

POTENTIAL, CHALLENGES AND PROSPECTS OF RABBIT FARMING IN URBAN AND PERI-URBAN AREAS OF DODOMA CITY, TANZANIA

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Abstract: This study highlights the current status of rabbit production, potential challenges facing the industry and the prospects for rabbit farming in Dodoma city, Tanzania. Data from 60 individuals keeping rabbits were collected through a structured questionnaire and direct observation. Results showed that 60% of the respondents were men and 40% women. Rabbits were kept mainly as a source of meat for families and income generation. Main sources of rabbit stock were local breeders (55%) and missionaries (25%), while the remainder were from agricultural institutes. The dominant rabbit breeds reared were California white (50%), New Zealand white (30%), Chinchilla (10%) and Dutch (10%). Ninety-five percent of the farmers kept rabbits in cages, while 5% confined them at night and let them out during the day to forage for feed. Fifteen percent of the respondents fed commercial rabbit pellets, 5% vegetables and kitchen waste only, whereas 80% fed both rabbit pellets, vegetables and kitchen waste. The number of rabbits kept by an individual farmer ranged from 5 to 180, with mean stock size of 22.80 ± 11.20 (mean \pm standard deviation). Rabbits were sold at 8 to 12 wk of age and each rabbit was sold for 20000 to 30000 Tanzanian shillings (8.00 – 12.00 USD). Major challenges in rabbit production were lack of feed resources, lack of readily available market, poor quality of breeding stock, low knowledge of rabbit production techniques and lack of technical support from extension services. Although rabbit farming in Dodoma is carried out at subsistence level, it is associated with a decrease in poverty among urban and peri-urban farmers. In conclusion, rabbit production in urban and peri-urban areas of Tanzania has the potential to contribute to food and nutrition security and poverty alleviation, thus improving living standards.

Key Words: Dodoma, rabbit, food security, challenges, prospects, poverty alleviation.

INTRODUCTION

Domestic rabbits (*Oryctolagus cuniculus*) are considered small livestock, which are kept for various purposes including provision of protein, fibre and as a source of income, or as pets and show animals (Fanatico and Green, 2012) as well as for game restocking (Machado *et al.*, 2017; Carro *et al.*, 2019). Rabbits are also kept as model animals for laboratory use in biomedical and pharmaceutical research (Mapara *et al.*, 2012). Rabbits are characterised by high reproductive potential and fast growth rate (Mukaila, 2023), with low utilisation of grain and high roughage diets and breeding all year round (Irlbeck, 2001). Other attributes rabbits possess are early sexual maturity, short gestation period, ability to rebreed shortly after kindling and short generation interval (Hassan *et al.*, 2022). These qualities make rabbits a potential source of protein to overcome the deficiency of animal protein in developing countries, where grain can only be vindicated for human consumption (Irlbeck, 2001; Hassan *et al.*, 2022). Rabbits in developing countries are kept by smallholders in subsistence-type integrated farming and gardening production systems (Oxley

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et al., 2018). Rabbit farming can be categorised as traditional (smallholder), intermediary and commercial (Colin and Lebas, 1996). In traditional production, fewer than 10 does are reared, and 10 to 100 does in intermediary farms, while in commercial production, over 100 does are kept and fed mainly on complete feeds (Colin and Lebas, 1996). Rabbit manure can be used as organic manure to fertilise crops and gardens (Schiere, 2004), while urine can be used as insecticide in gardens. Rabbits can be successfully raised on grain-free diets, based on forages and agro by-products. Greens such as weeds, tree leaves, tropical legume and grass forage, vegetable tops, waste fruits and vegetables can be used to feed rabbits and acceptable performance can be achieved (Cheeke, 1986). However, they can be supplemented with complete diets available in the market.

Increasing human population in developing countries has been observed to be associated with deficiency of protein sources (El-Raffa, 2004). Thus, domestic rabbits are recommended as an alternative source of dietary protein for the increasing human population in developing countries (El-Raffa, 2004). Rabbit meats are far better compared to other livestock meats, since they are richer in micronutrients (Kunnath, 2017). Rabbit meat is white and has low fat, sodium and cholesterol contents when compared with other meats (Bodnár and Bodnár, 2014). In addition, rabbit meat has less stearic and oleic acids and high proportions of essential polyunsaturated linolenic and linoleic acids (Kunnath, 2017). These qualities make rabbit superior to other meats, thus making it appeal to the health-conscious market. Few studies have been done on rabbit production in Tanzania, particularly in Dodoma region, due to overemphasis on larger livestock such as cattle, goats, pig and poultry; hence there is limited information on rabbit production in Dodoma region. Therefore, this study was conducted to investigate the status of rabbit production in the urban and peri-urban areas of Dodoma city, Tanzania.

