OPEN ACCESS
Journal of Animal Health and Production

Research Article

Assessment of Biosecurity Practices Adoption in Broiler Farms in East Africa: Case Study of Pwani Region in Tanzania

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Abstract | Broiler farming in Tanzania is an important poultry sub-sector, providing employment and the much-demanded meat hence, contributing to the income and nutrition of the population. However, for small to medium-scale producers the profitability has been hampered by high incidences of diseases and costs associated with their control. This study aimed to assess the biosecurity practices adopted by broiler farmers in the Pwani region, Tanzania. A structured questionnaire was administered to 78 broiler farmers complemented with on-site observations. Data collected were related to the socio-demographic characteristics, the structure of broiler farms, the level of biosecurity in the farms as well as the constraints related to levels of adoption. Descriptive statistics were used to determine the relative frequencies of categorical variables. The Biosecurity Index Score (%) as a measure of adoption level was computed using 44 Biosecurity Control Indicators. The results revealed that women (74.4%) were more represented in broiler production than men (25.6%). The respondents had received either formal training (education from primary to university) or informal training (vocational training: 7.7% of respondents). More than half of the households (53.8%) had activities annexed to broiler production including raising local chicken (75.76%) and other animal species such as cattle, goats, and rabbits (41.7%). The average mortality rate recorded in these farms was 11.7%. Biosecurity Index Score ranged from 44-66% (mean 53.83 ±4.23). There was low adoption of biosecurity between the farm's boundary and the poultry houses. The study concludes that in the Pwani region biosecurity was moderately applied, which shows that farmers in this region are aware of the need to exercise biosecurity measures to prevent disease outbreaks. Some challenges including technical support, finances, and negligence still remain and need to be addressed to reduce the incidence of disease outbreaks and indiscriminate use of drugs.

Keywords | Biosecurity. Broiler. Smallholder. Biosecurity Index. Pwani Region.Exclusion

Received | September 09, 2022; **Accepted** | January 15, 2023; **Published** | April 20, 2023
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Citation | Gomez RSA, Mbaga SH (2023). Assessment of biosecurity practices adoption in broiler farms in east africa: case study of pwani region in Tanzania. J. Anim. Health Prod. 11(2): 155-164.
DOI | http://dx.doi.org/10.17582/journal.jahp/2023/11.2.155.164
ISSN | 2308-2801

INTRODUCTION

Poultry has the greatest potential to contribute to the nutrition of populations, especially in developing countries due to its high feed conversion efficiency and relatively short production time (Brunel et al., 2006; Eze et al., 2017; Molnar, 2017; Yohannes and Tekle, 2018; EKN, 2020). In Tanzania like many developing countries in Africa, poultry farming is an integral part of the rural economy as a source of household income and nutrition, and chickens are considered a commercial crop (FAO, 2007a; Komba, 2017; MLF, 2019). In the recent past, there have been significant improvements in poultry farming in Tanzania, resulting from population growth and the availability of inputs for poultry farming. These improvements are reflected in part by the emergence of large-scale farms

(owned by multinational corporations or Tanzanian entrepreneurs) and small-scale commercial systems in the rearing of broilers and laying hens (EKN 2018, FAO 2019; EKN, 2020).

Unfortunately, the increase in demand for animal protein in recent decades (d'Orfeuil et al., 2015), has led to challenges related mainly to diseases and sometimes to the emergence of new pathogens (Vaillancourt, 2009; Conan et al., 2012; MLF, 2019; Toroghi et al., 2020). The poultry sector in Tanzania is characterized by a high prevalence of diseases affecting small-scale producers, particularly Newcastle disease, infectious bursitis, Marek's disease, salmonellosis, and colibacillosis; poor handling practices, poor quality medicines and vaccines, unreliable cold chain supply of vaccines, poor housing, and sanitation conditions, and inadequate extension services (TLMP, 2017; EKN, 2018; Sindiyo and Missanga, 2018).

