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Determinants of exotic chick morbidity and mortality Kept in small-scale commercial chicken farms in Bahir Dar, Northwest Ethiopia

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ABSTRACT

A longitudinal study was conducted on exotic chicks 'morbidity and mortality in small-scale chicken farms in Bahir Dar, Ethiopia. A total of 10006 from day-old to 45 days old exotic chicks from five small-scale farms were monitored for clinical health problems. Data on potential risk factors were collected using personal observations, postmortem examination, and laboratory analysis. Survival analysis was employed to model the presumed explanatory variables. The overall crude exotic chicken morbidity and mortality risk rates were 6.58% and 6.4%, respectively. The incidence and risk rate of chicken diseases were spraddling leg (15.08%, 0.99%), cannibalism (7.54%, 0.51%), ascites (6.77%, 0.46%), omphalitis (4.77%, 0.32%), avian salmonellosis (2.46%, 0.19%), avian mycoplasmosis (1.08%, 0.10%), respectively. Among the risk factors investigated, the experience of an attendant (HR= 2.45, P ≤ 0.001), source of day-old chick (HR= 2.64, P ≤ 0.001), attendant (HR= 0.41, P ≤ 0.001), and breed (HR= 2.35, P≤ 0.001) were found significantly associated with the incidence of crude morbidity and mortality. "Avian salmonellosis and avian Mycoplasma galisepeticum 30.7% and 14.8%, respectively, were confirmed based on serological tests. In conclusion, the morbidity rate and mortality rate of chicks were found to be higher than the economically tolerable level. Therefore, it is advised that further interventions be made against the identified pathogens and risk factors for chicks' morbidity and mortality that have been discovered.

1. INTRODUCTION

Livestock production in Ethiopia contributes 15 to 17% of the total gross domestic product, 35 to 49% of agricultural GDP, and 37 to 87% of the household incomes (EGDP, 2017). However, the contribution of poultry to the Ethiopian economy is only 2-5% of the potentiality of 56.06 million chickens (Dawit et al., 2017). Currently, in Ethiopia, there is a high demand for chicken meat and egg due to a substantial increase in the price of beef, mutton, and a growing population that can't be achieved by local chickens (Tadelle et al., 2013). As a result, the livestock master plan of the Ministry of Agriculture has been targeted to upgrade village chicken production by using exotic chickens to raise chicken meat production from 2.9 thousand tons to 10.2 thousand tons, and egg from 258 million to 894 million tons (Shapiro et al., 2015). Exotic chicken breed affected by various types of diseases made the situation worse, which is susceptible to several diseases that plague the chicken industry today (Tewodros, 2019). According to CSA, (2020), chicken mortality and morbidity in Ethiopia due to disease is 34% and 42.04%, respectively

In this regard, different researchers have investigated numerous determinant factors in chicken morbidity and mortality such as pullorum (Markos and Nejash, 2016), Avian mycoplasma (Adamu et al., 2017; Jibril et al., 2018), fowl typhoid considered to be the most important chicken disease reported in different parts of Ethiopia. Amhara National Regional State has given great attention to exotic chicken production to stabilize food security and increase job opportunities through organizing youth groups under small-scale chicken production systems. However, the expansion of small-scale chicken farms was intercepted as a result of the widespread occurrence of chicken diseases within poultry farms (Mohamed et al., 2018; Gebrewahd et al., 2017).

A comprehensive study on epidemiological determinants of exotic chicken morbidity and mortality using longitudinal study design has been scarce, especially in the present study area, where small-scale exotic chicken production is flourishing. Therefore, the objective of this study is to determine the prevalence of major economically important chicken diseases, determine the incidence rate, investigate determinant factors influencing exotic chicken morbidity and mortality rates in a small-scale production system

2. MATERIALS AND METHODS

2.1. Study area description

The study was conducted in Bahir Dar City, Northwestern Ethiopia, which is the capital of the Amhara National Regional State. The area is located at latitude 11. 5936° to 11° 35' 37.1" North, longitude 37. 3908° or 37° 23' 26.8" East, about 552-kilometer Northwest of the Ethiopian capital, Addis Ababa. It is located at an altitude of 1,820 meters (1819.7m) above sea level, which receives an annual rainfall of 1200-1600 mm with an average temperature from 10 to 38^{0}C.

