food security situation of rural communities.

An average of 11 (9-13) eggs/hen/clutch were determined in this current study and eggs/clutch/hen did not seem to vary widely between the eight regions. This rate of egg production per hen per clutch was higher than the 9.8 ± 2.4 eggs per clutch recorded in Ghana (Blackie, 2014), lower than the 16, 12.9 and 13.7 eggs reported in other studies (Moges et al, 2010; Guni and Katule, 2013; Hagan et al., 2013;), but within the range of 11-15 eggs reported in yet another study (Aboe et al., 2006). There is a potential to improve hen egg production through improving clutch size in village production systems through provision of supplementary feeding.

Mean hatchability was 74.3% (63.3-79.9%), which is close to the hatchability of 76.32% and 78.31% reported in Botswana (Malatji et al., 2016). Other studies in Africa have reported contrastingly higher hatchability of over 85% (Guni and Katule, 2013; Moges et al., 2014; Muhiye, 2007). The relatively lower hatchability recorded in the current study may be due to the absence of designated chicken houses on about 50% of the households which possibly exposed chicken eggs to extreme weather elements and predators during incubation. It is interesting to note that results of natural incubation by broody hens in this study and others gives a higher hatchability than commercial hatchery in Rwanda (about 57% for broilers and 42% for layers) (Mushonga et al., 2017).

About 42.4-69.1% (mean =56.4%) of the chicks hatched in all the regions survived up to the age of four weeks. This survival rate is lower than the mean survival rate of 69.8% obtained in Tanzania (Muhiye, 2007) but higher than the 25% reported by others (Blackie, 2014; Issa et al., 2013). The low chick survival rate obtained in this study confirmed the low productivity associated with extensive chicken production systems.

Reasons that were put forth for the attrition of chicken numbers in the flocks were disease (33.5%), own consumption (27.1%), predation (21.8%), sale (7.9%), theft (6.5%), starvation (2%) and trauma (1.3%). Disease and predation were the major cause of unavoidable chicken losses as has been reported by other studies (Goraga et al., 2016; Halima et al., 2007; Moreda et al., 2013; Muchadeyi et al., 2009). In Oshikoto, the proportion of deaths due to disease was significantly higher ($p<0.05$) than in other regions. These findings may be explained by the lack of effectiveness of herbal medicines that were used by 88.2% of the households or the absence of designated chicken housing in all households. Although, specific diseases were not identified, Newcastle disease has been reported as the major cause of mortalities in village chickens in many African countries (Moreda et al., 2013). A significantly higher level ($p<0.05$) of predation was observed in the Kavango region than other regions. Dogs, snakes, hawks, eagles and cats have been documented as the most common predators of chickens especially at chick level. Predation may be reduced by monitoring chickens during the day and by providing shelter at night. The majority of chickens (27.1%) were voluntarily culled for own consumption indicating that this is the main objective for raising village chickens. In the Kunene region, deaths due to starvation were significantly higher than in other regions due to the frequent drought periods and feed shortages that are a frequent occurrence.

Farmers responded in different ways to disease challenges in their flocks. Respondents reportedly treated diseased birds by making use of indigenous herbal medicines

(60.2%), conventional veterinary medicines (9.7%), and vaccines (9.5%) or by consulting a veterinarian (6.2%). Unspecified disease cases (14.3%) were slaughtered for human consumption thus putting humans at risk of zoonotic diseases especially in the Caprivi region where the highest proportion of sick birds (38.4%) were slaughtered. Despite the low illiteracy rate of about 49.3%, Kunene region had the highest proportion of farmers that used vaccines and consulted official veterinary services for the treatment of sick birds. In Kavango region, farmers did not consult the veterinarian at all. Although the use of conventional veterinary medicines was significantly higher in the Oshana region than in other regions, respondents from the rest of the regions used conventional veterinary medicines to treat sick birds. There was predominant use of ethno-veterinary medicines in Oshikoto, Ohangwena and Kavango regions. There is abundant indigenous knowledge systems and ethno-veterinary medicines among farmers in these regions and there is a need to find ways of harnessing this knowledge for the treatment of poultry diseases in the other regions.