Improved commercial poultry strains are highly sensitive to diseases which impact both their production performance and the farmer's income resulting from mortality, veterinary expenses, and low product quality (Eze et al., 2017; Yohannes and Tekle, 2018; Toroghi et al., 2020). Minimize disease incidences requires the adoption of biosecurity measures that entail a set of preventive management practices designed to exclude (bio-exclusion) or reduce (bio-containment) the risks of transmission and spread of disease to animals, humans, or an area unscathed (FAO, 2007b, c; FAO, 2011; Eze et al., 2017; Chenafi et Tchoketch Kebir, 2019). These measures were developed to respond to the disease risks faced by farmers and therefore to prevent the adverse effects of disease on the farm (Patrick et Jubb, 2010; Ajewole and Akinwumi, 2014; Jibril et al., 2016). While large-scale commercial farms can adhere to proper management including comprehensive biosecurity measures, small to medium-scale farmers remain with substantial challenges when it comes to managing diseases. This may arise due to inadequate awareness of "how" to address biosecurity given the smallholding.

Whatever the type of practice to adopt, the implementation of a biosecurity program requires on the one hand a good understanding on the part of the farmer of the potential entry routes of the disease in his farm and the risks incurred for animal and human health; and on the other hand, requires teamwork to maximize profits (Yohannes and Tekle, 2018). So, reducing the prevalence of poultry disease it requires a better understanding of current levels of biosecurity adoption as well as the barriers (socio-economic, conceptual, etc.) faced by smallholder poultry farmers in its implementation (Susilowati et al., 2013). Therefore, this study aimed at assessing the extent to which smallholder and medium-scale poultry farmers are aware of the importance of biosecurity and the levels of adoption of such measures using a case study of broiler farmers in the Pwani region, Tanzania.

MATERIALS AND METHODS

Study area

Geographically, the Coast or Pwani Region is in the middle Eastern side of Tanzania Mainland, between latitudes 6° and 8° south of the equator and longitudes 37°30` and 40° east of Greenwich. It borders Dar es Salaam Region and the Indian Ocean in the East, Tanga Region in the North, Lindi in the South, and Morogoro Region in the West. The bulk of commercial poultry farms (layers and/or broilers) identified in Tanzania was mainly located in the administrative regions of Pwani, followed by the administrative regions of Dar es Salaam, Arusha, Mwanza, Mbeya, then Ruvuma (FAO, 2007a). For this reason, the Pwani region was purposefully sampled for the study using Kibaha Town Council (Kibaha Municipality) and Mlandizi (Figure 1). Both Kibaha and Mlandizi are proximal to the City of Dar Es Salam, where the consumption of poultry products is higher, thus a large concentration of poultry farms and hence the inclusion of these areas (Kibaha Town Council and Mlandizi).

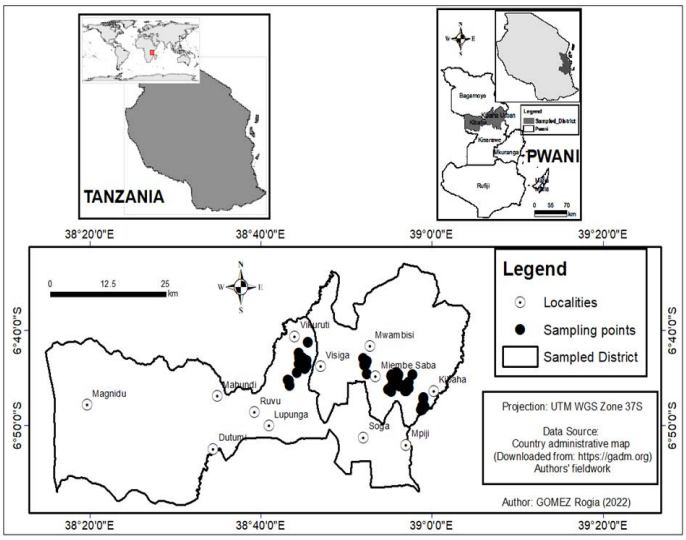

Figure 1: Map of study areas (Kibaha Municipality and Mlandizi) in the Pwani region.

Sampling

According to FAO (2007a), TLMP (2017), Msoffe et al. (2018), and EKN (2020), there are no precise data on the commercial poultry population in Tanzania, especially on the real number of broilers as well as the number of broiler farmers, and only estimates are used. This makes this category of farmers a "difficult-to-reach population" (Marpsata and Razafindratsima, 2010). Thus, in this study, the "Snowball sampling" sampling method allowed us to investigate 78 broiler keepers in the Pwani region. Snowball sampling is defined as a method of sampling making it possible to

obtain information relating to a given study from a certain number of people belonging to the population sought and to investigate those whom they would have designated and so on continued (Marpsata and Razafindratsima, 2010).