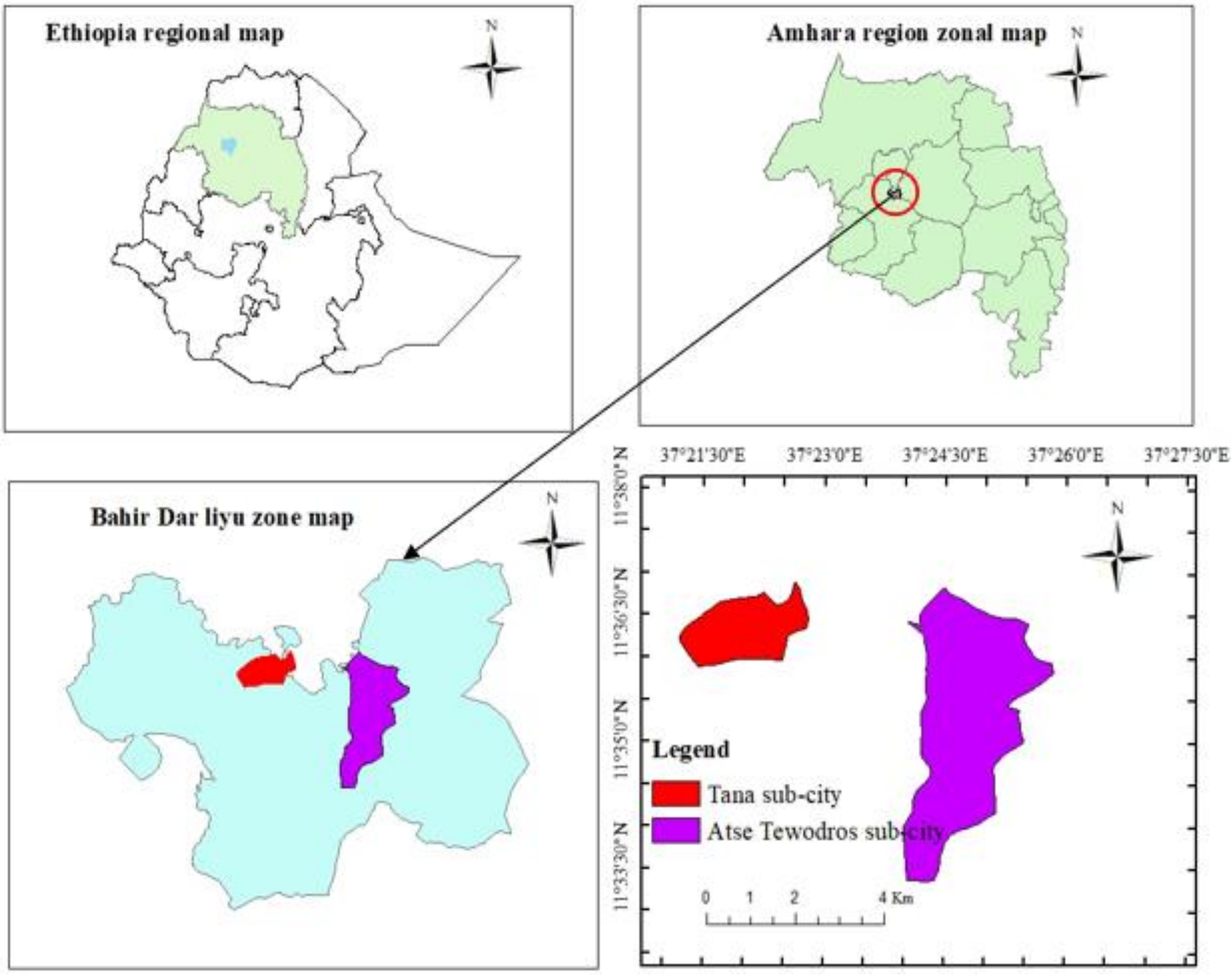

Figure 1: Map of the study area

2.2.Selection of study farms

A total of five small scale farms were enrolled, which were organized in youth group and actively engaged in chicken rearing. They received technical training on chicken production before starting rearing by the Bahir Dar City administration Micro and Small Enterprises Development Office.