The level of management and production of the flocks was low as confirmed by the absence of suitable poultry housing on most households; fewer eggs per clutch and low chick survival rates. The level of production was commensurate with the low inputs and management associated with these extensive and scavenging chicken production systems. Disease and predation were the major constraints to chicken production. There is, however, a great pool of ethno-veterinary medicine knowledge in these production systems that can be utilized to improve production.

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## REFERENCES

Aboe, P.A.T., Boa-Amponsem, K., Okantah, S.A., Butler, E.A., Dorward, P.T., Bryant, M.J., (2006). Free-range village chickens on the Accra Plains, Ghana: Their husbandry and productivity. Trop. Anim. Health Prod. 38, 235–248. doi:10.1007/s11250-006-4356-x

Alem, A.T., Yayneshet, G.T., Aklilu, A.H., (2014). Socio-economic characteristics of poultry production in lowland and midland agro-ecological zones of central Tigray, Ethiopia. Int. J. Livest. Prod. 5, 71–80. doi:10.5897/IJLP2013.0153

Assefa, H., Bogale, A., Gebremedhin, B., Mekuriaw, Z., Derso, T., Dessalegn, Y., Tegegne, A., Hoekstra, D., (2016). Village Chicken Production and Marketing in West Gojjam Zone, Ethiopia. Curr. Res. Agric. Sci. 3, 64–73. doi:10.18488/journal.68/2016.3.4/68.4.64.73

Awuni, J.A., (2002). Strategies for the improvement of rural chicken production in Ghana, Strategies for the improvement of rural chicken production in Ghana. Accra, Ghana.

Badubi, S.S., Rakereng, M., Marumo, M., (2006). Morphological characteristics and feed resources available for indigenous chickens in Botswana. Livest. Res. Rural Dev. 18.

Blackie, S., (2014). Village Chicken Production System in the Greater Accra Region , Ghana. J. Biol. Agric. Healthc. 4, 89–95.

Desha, N.H., Bhuiyan, M.S.A., Islam, F., Bhuiyan, A.K.F.H., (2016). Non-genetic Factors Affecting Growth Performance of Indigenous Chicken in Rural Villages 4, 122–127.

Gondwe, T.N., Wollny, C.B.A., (2007). Local chicken production system in Malawi: Household flock structure, dynamics, management and health. Trop. Anim. Health Prod. 39, 103–113. doi:10.1007/s11250-006-4293-8

Goraga, Z., Caron, L., Wilbert, C., Brockmann, G.A., (2016). Characterization of village chicken production systems and challenges across agro-climatic zones in Ethiopia. Int. J. Livest. Prod. 7, 94–105. doi:10.5897/IJLP2016.0320

Guni, F.S., Katule, A.M., (2013). Characterization of local chickens in selected districts of the Southern Highlands of Tanzania: I. Qualitative characters. Livest. Res. Rural Dev. 25.

Hagan, J.K., Bosompem, M., Adjei, I.A., 2013. The productive performance of local chickens in three ecological zones of Ghana. J. Agric. Biol. Sci. 8, 51–56.

Halima, H., Neser, F.W.C., Van Marle-Koster, E., De Kock, A., (2007). Village-based indigenous chicken production system in north-west Ethiopia. Trop. Anim. Health Prod. 39, 189–197. doi:10.1007/s11250-007-9004-6

Issa, A.Y., Mopate, L.Y., Ayssiwede, S.B., Missohou, A., (2013). Production practices, constraints and performance in traditional chicken breeding in chad. Int. J. Poult. Sci. 12, 367–376.

Khalafalla, A.I., Awad, S., Hass, W., (2002). Village Poultry Production in the Sudan, Characteristics and Parameters of family Poultry in Africa. Khartoum North, Sudan.

Malatji, D.P., Tsotetsi, A.M., van Marle-Koster, E., Muchadeyi, F.C., Muchadeyi, F., Marle-Koster, V., (2016). Onderstepoort Journal of Veterinary Research A description of village chicken production systems and prevalence of gastrointestinal parasites: Case studies in. Onderstepoort J. Vet. Res. 83, 1–8. doi:10.4102/ojvr.v83i1.968

Melesse, A., (2014). Significance of scavenging chicken production in the rural community of Africa for enhanced

food security. Worlds. Poult. Sci. J. 70, 593–606. doi:10.1017/S0043933914000646

Mlambo, T., Mbiriri, D.T., Mutibvu, T., Kashangura, M.T., (2011). Village chicken production systems in Zhombe communal area of Zimbabwe. Livest. Res. Rural Dev. 23.