MATERIALS AND METHODS

Study area

Dodoma region is centrally positioned in mainland Tanzania. The region lies between latitude 4 and 7° S and longitude 35-37° E. The region is bordered by four regions as follows: To the north, Dodoma region shares borders with Manyara, to the east with Morogoro region. In the south it shares borders with Iringa region and to the west, it shares borders with Singida region. Much of the region is plateau, rising gradually from some 830 metres in Bahi swamps to 2000 metres above sea level.

According to the 2022 Population and Housing Census, there were 1 698 996 inhabitants in Dodoma city and an average household size of 4.5 persons (National Bureau of Statistics, 2022). The number of agricultural households in Dodoma city was 323 719, of which 233 709 (72.2%) were involved in growing crops only, 608 (0.2%) were involved in livestock keeping only and 89 402 (27.6%) were involved in crop production as well as livestock keeping. Animals kept include cows, goats, pigs, poultry and rabbits.

Data on rabbit production were collected in urban and peri-urban areas of Dodoma city. Peri-urban areas included Ng'hong'hona, Mapinduzi, Mtumba and Ihumwa, while urban areas were Majengo, Kizota, Nkuhungu and Chang'ombe, as shown in Figure 1.

Data collection

A structured questionnaire was used to capture primary information on a face-to-face basis from individuals who were running a rabbit enterprise and were responsible for the management of rabbits. Interviews were conducted with sixty household heads and household members over 18 yr of age. The data gathered included farm and household characteristics, respondents' occupation, age, sex, level of education, source of stock, rabbit production, total number of rabbits, rabbit breeds, housing type, age at weaning, the ratio of breeding buck to does, feeds, frequency of feeding and watering rabbits, type of equipment used, health management, marketing, challenges faced and use of money from rabbit sales. The study was conducted for a period of six months (from January to June 2023). Key informant interviews were also conducted to gather information by interviewing representatives from the Ministry of Livestock and Fisheries as well as livestock extension officers, rabbit breeders and other rabbit industry stakeholders in Dodoma region. Eight key informants were interviewed, including two livestock extension officers (one from an urban and another from a peri-urban area), a veterinary officer and livestock marketing officer from the Ministry of Livestock and

Fisheries, two individuals selling animal drugs and feed and two local rabbit breeders. The information obtained from key informants included the services they provide to rabbit farmers, the plan to promote rabbit farming, obstacles hindering rabbit farming, market availability, breeding techniques, diseases and other information. Participation of rabbit farmers and key informants in the study was anonymous and by informed consent.

Data management and analysis

Collected data were coded in the computer using Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) software, version 16. Descriptive statistics were analysed with frequency distribution, means and percentages and were presented in tables. The correlation coefficient was calculated to establish the relationships of different variables. A multiple regression analysis was used to establish the relationship between rabbit sold (dependent variable) and socioeconomic characteristics of respondents (independent variable) represented by the given equation:

$$N = y + a_1\chi_1 + a_2\chi_2 + a_3\chi_3 + a_4\chi_4 + a_5\chi_5 + e;$$

where N=rabbit sold (number of rabbits sold), y=intercept, a₁-a₅=regression coefficients, χ₁=age, χ₂=education, χ₃=household size, χ₄=years of rabbit farming experience, χ₅=stock size and e=error term.

RESULTS AND DISCUSSION

Socioeconomic data

Results from this study show that over fifty percent (50%) of rabbit keepers were aged over 40 yr, followed by 26 to 39 yr (33.3%), and lastly 18 to 25 yr (13.3%) (Table 1). This indicates that rabbit farming is practiced by all age groups, although there were fewer individuals aged between 18 and 25 yr who raise rabbits. This finding is consistent with Moreki *et al.* (2019) and Hungu *et al.* (2013), who found that rabbit farming in Botswana and Kenya, respectively, cuts across all age groups. A large number of respondents who kept rabbits were males, comprising about sixty percent (60%), while the remainder were females. The reason for the small number of females participating in rabbit farming may be due to being occupied with other activities such as caring for the home, child rearing and fending for the home, as well as other household responsibilities in which the women were involved and demanded more of their time. Similarly, other studies in developing countries reported that rabbit production was dominated by men (Mailu