2.3.Study population and sampling technique

A total of 10006-day old exotic chicks were investigated. A list of small-scale chicken farms was obtained from Bahir Dar City Administration Small and Micro Enterprise Development Office. Purposive sampling procedures were employed to select representative farms based on the availability of small-scale chicken farms and willingness of producers for the frequent follow-up study.

2.4.Study design

A longitudinal study was employed from October 2020 to February 2020. Leg bands were used to identify the individual chicks and monitored throughout the study period. For this study, five farms were engaged and regularly visited to record management practices and occurrence of health problems. Observed chick health problems during the follow-up period were individually recorded based on their clinical signs, postmortem finding, and laboratory investigation.

2.5.Data collection method

Follow-up data collection was conducted for 45 days. Daily data collection formats were given to farm attendants to record any event exhibited by each chick in the respective study farms such as flock size, health problems, the number of sick and dead chick', additions, and withdrawals of chicks. Diagnosis of chicken disease observed in sick and dead chick during the follow-up period was, examined using case history, clinical sign, and laboratory analysis. Blood was collected from sick chicken and approximately 2ml of blood was taken from brachial veins using a syringe with 23-Gauge hypodermic needles. The syringe was tilted on a table for 24hours at room temperature to allow clotting for easily separating plasma (Pires et al., 2012). Then sera were filled in cryovials tubes with a specific code number for each chicken and kept frozen at – 20ºC until analysis. A total of 99 (52 salmonellosis and 47 Avian mycoplasmas) suspected serum samples were transported in a cold chain container to National Veterinary Institute (NVI) for slide agglutination (SAT) and ELISA tests respectively.

The SAT using undiluted polyvalent salmonella antiserum was used to diagnose salmonella by depositing the same 25µl volume of serum and antigen per test. After mixing the two liquids exactly for 2 minutes by using agitator, reading was done within 30 seconds. Visible aggregates were indicative of positiveness. ELISA test was used to detect specific antibodies against *Mycoplasma gallisepticum*. A final serum dilution of 1:100 was used, according to the instructions of the manufacturer. All serum samples collected from each chicken were run on the same test plate to prevent conclusion errors that could be due to day-to-day variation in the test. Positive and negative reference controls provided by the manufacturer were also used in each test run, for quality control and to confirm the results. Optical density values were set at a wavelength of 405 nm, using an ELISA reader.

*2.6.*Data management and analysis

Univariate and multivariable cox-regression was employed using Stata Statistical Software: Release 14 to examine and quantify the association between explanatory variables with chicken morbidity and mortality. The associations between explanatory variable and outcome variables were done by Cox's proportional hazard model. Incident density was calculated by dividing the number of diseases cases or deaths to the number of chick days at risk (Muraguri et al., 2005). Number of chick days at risk was calculated by adding the number of days that each chick stayed in the study group excluding days obtaining a new case in each chick or the days of removal from the study group. As directly taking true rate results tend to overestimate morbidity, mortality and other specific disease conditions were converted into risk rates based on the formula $RR=1-e^{-\text{True Rate}}$(Martin et al., 1987; Gitau et al., 2010; Yeshwas, 2015; Wudu, 2007).

In determining crude morbidity rate, a chick completely recovered from an illness was considered as a chick at risk for another illness and even to the same type of illness. As far as the second symptom of disease occurred after the disappearance of the clinical sign of the first disease was considered as different cases in calculating the incidence rate. In this case, the days in which the chick stayed ill were not counted as days at risk for the second occurrence.