Data collection

A total of 78 respondents (broiler farmers) were interviewed individually, through a field survey, from November 2021 to January 2022. The local language spoken in Tanzania is Kiswahili, so the interview with the broiler farmers was conducted with the help of an interpreter who translated the questionnaire from English to Kiswahili for the farmers and then the answers from Kiswahili to English for the interviewer. The questionnaire sent to the respondents contained questions related to farm characteristics, farmers, and biosecurity awareness. In addition, a checklist was also used for information requiring direct observations (e.g., the presence of a foot bath, fencing, etc.). Questions related to biosecurity practices were designed following the scoring system for assessing the adoption of biosecurity measures in small-scale poultry farms in Indonesia (Lestari et al., 2011; Susilowati et al., 2013) and adapted according to the context of the study area.

Respondents' level of biosecurity adoption was assessed on 7 different stages (Figure 2), namely: (1) Vector/fomite status of farm inputs; (2) Traffic onto the farm; (3) Level of biosecurity at farm boundary; (4) Level of biosecurity between farm boundary and poultry house; (5) Level of biosecurity at a poultry house door; (6) Traffic into poultry house; and (7) Susceptibility of broiler flock (Lestari et al., 2011; Susilowati et al., 2013). Each biosecurity stage has been subdivided into biosecurity control indicators (BCI), which received a score ranging from 1 to 3 (1 for a low level of biosecurity, 2 for a medium level, and 3 for a high level of biosecurity). So, each surveyed farm was evaluated on 44 BCIs, and the sum of the score of each of these 44 BCIs made it possible to determine the overall score of the state of biosecurity of the farms surveyed (Biosecurity Status Score: BSS).

The level of biosecurity adoption was determined using the Biosecurity Adoption Index formula (Rahman, 2007).

$$\text{Adoption index \%} = \frac{\text{Total score obtained by the farm}}{\text{Possible total score}} \times 100$$

Depending on the rate obtained, the respondents were classified into 3 categories, namely:
Low adoption of biosecurity: 0-33%
Partial adoption of biosecurity: 34-66%
High biosecurity adoption: 67-100%

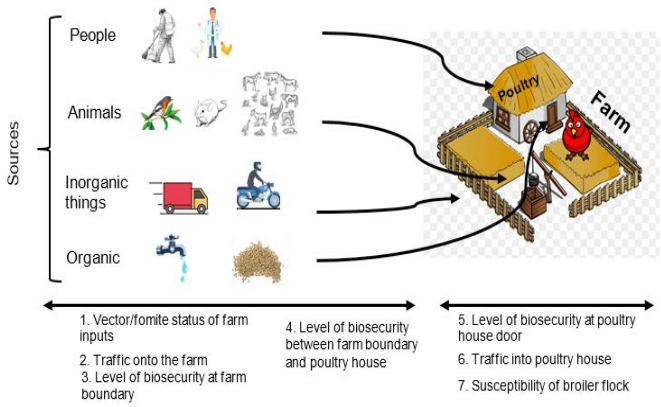

Figure 2: Scheme of biosecurity in a poultry farm. It is showing 7 important steps to insure biosecurity in a farm (Adapted from Patrick and Jubb (2010)).

Statistical analysis

Descriptive statistics were used to determine the relative frequencies of categorical variables. The answers (number of observations) were translated into centesimal proportions. Quantitative variables describing the broiler farmers surveyed were presented as means ± standard deviations. All data analyses were performed using R software, version 4.0.5 (R Core Team, 2021).

RESULTS

Sociodemographic characteristics of broiler farmers

From this survey, broiler keeping was mainly practiced by women (74.4%; Table 1) and most (82.1%) of the broiler farmers were married. The predominant educational levels were the secondary level (41%) and primary level (34.6%). In addition to the classic educational system (primary, secondary, and university), vocational training, such as that given by Vocational Educational and Training Authority (VETA), and Livestock Training Agency (LITA) was mentioned by 7.7% of respondents. The average age of the respondent was 52 years old with about 9 years of experience in poultry farming.

