International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
(A Peer Reviewed, Referred, Indexed and Open Access Journal)
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 10, Issue12-2023

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2023.10.12.001

Prevalence of Bovine Tuberculosis and the Associated Risk Factors in Dairy Cattle under Different Production System in Hawassa City and Yirgalem Town, Sidama National Regional State, Ethiopia

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Abstract

A cross-sectional study was conducted in Hawassa city and Yirgalem town from October 2019 to May 2020 to estimate the prevalence of bovine tuberculosis (BTB) and identify the associated risk factors in dairy cattle under different production systems and assess cattle owners' awareness of its zoonotic importance. One-stage cluster sampling method was applied to select farms and a single intra-dermal comparative tuberculin test (SICTT) was used to detect animal positive for BTB at the cut-of >4mm. Accordingly, 135 herds were selected randomly and all the cattle above 6 months of age found in the herds were included in the study. Of the 856 dairy cattle subjected to SICTT, 14.1% (121/856) were found reactive to BTB. The herd-level prevalence was 24.4% (33/135).In the mixed-effect multivariable model, the breed was the only factor found significantly associated with positive BTB reactivity ($P < 0.05$). It was noted that the odds of being reactive to BTB were 6.9 times higher among cross-bred cattle than local indigenous. Herd size, location, age, production system, source of animals, parity, body condition score, and pregnancy did not show a significant effect on the BTB reactivity. The questionnaire survey revealed that 75.4% (92/122) dairy farm owners consumed raw milk and 98.4% (120/122) owners were unaware of the zoonotic importance of bovine tuberculosis. In conclusion, this study result warrants the need for implementation of a control program at this stage to reduce the effect of bovine tuberculosis and enhance the awareness of dairy farmers on the zoonotic importance of BTB.

Keywords: Bovine Tuberculosis, Dairy Cattle, Ethiopia, Hawassa, Risk Factors.

Introduction

Tuberculosis (TB) is recognized as one of the most important threats to human and animal health causing mortality, morbidity and economic losses [1]. It is a chronic granulomatous disease caused by *Mycobacterium tuberculosis* (the agent of the disease in primates), *M. bovis* (in other mammals), and *M. avium* (in birds) [2]. Bovine tuberculosis (BTB) is a chronic bacterial disease of animals and humans characterized by the formation of granuloma in tissues and organs, more significantly in the lungs, lymph nodes, intestine, and kidneys among others. BTB is caused by slowly growing bacilli, members of the *M. Tuberculosis complex*: *M. bovis*. However, *M. bovis* is the most universal pathogen among mycobacteria and affects many vertebrate animals of all age groups including humans. Cattle, goats and pigs are found to be most susceptible, while sheep and horses show a high natural resistance [3, 4]. Bovine tuberculosis has been significantly widely distributed throughout the world and it has been a cause for great economic loss in animal production. In developed countries, it is a rarity with occasional severe occurrences in small groups of herds. In developing countries, however, such as in Africa, Asia and South America, sporadic occurrences and enzootic occurrences of BTB have been reported [5].

Bovine tuberculosis, apart from being the most important disease of intensification with a serious effect on animal production, also has a significant public health importance [6]. Although, the direct correlation between *M. bovis* infection in cattle and human populations is not well known [5], zoonotic BTB is present in most developing countries where surveillance and control activities are often inadequate or unavailable. Currently, BTB in humans is becoming increasingly important in developing countries, as humans and animals are sharing the same micro-environment and dwelling premises, especially in rural areas. At present, due to the association of mycobacteria with the *HIV/AIDS* pandemic and of the high prevalence of HIV/AIDS in the developing world and the susceptibility of AIDS patients to tuberculosis in general, the situation changing is most likely [7].

In tropical countries including Ethiopia, BTB has been found to affect a higher proportion of exotic breeds than local zebus [8]. Thus BTB is still a great concern in many developing countries and Ethiopia as a prevalent disease in cattle populations. Its zoonotic implication has also significantly indicated an increasing trend of public health hazards [9]. In Ethiopia, BTB is considered to be a prevalent disease in cattle populations where tuberculin skin test survey indicates that the prevalence ranges from 0.8% in extensive rural farming systems that keep Zebu cattle to 50% in intensive husbandry systems [10]. Today BTB remains an important disease of cattle, and wild animals, and is a significant zoonosis transmitted from animals to humans and vice versa. Many studies have shown that there are many risk factors responsible for the spread and persistence of BTB in developing countries such as demographic factors, eating habits, living and socio-economic status of families, illiteracy, culture and customs, the existence of HIV/AIDS, and close proximity with animals [11].

Ethiopian milk consumers generally prefer raw milk as compared to pasteurized milk because of its taste, availability and lower price. The zoonotic risk of BTB is often associated with the consumption (ingestion) of unpasteurized milk and other dairy products infected with M. bovis. Also, aerosol transmission from cattle to humans or vice versa should be considered as a potential risk factor [12]. According to a previous study by Regassa et al. (2008), the prevalence of bovine tuberculosis in Hawassa City is 48.7%, 11.6%, and 1.1% at the herd, individual animal, and postmortem examination respectively. Hawassa City and Yirgalem town are among the high-potential areas for dairy cattle production and raw milk consumption is widely practiced. Due to these, Regassa et al. [11] described that the area needs further investigation and the establishment of a strict controlling method to reduce the effect of BTB depending on the results of the study.