2.7.Survival analysis and investigation of risk factors

First, the Kaplan–Meier method was employed to estimate the hazard function of observed hazard differences for different explanatory variables with morbidity and mortality. However, Kaplan–Meier graph doesn't allow saying, with any confidence, whether or not there is a real difference between the groups (Hosmer and Lemeshow, 1999). The probability of obtaining the observed hazard curves was evaluated by the Log-rank test at $P<0.05$. Furthermore, Cox's proportional hazard model was used to evaluate and quantify the association between explanatory variables. Investigation of risk factors related to chick health problems were done by considering a total of 16 potential risk variables. The responses of all variables were dichotomized carefully to make the cut-off points reasonable, facilitate analysis and interpretation of results. In the analysis, only the first occurrence of cases was considered. Initially, the association of individual risk factors with an outcome variable was screened. Those variables significantly associated with the outcome variable at a 5% significance level in the univariate analysis were selected for multivariable analysis using Cox regression to ensure their independent effect. In the multivariable analysis, a model was fitted for each outcome variable by stepwise backward elimination of insignificant variables ($P>0.05$).

3. RESULTS AND DISCUSSION

3.1.Chick morbidity and mortality

During the study period, a total of 10,006 chicks were employed for this study from five (5) small-scale chicken farms, in Bahir Dar City. The only chicken health service provided for small-scale chicken producers were Newcastle disease vaccine and infectious bursal disease from day-old chicken suppliers. Among, all chicken studied, 4490 (44.90%) were Koekoek, 3300 (32.98 %) Bovans Brown, and 2216 (22.15%) SassoT-44. About 93.5% of chicken were completed the follow-up period and the remaining (6.37%) lost the follow-up due to death. Among total chicks observed, 650 chicks (6.5%) were sick. Out of 650 sick chicks, 637 (98%) were dead and only 2% recovered from the disease during the follow-up period. This indicates the probability of sick chicken between 0 to 45-day old age to recovered from the disease was very low. The present study revealed that the crude exotic chick morbidity and mortality rates in the study area were 6.5% and 6.3 %, respectively (Table 1).The present incidence of crude morbidity and mortality findings were found higher than the Western standard, normal (≤ 1.2%) or high (> 1.2%) (Pereira et al 2010) as well as the expected level of mortality rate in African standards of ≤ 2.5% in broiler and 2 to 5% in layer chicken that chicken that can be achieved through good chicken health management (Boulianne et al., 2013).

The present morbidity and mortality finding was lower when compared to other previous findings in Ethiopia (Hailu et al., 2012; Uddin et al., 2012; Muhammad et al., 2010). For instance, Hailu et al. (2009) has reported the highest 45% and 29.9% of chicken mortality in sixteen districts of Amhara National Regional State and, in Andassa Poultry Farm, respectively. Uddin et al. (2012) has reported 32.38 % and 21.3% morbidity and mortality respectively in the cage system in India, and (Muhammad et al., 2010) has reported 11.41% mortality under the small scale production system in Nigeria. The variation observed among the studies might be associated with variations in the source of day-old chicken, management of chick, type of chick breed, and production system. For instance, poor health management of sick chick and extended time of day-old chicken transportation was observed in the present study of chick farms and source of day-old chick respectively.

Table 1: Causes of exotic chick morbidity and mortality across breeds under a small-scale commercial farm

Causes of morbidity	Bovance Brown		Koekkoek		SassoT-44		Overall (%)
	n	%	n	%	n	%	
Ascites	6	5.17	28	6.36	10	10.64	6.77
Omphalitis	4	3.45	17	3.86	10	10.64	4.77
Spraddle Leg	10	8.62	63	14.31	25	26.59	15.08
Avian Mycoplasmosis	1	0.86	1	0.23	5	5.32	1.08
Avian Salmonellosis	11	9.48	5	1.14	0	0	2.46
Cannibalism	11	9.48	31	7.05	7	7.45	7.54
Mismanagement	50	43.10	157	35.36	32	34.04	36.77
Unknown	23	19.83	138	31.36	5	5.31	25.54

Mismanagement = inappropriate handling chicken during feeding, watering, and vaccination. The morbidity and mortality variations observed among the present and previous studies might be associated with variations in chicken production systems, breed type used, management practice, and locations. The major chicken diseases diagnosed in the present study were mismanagement (36.77%), unknown (25.54%), spraddle leg (15.08%), cannibalism (7.54%) ascites (6.77%), omphalitis (4.77%) avian salmonellosis (2.46%) and avian mycoplasmosis (1.08%) (Table 1). Major chicken health problems found in the present study were consistent with other previous studies in Ethiopia and abroad (Selam and Kelay 2013; Mishamo 2019; Uddin et al 2012; Tirunesh and Girma 2016); Hailu et al 2012); Tadesse 2017). Higher magnitude of morbidity and mortality was recorded in Koekoek as compared to Bovance Brown and SasoT-44. The incidence of morbidity for Bovance Brown, Koekoek, and SasoT-44 was 3.5%, 9.8%, and (4.24%, respectively. Likewise, the prevalence of mortality for Bovance Brown, Koekkoek, and SasoT-44 was 3.4% 434 9.67%, and 4.15%, respectively.