Although animal husbandry (98.7 % of the respondents) is the main economic activity in this region, 53.8% of the respondents had declared having other activities, providing them with additional income. Most of the farmers (89.7%) were aware of some elements of biosecurity, even though almost (61.5%) had never been trained in management and farming techniques and on biosecurity in poultry farming (60.3%). In addition, very few (23.1%) farmers were members of farmers' groups and were in regular contact with veterinary or agricultural service agents (33.3%).

Table 1: Socio-demographic characteristics of the interviewed broilers farmers

Variables	Number	Percentage (%)
Farmer gender		
Male	20	25.6
Female	58	74.4
Marital status		
Divorced	3	3.8
Married	64	82.1
Single	2	2.6
Window(er)	9	11.5
Educational level		
Illiterate	2	2.6
Primary school	27	34.6
Secondary school	32	41.0
University	11	14.1
Other	6	7.7
Economic activities		
Agriculture	26	33.3
Poultry rearing	77	98.7
Other	42	53.8
Attending seminar on broiler management		
Yes	30	38.5
No	48	61.5
Knowledge on biosecurity		
Yes	70	89.7
No	8	10.3
Training on biosecurity for a poultry farm		
Yes	31	39.7
No	47	60.3
Membership in production group		
Yes	18	23.1
No	60	76.9
Contact with veterinarians or agricultural service agents		
Regular	26	33.3
Irregular	29	37.2
None	23	29.5
Mean ± Standard error		
Farmer age (year old)	52.1 ± 11.4	
Experience in poultry keeping (year)	9.6 ± 8.8	

Structural characteristics of the farms surveyed

In the Pwani region, broiler farms were distributed almost everywhere with a predominance for peri-urban areas (46.2%) (Table 2). Almost all farmers (96.2%) owned their poultry farms. Other poultry species such as local chickens (75.6%), layers (10.3%), and common ducks (10 .3%) were an integral part of the farms. In addition to poultry, other animal species such as cattle, sheep, goats, and rabbits were observed in 51.3% of surveyed farms.

Mortality and sources of death

Mortality was about 11.7% on average per flock of broilers reared. According to the farmers surveyed, avian diseases were the main cause of broiler death (62% of death cases) (Figure 3). The fragility or physical malformation of day-

Table 2: Structural characteristics of the farms surveyed

Variables	Number	Percentage (%)
Location of the farm		
Peri urban area	36	46.2
Rural area	18	23.1
Urban area	24	30.8
Ownership of the farm		
Inherited	3	3.8
Purchase	75	96.2
Poultry species raised on the farms		
Broiler	78	100
Layer	8	10.3
Common ducks	8	10.3
Geese	4	5.1
Pigeon	1	1.3
Guinea fowl	1	1.4
Local chickens	59	75.6
Other	40	51.3
Mean ± Standard error		
Average mortality (%)	11.7 ± 10.7	

Table 3: Biosecurity Status Score based on 7 risk stages

Risk stages	Mean	Standard error	Risk score range	Ratio of adoption	BSS	Possible total score
1. Vector/fomite status of farm inputs	14.21	1.05	[7-21]	0.68	71.05	132
2. Traffic onto the farm	7.54	1.14	[4-12]	0.63		
3. Level of biosecurity at farm boundary	14.55	2.20	[13-39]	0.37		
4. Level of biosecurity between farm boundary and poultry house	2.59	1.18	[2-6]	0.43		
5. Level of biosecurity at poultry house door	13.99	2.12	[7-21]	0.67		
6. Traffic into poultry house	5.53	1.07	[5-15]	0.37		
7. Susceptibility of broiler flock	12.65	1.26	[6-18]	070		

BSS: Biosecurity Status Score

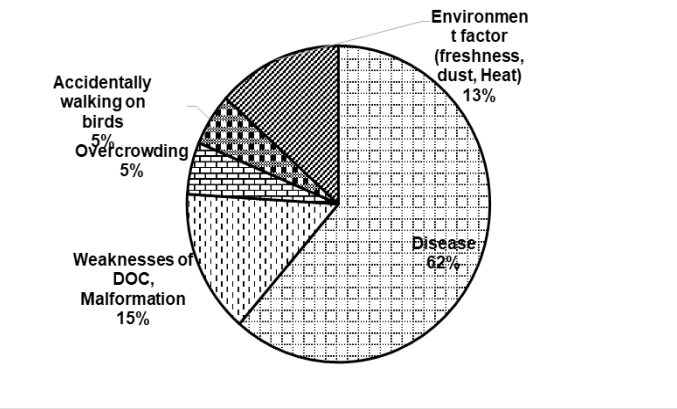

Figure 3: Causes of broilers' death in the Pwani region. Doc: day-old chicks

old chicks (DOC) and certain environmental factors (heat, dust, or cold) were also mentioned by 15% and 13% of respondents respectively as causes of bird death, especially during the first weeks of rearing. Only 5% of respondents admitted to accidentally causing the death of their birds either by stepping on them or by having higher stocking density.