Although there are several BTB studies in Ethiopia, most of these focused on estimating its prevalence in intensively managed commercial dairy farms using tuberculin tests or postmortem examination of organs of cattle slaughtered at abattoirs. In contrast, little attention was paid to the status of the disease in cattle managed under the traditional husbandry system and to the awareness of farmers towards the public health importance of the disease. Thus, the current study was initiated to bridge these gaps following a holistic approach. Therefore, the present study attempts to address simultaneously the prevalence of the disease in intensive commercial dairy farms located in urban areas, the distribution of the disease in extensive production systems, the potential risk factors in both production systems, and also to assess the awareness of the livestock farmers about the zoonotic significance of the disease.

Objective of Study

General objective: To estimate the prevalence of bovine tuberculosis (BTB) and the associated risk factors in dairy cattle under different production systems, in Hawassa City and Yirgalem town, Sidama National Regional State.

Specific objectives:

- To estimate the prevalence of BTB in dairy farms of Hawassa city and Yirgalem town;
- To identify potentially risk factors associated with the occurrence of BTB in dairy cows;
- To asses awareness of the zoonotic importance of BTB among dairy farm owners.

Materials and Methods

The Study Area

The study was conducted in Hawassa City and Yirgalem town, Sidama national regional state. Hawassa city is located in the Southern part of Ethiopia, on the shores of Lake Hawassa in the Great Rift Valley and located 270 km South of Addis Ababa. The city serves as the capital of the Sidama national regional state and Southern national regional state and its total area is 157.21 square kilometers and is divided into 8 sub-cities and 32 Kebeles. These eight sub-cities are Hayek Dare, Menehariya, Tabore, Misrak, Bahile-Adarash, Addis Ketema, Hawela-Tula and Mehal sub-city. It is bounded by Lake Hawassa on the West and Northwest, the Chelelaka swampy area on the East and southeast, the Tikur Wuha River on the North, and the Hawela-Lida district on the South. Geographically it lies 7°03′ 43.4"N latitude and 38°28′ 34.9"E longitude and has an elevation of 1750m above sea level. The city has 9.7oc and 30.91oc annual minimum and maximum temperatures respectively and 89.25 mm average annual rainfall. The total population of the city is 343,175. From this, 176, 834 are male where as166, 576 females. The livestock resource of the city comprises 61, 123 cattle, 14,764 sheep, 17,735 goats, 5,544 equines, and 56,961 poultry. The city has 140 private and 84 cooperative small-scale dairy farms [13].

Yirgalem is a town administration in the Dale district. It is surrounded by two Shore Rivers woyima at the Mesincho side and River Gidawo at the Ganale side and located 313 kilometers south of Addis Ababa and 40 kilometers south of Hawasa in the Sidama regional state. The town is geographically located at 6°45′to 38°25′ latitude north and 6.750°to 38.417° longitude east and at an elevation of 1776 meters above sea level. The total population of Yirgalem town is 43,815 based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia [14]. In the town, there are 39,904 cattle population. Of this 24,880 are local cattle and 15,024 are cross and there are also 64 smallholder dairy farms. The annual minimum and maximum temperature are 5.1o and 27.4oc respectively and the town receives 247mmHg average annual rainfall [15].

From Hawassa city, Addis-Ketema, Misrak, Tabor, and Tula sub-cities and six Kebeles such as Dato-Odahe, Chaffe, Hiteta, Philadelphia, Addis- Ababa and Gameto-Gale were selected. Awaada, Mesincho, Tula and Mehal-ketema kebeles were selected from Yirgalem town. In both study areas, the selection of Kebeles was based on the availability of dairy cattle population.

Study Population

The study population was dairy cattle in the study sites managed under intensive, semi-intensive, or extensive husbandry practices. Specifically, the study population consists of animals above 6 months of age in randomly selected dairy farms. The breed of the study animals was either crosses of Holstein Friesian and Zebu, crosses of Jersey and Zebu, or pure Zebu.

Study Design

The study design was cross-sectional and the study was conducted from October 2019 to May 2020 in Hawassa City and Yirgalem town.

Sampling Method and Sample Size Determination

One-stage cluster sampling strategy was used. Volunteer herds with herd sizes of greater than 20 cattle were selected without any prerequisite in all the sites as they were few in number, while herds with fewer than 20 animals were recruited by a lottery system among the list of dairy herds obtained from local agricultural agents. Within the selected herds, all female animals greater than 6 months of age were subjected to a comparative intra-dermal tuberculin test.