Table 2: The incidence of disease conditions and causes for exotic chicks' morbidity, and mortality on small scale commercial farms

Variables	N	Chick days at risk	Chick45 days at risk	Incidence Rate	
				True	Risk (%)
Crude morbidity rate	650	430772	9572	0.0679	6.58
Crud morality rate	637	430785	9573	0.0665	6.48
Cannibalism	49	431317	9584	0.0051	0.51
Ascites	44	431310	9584	0.0046	0.46
Omphalitis	31	431353	9585	0.0032	0.32
Spraddle Leg	98	431151	9581	0.0102	0.99
Avian Mycoplasmosis	7	431391	9586	0.0013	0.10
Avian Salmonellosis	16	431326	9585	0.0016	0.19

The hazard function curve for chick morbidity and mortality indicates that the median age for chick morbidity and mortality was in 10 days. The cause of chick morbidity and mortality found in these findings were relatively comparable with various previous findings in chicken (Mishamo, 2019; Uddin et al., 2012). The incidence of crude morbidity and crude mortality rates under small-scale farming in the study areas were 6.58% and 6.48%, respectively (Table 2). The incidence of chick health problems diagnosed during the follow-up study period was spraddle leg (0.99%) followed by cannibalism (0.51%), ascites (0.46%), omphalitis (0.32%), avian salmonellosis (0.19%), avian mycoplasmas (0.10%) (Table 2).

Risk factors

The present study tried to investigate the determinant factors affecting exotic chick morbidity and mortality that were recorded from direct observation. Among sixteen, initially considered potential risk factors for exotic chick morbidity and mortality, only seven explanatory variables were associated with chick morbidity and mortality based on univariate Cox regression analysis. Additional job (HR= 0.66, P ≤ 0.001), ownership of chick attendant (HR= 0.68 P ≤ 0.002), experience chick attendant (HR= 1.46, P ≤ 0.001), source of chick (HR= 1.52, P ≤ 0.021), season of chick hatching (HR= 1.29, P ≤ 0.021) breed (HR= 2.35, P= 0.00) and arrival time (HR= 0.56, P ≤ 0.004) variables were associated with chick morbidity and mortality based on Univariate Cox regression

Table 3: Potential variables significantly associated with chick morbidity and mortality based on Univariate Cox regression

Risk Factors	Categories	Morbidity			Mortality		
		HR	95% CI	P-Value	HR	95% CI	P-Value
Additional Job	No vs Yes	0.66	0.52 - 0.83	0.000	0.64	0.51 - 0.81	0.000
Ownership*	Owner vs Hired	0.68	0.53 - 0.86	0.002	0.64	0.49 - 0.81	0.000

Experience*	≤ 2 yrs vs ≥2yrs	1.46	1.15 - 1.87	0.002	1.49	1.17 - 1.91	0.001
Source of chicken	Ethio chicken vs Hawassa	1.52	1.21 - 1.91	0.000	1.56	1.23 - 1.97	0.000
Season of hatching	Autumn vs Winter	1.29	1.04 - 1.60	0.021	1.31	1.03 - 1.66	0.025
Arrival time	Day vs Night	0.56	0.37 - 0.83	0.004	0.54	0.36 - 0.81	0.003
	SassoT-44	Ref					
Breed	Koekkoek	2.35	1.90-2.94	0.000	2.39	1.90-2.99	0.000
	Bovance Brown	1.10	0.94-1.19	0.351	0.99	0.87-1.14	0.453