Moges, F., Nega, M., Zeleke, G., (2014). Characterization of village chicken production and marketing systems in selected districts of North Western Amhara region, Ethiopia. African J. Agric. Res. 9, 3091–3097.

Mohammad, J.T., Hussein, H.H., 2017. Production systems of village chickens in the Abu-Dhabi Emirate, UAE. African J. Agric. Res. 12, 2986–2994. doi:10.5897/AJAR2017.12457

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. Br. J. Poult. Sci. 2, 25–32. doi:10.5829/idosi.bjps.2013.2.3.7526

Muchadeyi, F.C., Wollny, C.B.A., Eding, H., Weigend, S., Simianer, H., (2009). Choice of breeding stock, preference of production traits and culling criteria of village chickens among Zimbabwe agro-ecological zones. Trop. Anim. Health Prod. 41, 403–412. doi:10.1007/s11250-008-9204-8

Muhiye, M.G., (2007). Characterization of smallholder poultry production and marketing system of Dale, Wonsho and Loka Abaya Werdas of southern Ethiopia. Hawassa University, Ethiopia.

Mushonga, B., Benimana, T., Kandiwa, E., Chinyoka, S., Samkange, A., Bishi, A., Habarugira, G., (2017). Determination of Fertility, Hatchability and Stage of Embryonic Death in Non-Hatching Eggs at Rubilizi National Hatchery. Focus Sci. 3, 1–6. doi:10.21859/focsci-03031440

Mutombo, P.K., Orenge, C., Kanui, T.I., Wambua, S., (2015). An assessment of natural and socio- economic impacts on village chicken production:-a case study of Katangi and Ikombe Divisions of Yatta Sub-County. Int. J. Educ. Res. 3, 53–62.

Mwale, M., Masika, P.J., (2009). Ethno-veterinary control of parasites, management and role of village chickens in rural households of Centane district in the Eastern Cape, South Africa. Trop. Anim. Health Prod. 41, 1685–1693. doi:10.1007/s11250-009-9366-z

Namibia Statistics Agency, (2011). Namibia 2011 Population & Housing Census - Main Report. Windhoek, Namibia.

Olwande, P.O., Ogara, W.O., Okuthe, S.O., Muchemi, G., Okoth, E., Odindo, M.O., Adhiambo, R.F., (2010). Assessing the productivity of indigenous chickens in an extensive management system in southern Nyanza, Kenya. Trop. Anim. Health Prod. 42, 283–288. doi:10.1007/s11250-009-9418-4

Padhi, M.K., (2016). Importance of Indigenous Breeds of Chicken for Rural Economy and Their Improvements for Higher Production Performance. Scientifica (Cairo). 2016. doi:10.1155/2016/2604685

Petrus, N.P., (2011). Characterization and production performance of indigenous chickens in Northern Namibia regions.

Stangroom, J., (2017). Social Science Statistics [WWW Document]. Soc. Sci. Stat. URL http://www.socscistatistics.com/Default.aspx (accessed 11.2.17).

Tadelle, D., 2003. Phenotypic and genetic characterization of local chicken ecotypes in Ethiopia. Humboldt-Universität zu Berlin.

Tadelle, D.., (1996). Studies on village poultry production systems in the central highlands of Ethiopia. Swedish University of Agricultural Sciences, Uppsala.

Tarekegn, G., Ewonetu, K., Negassi, A., Aemro, T.T., (2015). Village Chicken Husbandry Practice , Marketing and Constraints. J. World's Poult. Res. 5, 104–108.

Yusuf, S.F.G., Lategan, F.S., Masika, P.J., (2014). Characterization of Indigenous Poultry Production Systems in the Nkonkobe Municipality , Eastern Cape Province South Africa. Agri Sci 5, 31–44.