Biosecurity Status Score of broiler farms and Adoption level of biosecurity

Results for adherence to biosecurity practices (Table 3) show a score of 14.21 points out of 21 for the quality of agricultural inputs, 7.54 points out of 12 for traffic management around the farm, 13.99 points out of 21 for biosecurity at the poultry house door and 12.65 points out of 18 for broiler health management. The least applied indicators were those related to biosecurity at farm boundaries (14.55

points out of 39); biosecurity between the boundaries of the farm and the poultry house (2.59 points out of 6); and those related to the management of movements within and between poultry houses (5.53 points out of 15).

Similarly, the score for each risk stage was proportional to the number of farmers who adopted these risk stages. In other words, more farmers among the respondents had moderately respected the quality indicators of agricultural inputs (68%); traffic management around the farm (63%); biosecurity at the poultry house door (67%); and broiler health management (70%). However, the practices of biosecurity at the farm boundary, biosecurity between the farm boundary and the poultry house, and movement management in the poultry house were only applied by a minority (approximately 40%) of farmers. Almost all broiler breeders surveyed had partially adopted biosecurity measures (98.72%. Table. 4).

Table 4: Level of adoption of total biosecurity measures

Level of Adoption	Number of respondents	Relative frequency of respondent (%)	Mean (±sd) of Adoption Index
Low adopter	0	0.00	53.83 (±4.23)
Partial adopter	77	98.72	
High adopter	1	1.28	
Total	78	100	

sd: standard deviation

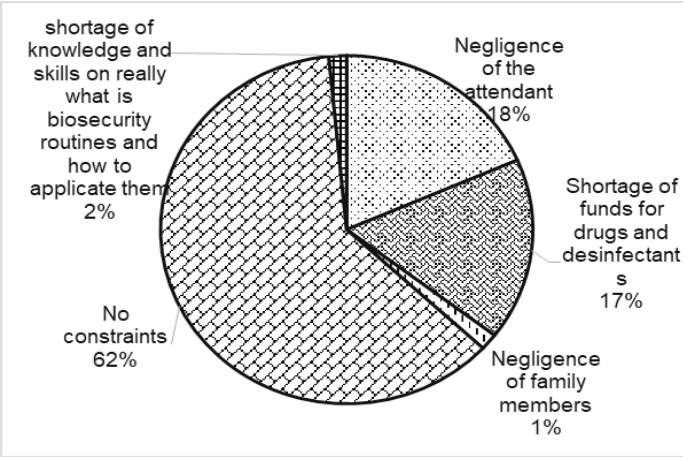

Figure 4: Constraints relative to biosecurity measures adoption.

Constraints of biosecurity practices adoption in the Pwani region

The constraints encountered in the application of biosecurity measures by the broiler breeders surveyed have been presented in Figure 4. About two-thirds of the farmers (62%) in the sample declared that they encountered no constraints in the application of biosecurity measures. For the rest of the respondents, the main constraints encountered are the negligence of broiler breeders (18%) and the lack of financial means for the purchase of medicines and disinfectants (17%). Only 2% of them admit that they do not apply biosecurity measures because they do not know what biosecurity in poultry farming is.

DISCUSSION

Data collected from broiler farmers in the Pwani region showed that women were more represented in broiler production than men. These women were either the owners or the managers of the farms visited. Broiler production was entrusted to the women by their husbands. These results were similar to the findings of some authors (Msami, 2000; Levard, 2014; EKN, 2020). This implies that for small-scale domestic animal farms, women play a greater role in raising small stock including poultry. To add to this, EKN (2020) found that poultry production is more conducive to women because it allows them to easily combine their breeding activities with family tasks. This predominance of women in broiler production in the Pwani region contributes to empowerment as well as a way to increase household incomes.