** ref = reference, yrs. = Years HR = hazard rate*

However, when those significant variables at univariate cox regression were allowed to fit the multivariable cox-regression, only four explanatory variables were found significant for the final model. These include the experience of chick attendant, source of the chick, breed, and the ownership of chick attendant have a strong significant relationship with exotic chick morbidity and mortality. The hazard of chick morbidity was 2.35 times higher in the Koekoek breed as compared to the SassoT-44 breed (Table 4). Experience of chick attendant (HR= 2.45, P ≤ 0.001), breed (HR= 2.35, P ≤ 0.001) and source of chick (HR= 2.64, P ≤ 0.001) were found the most determinant factors of chick morbidity. Based on the final model, the hazard for morbidity is 2.45 times higher in those chick attendants who had below two years of farm management experience as compared to those who have more than two years of experience (Table 4). The hazard of chick morbidity was 2.64 times higher in chicks coming from Hawassa as compared to chicks from Ethio-chicken. The effects of chick breed on morbidity depicted under the following hazard function curve (Figure 2).

Table 4: Potential variables that were significantly associated with chick morbidity based on multivariable Cox regression

Risk Factors	Categories	Morbidity		
		HR	95% CI	P-Value
Experience*	≤ 2 Years Vs ≥ 2 years	2.45	1.94 – 3.11	0.000
Source of chicken	Ethio chicken Vs Hawassa	2.64	2.23 - 3.11	0.000
Ownership*	Owner Vs Hired	0.41	0.32 - 0 .52	0.000
Breed	SassoT-44	Ref		
	Koekoek	2.35	1.90-2.94	0.000
	Bovance Brown	0.82	0.62-1.07	0.154

** ref= reference, HR = hazard rate*

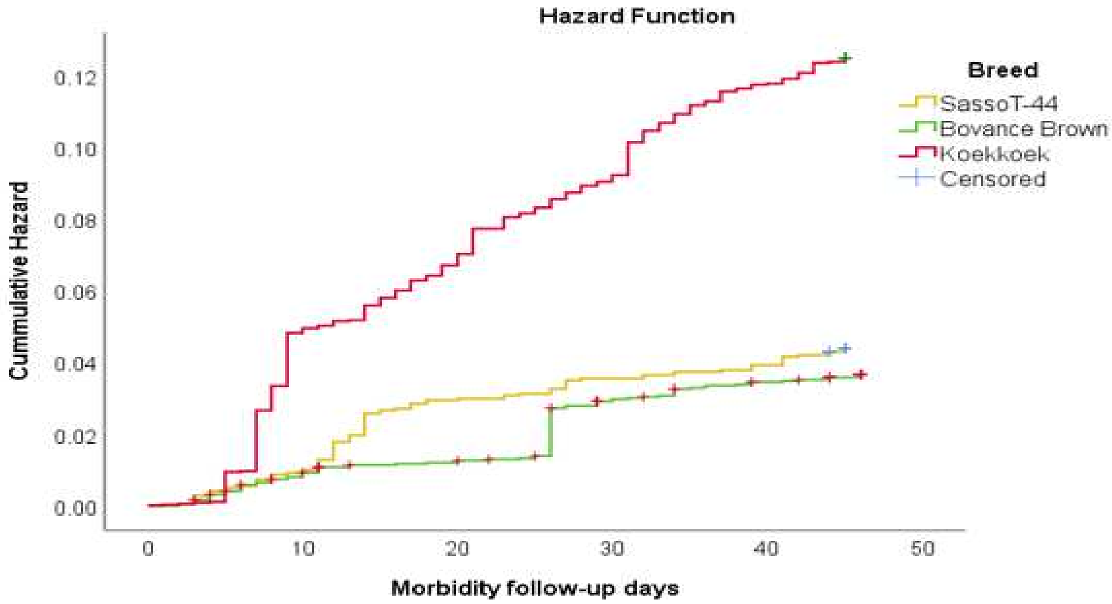

Figure 2: Hazard functions based on breed factor, of morbidity across exotic chick, breed under small scale chicken production

Experience of chick attendant (HR = 2.51, P ≤ 0.001), breed (HR=2.39, P ≤ 0.001) and source of chick (HR = 2.70, P ≤ 0.001) were found the most determinant factors of chick mortality. According to the final model, the hazard for mortality was 2.51 higher in those chick attendants who had below two years of farm management experience when compared to those who have more than two years of experience (

Table 5: *Potential variables that were significantly associated with crude mortality based on multivariable* Cox regression. The hazard of chick mortality was 2.39 times higher in the Koekoek breed as compared to SassoT-44. Likewise, the hazard for experiencing mortality is 2.70 times higher in those chicks who sourced from Hawassa as compared to Ethio Chicken (Table 5).