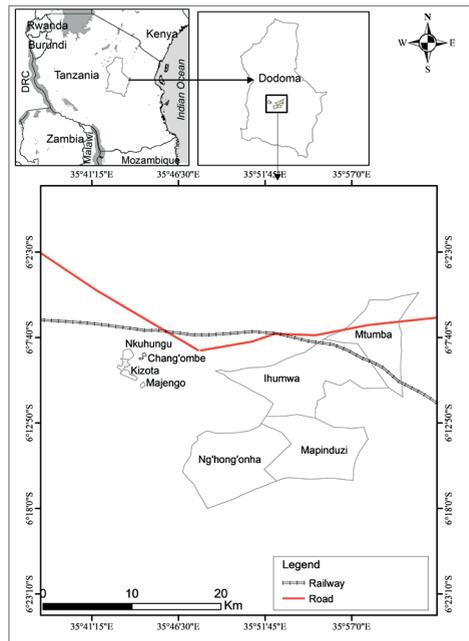


Figure 1: Map of Dodoma city showing the sampled study areas.

Table 1: The respondents' socioeconomic data.

Category	Frequency (n=60)	Percentage (%)
Age		
18 to 25 yr	8	13.33
26 to 39 yr	20	33.33
Over 40 yr	32	53.34
Gender		
Male	36	60.00
Female	24	40.00
Occupation		
Teacher	10	16.67
Farmer	22	36.67
Secretary	6	10.00
Pensioner	5	8.33
Field assistant	5	8.33
Student	4	6.67
Self-employed	8	13.33
Education level		
University level	5	8.33
Diploma level	10	16.67
Secondary school	30	50.00
Primary school	12	20.00
Non formal education	3	5.00
Marital status		
Married	17	28.33
Single	28	46.67
Widow	15	25.00

et al., 2012; Mutisya, 2014; Moreki *et al.*, 2019). In addition, about 80% of the respondents were employed in either the public or private sector, while the rest (20%) comprised students, pensioners and those that were self-employed. These results indicate that rabbit keeping is carried out as an extra tangential activity by most of the respondents. All the respondents in this study were literate, with 75% of them having secondary education and above (Table 1). This implies that most of the respondents could grasp technical information/messages from extension services providers. Education is deemed to be important in managerial capacity and decision making; therefore, it may be concluded that farmers will be able to adopt and implement new technologies. The educational status of the respondents in this study is higher than that reported by Tembachako *et al.* (2014) in Zimbabwe, but was the same as those reported by Moreki *et al.* (2011) in Botswana. Additionally, 46% of the respondents were single, followed by married (28%) and widowed (25%). This shows that rabbit farming is carried out by all people with different marital status and this provides cheap and readily available labour.

Source of rabbit stock

Fifty-five percent (55%) of rabbit breeders sourced their breeding stock locally from other breeders, 25% from missionaries, while the remainder sourced rabbits from local breeders. The reason behind most farmers obtaining breeding stock from local breeders is attributed to the low cost of acquiring new stock from them. Similarly, Hungu *et al.* (2013) and Kale *et al.* (2016) found that 64 and 76.9% of farmers in Kenya, respectively, sourced their breeding stock from other farmers. In the view of Hungu *et al.* (2013), sourcing breeding rabbits from fellow farmers could lead to inbreeding if not done properly. Oseni *et al.* (2008) observed that the practice of acquiring rabbit stock from other farmers in Ghana has disadvantages because of lack of a reliable and steady supply of good rabbit stock. In this study, breeding stocks were also sourced from local breeders, which sometimes limits the potential of rabbit due to inbreeding as a result of lack of controlled breeding. A study by Moreki *et al.* (2019) in Botswana reported that rabbits were obtained outside the country in order to access a wide range of genetic materials and also to avoid inbreeding. Dairo *et al.* (2012) reported that 74% of the respondents in Ekiti State of South-Western Nigeria obtained foundation stock as gifts from friends, while the remainder purchased stock on the open market. The authors attributed farmers' failure to import foundation stock to lack of credit facilities.