Most of the respondents were married or widowed with an average age of 52 years. At this age, it is presumed that such households have families and the need to provide for their welfare. Broiler farming would be one of the income options which is less demanding. Education-wise, most of the farmers had attained a secondary level which pre-supposes that they can follow instructions leading to proper bird management. A few mentioned having received professional training through vocational training. Sindiyo and Missanga (2018), in their studies, found that almost half of the farmers had basic primary education, some informal education, and the rest had secondary and post-secondary education. Their findings confirm to a certain extent the results of this study, in that in Tanzania, poultry farming activities especially commercial types require some level of literacy, contrary to the farming of local chickens where requirements are much less. It was also common to find of the broiler farmers had other activities in addition to broiler production. These secondary activities included agriculture, commercial activities (general human food or agro-veterinary shops), institutional jobs (State officials, agricultural or veterinary agents, etc.), and many others. These various activities would be complementary sources of income for these farmers.

Although many of the respondents had never had training in the technical management of a poultry farm and biosecurity within a farm, almost all of them knew roughly what biosecurity could mean. According to them, biosecurity was a way of preventing diseases from entering the broiler

flock and was essentially limited to keeping the building and equipment (drinkers, feeders) clean, vaccinating the animals, and treating them in case of diseases. For others, these practices could be supplemented by the installation of a footbath at the entrance to the hen house, the regular removal of litter, and isolating sick chickens from healthy chickens. These results corroborate the findings of Komba (2017) who concluded that the use of a footbath at the entrance of poultry houses for example, and the isolation of diseases on most farms reflected a certain degree of awareness of biosecurity. Moreover, our findings implicate that knowledge of biosecurity seemed to be limited and often farmers carried out their production activities without in-depth knowledge of the field of broiler production. As such it is more likely to expose their flocks to diseases (Mahmoudi et al., 2015; Sindiyo and Missanga, 2018).

Although farming groups or associations, especially women groups do exist in many parts of the country (EKN, 2020) including having a national association of broiler farmers (source), our results showed that more than half of the broiler farmers sampled were not members of any producer groups or associations. Such associations are deemed to be critical for the success of the sub-sector and save as a platform where farmers can resolve challenges and exchange information on good practices including market linkages. Thus, the acquisition of new knowledge relied on farmer-to-farmer or farmer-to-veterinary/agricultural agents which were again irregular. Only a minority of farmers mentioned having regular contact with veterinary or agricultural service agents. The reasons that could justify this low level of contact are among others: the low coverage of the national animal health service, few public and private agencies, and the inadequacy of extension services (MLF, 2019; TLMP, 2017; Msoffe et al., 2018).

Despite the challenges, it appears that farmers have accumulated experience through trial and error whereby the average experience in raising broilers was found to be about 9.6 years. Most of the broiler farms visited during this study were located in peri-urban and urban areas. This finding aligns with the earlier studies carried out in Tanzania (MLD, 2006; MLF, 2019) that found that commercial poultry production in Tanzania takes place mainly in peri-urban and rural areas, and sometimes in urban areas. Proximity to the market is the main reason for the choice of location but also access to inputs such as feeds and medicines. The farms were also owned by the household implying that they had deliberately chosen the location for production. This is in support of the findings of Msami (2000) and Msoffe et al. (2018) who reported that irregular contact, sometimes not at all with the agents of the veterinary or agricultural services depends on proximity to services centers.

In addition to broiler production, more than half of the farms visited housed other animal species. These animal species were among others local chickens, layers, common ducks, geese, pigeons, beef, sheep, goats, and rabbits. Some farms had several of these animal species in their farms. Several authors had made the same observation (Msami, 2000; Komba, 2017; Sindiyo and Missanga, 2018; MLF, 2019). According to some previous studies (de Glanville et al.,2020; Orounladji et al., 2022), the sale of products derived from livestock (animal production) allowed households in rural areas to make up additional income. These animals could also play a social role (local consumption, customary practices, religious, etc.) and production (manure) for the producers who raised them (Wilson, 2015; Coulibaly et al., 2018; Orounladji et al., 2022). However, a mix of species such as layers, local chicken, and ducks can pose a biosecurity risk.