Table 5: Potential variables that were significantly associated with crude mortality based on multivariable Cox regression

Risk Factors	Categories	Mortality		
		HR	95% CI	P-Value
Experience*	≤ 2 Years Vs ≥ 2 years	2.51	1.98 - 3.19	0.00
Source of chicken	Ethio Chicken Vs Hawassa	2.70	2.28 - 3.18	0.000
Ownership*	Owner Vs Hired	0.40	0.31- 0 .50	0.000
	SassoT-44	Ref		
Breed	Koekkoek	2.39	1.90-2.99	0.000
	Bovance Brown	0.80	1.61-1.06	0.132

** ref = reference*

Those chicks sourced from Hawassa were more likely at risk for morbidity and mortality as compared to Ethio-chicken form Mekelle. This could be associated with an extended time of travel and mismanagement of day-old chicken during loading and unloading during night times, as flock level survey results revealed that those DOC chicks sourced from Hawassa were frequently arrived at night times due to extended time of travel. This justification is supported by Caffrey et al. (2017), who reported that the risk of chicken mortality increased as the duration of the journey increased. As reported by Whiting et al. (2007) the longer duration between loading and unloading of day-old chicken, the higher variation in the mortality risk. Moreover, the significant association between chick farm experience and ownership with chick morbidity and mortality in the present finding was not found in other previously published studies. However, such association has been reported in other species of animals. For instance, low calf mortality was observed in farms managed by more experienced managers (Heinrichs and Radostits, 2001). This suggests that owners might be motivated sufficiently to provide the care necessary to ensure high survival (Wymann et al., 2006).

Serological investigation

A serological investigation was conducted to confirm the causes of chick morbidity and mortality. Those suspected, active clinical cases during the follow-up period were partially subjected to further laboratory analysis. About 52 and 47 serum samples from salmonella and mycoplasma suspected cases were collected for laboratory analysis, respectively. Accordingly, the prevalence of avian salmonellosis was 30.7% (16/52). This finding was relatively consistent with other previous studies from apparently healthy chicken in Ethiopia (Genet et al., 2014) and lower than other some previous reports in Ethiopia and abroad (Tadesse, 2018; Minte et al., 2010; Uddin et al., 2012). Similarly, the prevalence of avian mycoplasmosis was 14.8% (7/47). This finding was relatively small as compared to some previous reports in Ethiopia and abroad (Yasmin et al., 2018; Muhammad et al., 2010; Rahman and Samad, 2003). The discrepancy between the present and previous reports on the prevalence of avian salmonellosis and mycoplasmosis might be associated with variations in various epidemiological factors; chicken breed, chicken health management, location, pathogen detection techniques, sample size, the health status of chicken, and chicken management practices.

4. CONCLUSION AND RECOMMENDATION

The overall prevalence and incidence risk rate of chicken morbidity and mortality in this study was higher than economically tolerable set as a standard. Moreover, more than half of chicken farms in the study area lack the required knowledge about the role of biosecurity, as they didn't follow proper disposal of dead chickens. As the magnitude of chick morbidity and mortality in the study area, tailor-made subsequent intervention towards the identified diseases and significant determinant factors is suggested to improve exotic chicken health. Careful handling and good health management during transportation, loading, and unloading of DOC is suggested to reduce chick morbidity and mortality. As significantly higher morbidity and mortality rates were observed from Koekoek breed as SassoT-44 and Bovance Brown, further breed specific study is suggested to verify the association between breed, morbidity and mortality. Sustainable technical training towards manipulating the identified risk factors, prevention, and control of the identified economically important chicken diseases is warranted to improve the production and productivity of chicken

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