Rearing experience and reasons for keeping rabbits

In the present study, rabbits were used as a source of income (40%) and food (35%) for the rabbit keepers, while a small portion of rabbit keepers reared rabbit as both source of income and food source (15%), and the rest reared rabbits as pet animals (10%). Similar results were reported in Kenya by Kale *et al.* (2016), who found that farmers valued rabbits as a source of food (46.2%) and an income generating enterprise (53.8%). Similar observations were also made by Tembachako and Mrema (2016), who found that in the Mt Darwin District of Zimbabwe rabbits were mainly kept as a source of food, with few being sold for income generation. Thirty-seven percent (37%) of the respondents said they had been rearing rabbits for 3 to 4 yr, followed by over 4 yr (30%), 1 to 2 yr (20%) and less than a year (13%) (Table 2), indicating that rabbit farming is still in its infancy stage in Dodoma city. The majority of Dodoma city dwellers are still not aware of the importance of raising rabbit. Rabbit farming in Dodoma region was introduced in 2016 by the USAID-Tanzania under the programme known as sustainable nutrition (Kaganda, 2020). This indicates that technical support is needed to raise the knowledge level and awareness of rabbit keepers in Dodoma. Tembachako and Mrema (2016) and Deliwe and Mrema (2014) predicted that more experience in rabbit farming means that farmers have more and better information and the ability to improve rabbit production. As farmers' experience improves, rabbit productivity is predicted to improve in

Table 2: Common breeds of rabbits reared in Dodoma city.

Category	Frequency (n=60)	Percentage (%)
Breeds of rabbits kept		
New Zealand white	18	30
Chinchilla	6	10
California white	30	50
Dutch	6	10
Time farmers have been keeping rabbits		
<1 year	8	13
1 to 2 yr	12	20
3 to 4 yr	22	37
>4 yr	18	30

consequence (Deliwe and Mrema, 2014). These results are consistent with the findings of Mutisya (2014), who attested that experience in any enterprise is very important and cannot be underestimated in rabbit production. Therefore, for improved productivity and proficiency in rabbit production, experience is vital.

Types of breeds and reproductive performance of rabbits

Common rabbit breeds in Dodoma city included California white, Chinchilla, Dutch and New Zealand white. The predominant breeds were California white (50%) and New Zealand white (30%), followed by Chinchilla and Dutch, both with 10% each (Table 2). Some of the rabbit keepers reared more than one breed with the purpose of crossbreeding to obtain rabbits of high quality and production potentials. California white, New Zealand white and their crossbreeds (though they were named as either California white or New Zealand white) were preferred due to their large size, high growth rate, best quality meat products and production potentials. Creole rabbits might also be present in the study areas, but it was not easy to determine them due to lack of proper data from rabbit keepers. The total number of rabbits (growing rabbits) kept by an individual farmer ranged from 5 to 180 rabbits. On average, the number of rabbits kept by an individual farmer was 22.80 ± 11.20 (mean \pm standard deviation).

On production performance, more than 50% of the respondents said that the gestation period of a rabbit was 31 d (Table 3). This is consistent with the findings of Kpodekon *et al.* (2004), Schiere (2004) and Moreki *et al.* (2019) in backyard production systems. A doe produced a litter size between 6 and 10 kits born alive with 5 to 6 litters per year (5.5 average) (Table 3). The finding on the number of litters produced by a doe per year is low compared to the average 6.98 reported by Lebas (2009), 6.52 ± 0.53 (Xiccato, 2010) in an intensive production system, but similar to 5 to 6 litters reported by Kunnath (2017) in a backyard production system. However, it was higher than the findings by Yadav (2014) who reported 3 to 4 litters per doe per year in a backyard production system in Kenya. The differences in litters per doe per year might be attributed to the management system applied by the individual rabbit keeper.

Most rabbit keepers (55%) used a buck-to-doe ratio of 1:10 (1 male to 10 females) in natural mating practice. Other farmers used the ratio of 1:1 and 1:3 with 15% each, 1:8 (10%) and 1:5 (5%) (Table 3). On average, the ratio of breeding buck to does in this study was 1:5.4 (with a range of 1:1 to 1:10). The buck-to-doe ratio of 1 to 10 in this study is consistent with that reported by Sicwaten and Stahl (1982) in the Philippines in a backyard production system. A study by Gono *et al.* (2013) in Zimbabwe reported the common average buck-to-doe ratio of 1:6. According to Lebas *et al.* (1997), a buck can attend 7 to 8 does and 10 to 15 does in intensive system and extensive system, respectively.