On average, broiler mortality could reach 11.7% and the main causes mentioned by the farmers themselves were avian pathologies, fragility or physical malformation of Day-Old Chicks (DOC), environmental factors (cold, heat, dust), accidental steps on chickens and overcrowding. This mortality rate encountered in broiler farms in the Pwani region is closer to the value of 13.8% reported by Mahmoudi et al. (2015) in Algerian broiler farms. Some previous studies (Msami, 2000; MLF, 2019) found similar results on local chickens in Tanzania. The high mortality rate as reported in the current study could be associated with the characteristics of the farms (for example the lack of hygiene of the buildings, the accumulated deep litter) and the farmers (limited knowledge and skills) which could reduce broilers' performance (Msami, 2000; Douifi et al., 2011; Swai et al., 2013; Mahmoudi et al., 2015; Coulibaly et al., 2018; Sindiyo and Missanga, 2018).

Generally, broiler farmers in the Pwani region had partially adopted biosecurity measures or practices on their farms based on four risk stages of adoption on 7 risk stages. These are the quality of agricultural inputs, management of traffic around the farm, biosecurity at the poultry house door, and management of the health of broiler chickens. Indeed, all sampled households had approximately the same biosecurity practices within their farms. All farmers sourced DOC from local hatcheries, although sometimes surveyed farmers did not approve of the quality of DOC (FAO, 2007a). Some farmers had admitted to accumulating the deep litter over the entire period or several weeks before removing it, while others had claimed to renew the litter every week. But on most of the farms visited, the litter was either wet or or too dusty providing a breeding ground for diseases such as coccidiosis.

Most often, the farmers sampled during this study had at

least two batches of broilers of different ages either on the same farm or in the same breeding building. Traffic control was generally poor as most houses lacked fencing, hence allowing uncontrolled movement around the bird's house. Clothing protection was only limited to changing shoes. However, all the breeders had affirmed to restrict access to the farms, especially poultry houses, to the employee and/or the owner only. Very few (5 respondents out of 78 sampled) of the farms visited had functional footbaths (containing water and disinfectant, changed regularly) at the entrance to the henhouses. Regarding disease prevention, all respondents vaccinated their broilers against Newcastle and Gumboro diseases, but none were vaccinated against Highly Pathogenic Avian Influenza (HPAI). Not vaccinating animals against HPAI could be because Tanzania is so far free of HPAI even though there are potential risks for introducing this virus into the Tanzanian poultry flock (FAO, 2007a).

According to some farmers, the obstacles to the implementation of biosecurity practices were the lack of financial means for the purchase of drugs and disinfectants, for others, it was the negligence of the employee or members of the family in charge of raising broiler chickens. Only a minority of farmers admitted to not applying biosecurity because they had limited knowledge of biosecurity practices on a farm. But more than half of the farmers mentioned not encountering any difficulty in implementing biosecurity measures on their farms. Yet the level of adoption, in general, was average, which showed that broiler farmers in the Pwani region were aware of the need to apply biosecurity measures in their farms. These findings could therefore indirectly impact the production performance of broiler chickens, such as the high mortality rate that was recorded in the surveyed farms. Financial difficulties were also mentioned by farmers in previous studies by Mahmoudi et al. (2015) and MLF (2019). Indeed, actions such as having different ages, sick animals, and healthy animals in the same livestock building, raising several animal species on the same farm, accumulating or leaving used litter near poultry houses, or even having livestock farms close to each other could be means of spreading germs quickly and contaminating healthy animals (Msami, 2000; TLMP, 2017). This implies that the appearance of most avian diseases was linked to poor biosecurity, the absence of solid progress in disease control, and inadequate advice from animal health professionals.

CONCLUSION

This study concludes that practices of biosecurity in the Pwani region (Tanzania) were moderately applied indicating some degree of awareness to control the disease. However, additional technical knowledge on broiler management, with greater emphasis on biosecurity as well as less costly but effective biosecurity measures, needs to be provided. In addition, extension agents or veterinarians need to work closely with the farmers and advise them accordingly.

ACKNOWLEDGMENTS

The authors thank the Partnership for Skills in Applied Sciences, Engineering & Technology Regional Scholarship and Innovation Fund, the Sokoine University of Agriculture through the Department of Animal, Aquaculture and Range Sciences and Southern African Centre for Infectious Disease Surveillance Foundation for One Health, as well as the staff of the Service in charge of Livestock officers of Kibaha and Mlandizi townships.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

The first draft of the manuscript was written by [Rogia Saïdath Adéline Gomez] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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