Housing and equipment

Seventy percent of the respondents interviewed reported keeping their rabbits in outdoor cages; 21% kept them in shelters with solid floors and bedded with Lucerne or lablab, while fewer than 9% allowed rabbits to range free but confined them at night. Most of the rabbit keepers constructed rabbit shelters using locally available materials such as wood, wire mesh, metal rods, bricks and corrugated iron sheets. A similar finding on types of materials used to construct rabbit shelters was also reported by Moreki and Seabo (2012) and Moreki *et al.* (2019) in Botswana. Physical observation during this study showed that rabbit houses were constructed using locally available materials (Figure 2). This is due to inadequacy of funds or technical support provided by the livestock extension services. There are no specific

Table 3. Rabbit production performance in the Dodoma city.

Category	Frequency (n=60)	Percentage (%)
Gestation period		
31 d	32	53.33
32-34 d	20	33.33
26-30 d	8	13.33
Average litter size (kits born alive per birth)		
1-6 kits	10	16.66
7-10 kits	25	41.67
>10 kits	25	41.67
Number of litters/doe/yr		
5	45	75.00
6	15	25.00
Buck to does ratio		
1:1	9	15.00
1:3	9	15.00
1:5	3	5.00
1:8	6	10.00
1:10	33	55.00



Figure 2: Rabbit houses constructed using local materials.

cages for rabbit commercially available in the study areas. Hungu *et al.* (2013) ascribed the poor design and construction of rabbit hutches to limited access to technical information and inadequate funds for purchasing construction materials by farmers.

Feeds, feeding and nutrition

Three types of feeds were observed to be used by rabbit farmers in Dodoma city. These included commercial rabbit pellets (15%), vegetables, crop residues and kitchen waste (5%) and a combination of rabbit pellets, kitchen waste and vegetables (80%) (Table 4). Similarly, a study by Hungu *et al.* (2013) in various parts of Kenya showed that 11% of farmers used pellets and 19% used vegetables, while 70% used vegetable, kitchen waste and pellet mixtures in intensive production. In addition, a study by Borter and Mwanza (2011) reported that locally available feed materials with little supplementation using commercial rabbit pellets are mainly used to feed rabbits kept in backyard production systems in Kenya. The study by Mailafia *et al.* (2010) in Nigeria showed that rabbit production can be integrated into small farming systems, with the rabbits being fed on crop residues, forages, fruit wastes, vegetables and poultry droppings. A related study by Abu *et al.* (2008) in Nigeria reported that the diets of rabbits were primarily forages, grasses and legumes supplemented with kitchen wastes and agricultural by-products such as dried cassava peels and wet milled cereal by-products. A balanced diet containing adequate crude fibre (20- 25%) with minimal starch and optimum protein concentration should be fed to rabbits to prevent gastrointestinal distress and to improve production (Samkol and Lukefahr, 2008). In the present study, the majority of rabbit farmers fed their rabbits on vegetable crop residues and kitchen waste, which are rich in fibre with low protein content. Some of the farmers supplement their rabbits with pellets to meet protein demand. In the present study, 50% of the respondents fed and gave water to their rabbits once a day, which is normally early in the morning, followed by *ad libitum* (35%) and twice a day, i.e., morning and late afternoon (15%) (Table 4). The reason for feeding rabbits once per day might be due to less priority being given to rabbits by farmers. A study by Ogbonna (2015) in the Enugu state of Nigeria reported that 62.55% respondents fed their rabbits twice a day, while Lukefahr and Cheeke (1990) observed that there is limited data on feeding systems in backyard production systems.

Table 4: Feeds and frequency of feeding and watering rabbits.

Category	Frequency (n=60)	Percentage (%)
Type of feeds		
Pellets	9	15
Green vegetables and kitchen waste	3	5
Pellets, kitchen waste and green vegetables	48	80
Feeding and watering frequency		
<i>Ad libitum</i>	21	35
Once a day	30	50
Twice a day	9	15

Health management

Among the rabbit farmers, forty percent (40%) said their rabbits encountered diseases and parasites. Thirty percent (30%) of respondents mentioned ear plague (psoroptic mange) as a common parasitic infection in rabbits. Moderate low disease incidence could imply that the rabbit farmers were conversant in disease prevention, and therefore were likely to have undertaken required measures to contain the disease. In agreement with this finding, Moreki *et al.* (2011) reported that ear canker was the most widespread parasitic infection of rabbits in Botswana. Poor hygiene and mite attack on ears are the main source of ear canker in rabbits (Borter and Mwanza, 2011). During this study, it was observed that farmers treat ear canker infection by rubbing rabbits' ears with cooking oil. A study by Gono *et al.* (2013) reported that ear canker was treated by rubbing the affected rabbit skin with used automobile oil and aloe vera juice. Furthermore, Lebas *et al.* (1997) mentioned that glycerine and iodised oil are effective against ear canker when applied regularly. The present study also observed the prevalent use of ethnoveterinary medicine in the treatment of ear canker. Ivermectin is effective against ear canker (Bowman *et al.*, 1992). Fifty-five percent (55%) of the respondents said that they were able to identify signs/symptoms of rabbit diseases such as discharges around the eyes, ears, nose or anal area; loss of appetite; depression; diarrhoea; head tilt; loss of balance and laboured breathing. However, it was difficult for the farmers to relate the signs/symptoms to any specific disease. Despite the respondents' ability to identify signs/symptoms of diseases, only about 30% of them sought assistance from animal health practitioners. This confirms that rabbit farmers' knowledge on disease control using modern medicine was limited. In agreement with the present results, Hungu *et al.* (2013) observed that despite the fact that the majority (83%) of farmers had reported disease and recognised their symptoms/signs, only 69% sought treatment from veterinarians for their rabbits.

Extension services/technical support

Three-quarters of the respondents (75%) said that they obtained information on rabbit production from their fellow rabbit keepers and Internet; 5% obtained information from extension services provider with a little payment, whereas the remainder said they received information from a combination of fellow rabbit keepers, Internet and livestock extension services providers. The fact that only 5% of the respondents received technical information from livestock extension services indicates that extension services are inadequate and not technically equipped to promote rabbit production in the city and country at large. Thirty-five percent (35%) of rabbit keepers said that they were visited by the government livestock extension staff once a month to count and record rabbit numbers. Fewer than 10% of the respondents said they were formally trained in rabbit production. These findings show a shortage of technical support and lack of access to information on rabbit production, which has an influence on production performance. Similar observations were reported by Lukefahr and Cheeke (1990) and Oseni *et al.* (2008) in Western Nigeria and by Moreki *et al.* (2019) in Botswana.

Marketing and pricing of rabbits

Fifty percent (50%) of the respondents marketed their rabbits by word of mouth and flyers, followed by word of mouth only (25%) and flyers and social media such as WhatsApp groups, Instagram, etc. (5%) (Table 5). Flyers and social media marketing is only used by those who have access to Internet services. Most rabbit keepers do not use social media and flyers to market their rabbits due to limited Internet access. In most cases, rabbits were only sold when there was a need for money. In Zimbabwe, three methods are commonly used in marketing rabbits, including advertising through posters,

Table 5: Marketing and pricing of rabbits in Dodoma city.

Category	Frequency (n=60)	Percentage (%)
Marketing strategies		
Word of mouth	15	25
Advertising using flyers & social media	3	5
Word of mouth and flyers	30	50
No response	12	20
Pricing strategies		
Age	6	10
Age, sex and weight (size)	15	25
Age and weight (size)	27	45
No response	12	20
Clients		
Individuals	30	50
Individuals and restaurants/supermarkets	21	35
No response	9	15

waiting for customers and door-to-door marketing (Tembachako *et al.*, 2017). In Ghana and Nigeria, rabbits are only sold when there is a willing buyer or a strong need for a farmer to raise money (Karikari and Asare, 2009; Osei *et al.*, 2012). Age and weight are the determining factors of rabbit price (Table 5). In the present study, forty-five percent (45%) of the respondents used age and weight to set prices for their rabbits, followed by 25% who used a combination of age, sex and weight, and 10% who used age only. Heavy rabbits fetched a better price than lighter rabbits. Fifty percent (50%) of the farmers said their clients were individuals, while thirty-five percent said their clients were a combination of individuals, restaurants, hotels and supermarkets, as well as government institutions (5%) such as schools. Rabbits were sold live or dressed. In Dodoma city and Tanzania at large, there are no rabbit slaughter facilities, so rabbits were slaughtered and dressed in home kitchens prior to delivery to retailers and individual buyers. The finding of this study is consistent with the finding by Bodnár (2009) in Hungary, who reported that customers bought live rabbits, whole carcasses or different rabbit meat cuts. In the present study, rabbits were sold from six weeks of age and a rabbit was sold for TZS 20 000 to 30 000 (equivalent to USD 8.0 to 12.0) depending on the size of the rabbit. This implies that rabbit farming contributes to family income generation, economic empowerment, household food and nutrition security.

Use of money from rabbit sales

The respondents specified that rabbits contribute towards household food supply as a source of protein. They also said that money from rabbit sales were used to purchase food, clothing and to pay electricity and water bills. The money was also used to buy additional rabbit stock, equipment such as cages, drinkers, feeders, nest boxes and rabbit feed. In Ghana, a study by Osei *et al.* (2012) reported several main uses of income generated from the sale of rabbits which included school fees, utilities, health care, clothing, food, hired labour, general household expenses and expansion of the rabbit unit. The authors stated that rabbit keepers used the income generated mainly for paying school fees and operated on backyard and small-scale commercial enterprises. Rabbit farming has shown to be associated with decreased poverty among rural and urban dwellers (Mutsami and Karl, 2020).

Relationship between the socioeconomic characteristics of respondents and rabbit sales

The results of the multiple regression analysis between the socioeconomic characteristics of respondents (age, education, household size, years of experience and stock size) and number of rabbits marketed are presented in Table 6. The results show that four independent variables: age ($t=-2.10$), education ($t=2.06$), stock size ($t=2.01$) and years of experience in rabbit farming ($t=2.02$) were significant in elucidating 25 per cent of the variation in rabbit marketing. The estimated value of rabbit sold (m) is shown as follows: number of rabbits sold (N)= $3.40-0.02_{x_1}+0.05_{x_2}+0.02_{x_3}+0.07_{x_4}-0.03_{x_5}$.

In this study it was found that age correlated negatively with rabbit marketed (sold). This might be due to the fact that rabbit keepers in all age groups sell their rabbits in order to meet their demands. Young people of school age would sell their rabbits in order to purchase school requirements such as pens, books etc., while adults would sell rabbits to meet family needs such as paying electricity and water bills. In addition, people in all age groups would like to sell rabbits in order to have 'pocket money'. Chamboko *et al.* (2017) reported that young people are more business oriented, ambitious and entrepreneurial and therefore make use of money obtained from rabbit sales to run or start other businesses.

Table 6: Multiple regression analysis on the relationship between socioeconomic variables and rabbits sold.

Variables	Coefficient	T-value	F-ratio	R ²
Constant	3.40 (0.37)	10.30 ^a	2.01	0.25
Age	-0.02 (0.01)	-2.10 ^a		
Education	0.05 (0.03)	2.06 ^a		
Household size	0.02 (0.03)	0.60		
Years of experience	0.07 (0.04)	2.02 ^a		
Herd size	-0.03 (0.02)	-2.01 ^a		

The values in parentheses are standard deviations (SD).

^aSignificant at 5.

Another significant variable in this study was education. Young people who were still in secondary schools and colleges/universities had the highest chance to gain required knowledge on rabbitry farming, including marketing. They can obtain knowledge from the school curriculum, Internet and informally from their fellow friends about rabbitry production and market availability. The finding of the present study is in harmony with that of the study by Mutsami (2019) in Kenya, which revealed a significant and positive relationship between education and rabbit marketing. It is also expected that household heads that are educated can easily access various information sources, including the market and price of their rabbits (Kiwanuka and Machethe, 2016).

Likewise, the years of experience in rabbit farming showed a positive relationship with marketing of rabbits. The longer a farmer has been keeping rabbits, the more he/she knows when and where to sell his/her rabbits at a reasonable price. These findings are to some extent in line with the study by Ozor and Madukwe (2005) in Nigeria, which reported that years of farming experience was positively correlated with the adoption of innovations and marketing of rabbits.

Stock size also showed a significant negative correlation with the number of rabbits sold. As rabbit numbers increase, farmers are likely to sell the rabbits in order to get money for various uses. In addition, farmers will sell their rabbits in order to maintain a manageable stock size, thus reducing the operational costs incurred in rabbit management.

On the other hand, household size did not significantly correlate with the number of rabbits sold. This indicates that family size has less influence on the decision to sell the rabbits. This means that neither large nor small households can influence rabbit sales.

Challenges in rabbit production

A study by Kumar *et al.* (2010) in India categorised challenges facing rabbit farming into production, financial, marketing and institutional problems. In the present study, challenges hindering rabbit production are summarised in Table 7 above. The study identified four major challenges facing rabbit farming, which included unreliable market, limited technical information, lack of government support and high feed expenses. Similar results have been reported by other scholars from different parts of world. Some of the scholars with similar results, including Soyebó (2006), Dairo *et al.* (2012), Moreki and Seabo (2012), Ogbonna (2015) and Roy (2015), reported lack of foundation stock, lack of government support, lack of research support and inadequate extension/technical support when facing challenges in rabbit production. Other challenges include lack of access to credit and feeds (Moreki and Seabo, 2012; Ogbonna, 2015; Tembachako and Mrema, 2016), diseases/pest infestation (notably mange) and inability to purchase good quality feed (Dairo *et al.*, 2012). Ouertani *et al.* (2016) reported high feed expense and quality of feeds to be major obstacles in the development of the rabbit subsector in Tunisia. Other challenges identified as faced by rabbit enterprises are diseases, environmental conditions, lack of skills, predation (Baruwa, 2014; Kale *et al.*, 2016), lack of market access (Baruwa, 2014; Kale *et al.*, 2016; Tembachako *et al.*, 2017), some religious beliefs (Tembachako *et al.*, 2017), low interest in the enterprise, lack of proper awareness and poor marketing channels (Odinwa *et al.*, 2016). Borter and Mwanza (2011) observed that rabbit production in Kenya is not structured, resulting in farmers not being able to ascertain the number of rabbits they can make available to the market at any given time. The authors also reported that the market is not clearly defined, as many people do not know that rabbit meat can adequately replace other protein sources. Lack of a readily available market and low interest in rabbit enterprises were also observed in the present study in Dodoma city, Tanzania. Oseni and Lukefahr (2014) reported the key

Table 7: Challenges in rabbit production in Dodoma city.

Category	Frequency (n=60)	Percentage (%)
Predation	2	3.33
Unreliable market	10	16.67
Diseases	5	8.33
Limited availability of technical information	10	16.67
Inadequate stock and breeds replacement	5	8.33
Lack of technical support	10	16.67
Medication for rabbits not readily available	8	13.33
High expense of rabbit feeds	10	16.67

challenges to the development of a viable rabbit industry in Africa, ranging from institutional and policy limitations to critical environmental conditions such as heat stress, poor stock and poor diet quality. The challenges reported in the present study show that rabbit farming in Tanzania and most African countries faces numerous challenges that must be addressed if productivity levels are to be raised and become profitable.

Recommendations

Based on the present findings, the following recommendations are made:

1. Technical information on rabbit farming should be provided by the Ministry of Livestock and Fisheries through extension services and made available to rabbit farmers. Digitalisation will play a key role in quick and smooth dissemination of technical information to farmers.
2. Extension agencies in the study area should create proper awareness, such as through widespread publicity of rabbit enterprise including its economic potential, nutritional values, rearing and marketing, as well as value-chain additions as a viable business to generate income in the area.
3. Extension services should be strengthened in order to mobilise more farmers to venture into rabbitry enterprise.
4. Since insufficient information on rabbit management, inadequate veterinary services and poor markets for production are among the problems facing rabbit farmers in the study area, the Government, through the Ministry of Livestock and Fisheries, should provide support to farmers to overcome the challenges facing them.
5. Education and awareness should be created and raised among individuals on the importance of rabbit production so that more people can venture into rabbit enterprise.

CONCLUSION

Rabbit farming in Dodoma city is still at an infancy stage and is a source of protein and income for smallholder farmers. It is practiced as a subsistence activity under the backyard production system. The nutritive qualities of rabbit meat suggest that rabbit production has the potential to significantly subsidise the food and nutrition security in Tanzania. This study identified an unreliable market, limited technical information on rabbit production, less support from government and high feed expenses as the major challenges to the development of rabbit industry in Tanzania. The present results suggest that rabbit production can contribute to increased protein demand by families in both rural and urban and peri-urban areas, thereby playing an important role in food and nutrition security.

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