The sample size required for the study was calculated using the technique described in Thrusfield [16], for one-stage cluster sampling as indicated below. For this purpose, a herd level prevalence of 48.7% was obtained from a previous study in Hawassa city smallholder dairy farms [11], an average number of 10 animals per farm (cluster), 95% confidence level, and 5% absolute precision were considered.

$$g = \frac{1.962 \text{ x } (nVc+P\ (1-P)),}{nd^2}$$

Where,

g = number of clusters (herds) to be sampled;

n = predicted average number of animals per cluster; Pexp = expected prevalence;

d = desired absolute precision; Vc = between-cluster variance.

Cluster variance (VC) was calculated as follows:

S.D (standard deviation) = $(Pexp)^2 = (0.487)^2 = 0.237$ Cluster variance (VC) = $(S.D)^2 = (0.237)^2 = 0.056$

Using the above formula, the sample size computed was 122 clusters (dairy farms). However, due to the small number of cattle in most of the farms identified, the sample size was increased to 135 farms. Accordingly,856 dairy cattle present in the selected farms in both study areas were included in the study. The sample size was allocated proportionally to Hawassa city and Yirgalem town based on the number of dairy farms available in the areas. Firstly dairy farms were listed according to data obtained from the Livestock and Fisheries Department of the respective town. Then the required numbers of dairy farms were selected from the list by a simple random sampling technique using a lottery system. In the selected farms, all eligible animals except those less than 6 months of age, pregnant cattle near to term, and recently delivered cows, were included for the tuberculin test. Various information regarding the potential risk factors for the occurrence of BTB, including sex, age, pregnancy, breed, body condition, management type, and herd size of the animal was recorded in the selected dairy farms in data recording format.

The age of the animals was determined based on farm records or information obtained from owners. Body condition scoring was performed according to the technique described by Nicholson and Butterworth [17], for Bos indicus (zebu) cattle. The three main conditions - Good (G), medium (M), and lean (L) were considered. L (Transverse processes project prominently, neural spines appear sharply), M (Animalsmooth and well covered; dorsal spines cannot be seen, but are easily felt and G (Heavy deposits of good clearly visible on tail-head, brisket, and cod; dorsal spines, ribs, hooks, and pins fully covered and cannot be felt even with firm pressure) [17].

Materials

The materials used for this study during CIDT were a digital caliper, insulin syringe, blades, scalpel handle, detergents, sample bottle, cotton, gloves, gauze, rope, and bovine (M. bovis, strain AN5 3000 IU/ml) & avian PPDs (M. aviumsubspavium, strain D4 ER 2500 IU/ml), boot, overall or gown.

Methodology

Comparative intra-dermal tuberculin test (CIDT). CIDT was applied to 856 dairy cattle selected from intensive, semi-intensive, and extensive smallholder dairy cows. Prior to injection, the two injection sites around the middle of the neck region were cleaned and shaved. A fold of skin thickness within the shaved area was measured with calipers and recorded. A 0.1 ml needle, and graduated syringe of tuberculin were inserted obliquely into the deeper layers of the skin intradermally. The dose of tuberculin injected was 150 and 125 International Units (IU) or 0.1 ml of bovine and avian tuberculin respectively on two different sites on one animal. The distance between the two injection sites was approximately 12 cm. Perfect injection was checked by palpating a pea-like small nodule on the injection site. The skin-fold thickness of each injection site was measured before injection and 72 hours after injection. If the difference between skin thickness at the bovine site of injection and the avian site of injection after 72 hours is 2 mm, between 2 mm and ≤4mm, or >4 mm, the animal was classified as negative, doubtful (inconclusive), or positive for BTB, respectively [18]. A herd with at least one positive reactor considered as ‘‘PPD positive’’

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Questionnaire survey.

A total of 122 farm/herd owners (96 from Hawassa city and 26 from Yirgalem town) were interviewed using pre-tested structured questionnaires to collect information about issues related to the production system, housing, feeding and watering frequency, history of BTB occurrence in the herd, awareness about BTB, milk selling, raw milk consumption and human TB history. Each voluntary farm owner or attendant was interviewed in the local languages (using Amharic or Sidamic) depending on the preference of the respondent at the time the CIDT was done.

Ethical considerations

The farm owners selected for the study were informed why they were chosen and what the purpose of the research was. All skin testing and data collection were reliant on the willingness of herd owners and/ or managers following elaboration of the study purpose, adverse effects, and benefits of the research. As part of the survey, the BTB testing team also treated sick animals in the herds with antibiotics, anthelminthic drugs, and disinfectants and the team also advised owners on their cow’s management and the way they can improve productivity. The participants were allowed to consider their participation and given the opportunity not to participate in the study if they wished to do so.

Data analysis

Data collected through questionnaire survey and CIDT were entered into a Microsoft Excel spreadsheet and then exported to Stata 14.2 statistical software (Stata Corp, 4905 Lake Way Drive, College Station, Texas) for analysis. The animal-level prevalence of BTB was calculated by dividing the number of PPD-positive animals by the total number of cattle tested while herd-level prevalence was determined by dividing positive herds by the total number of herds tested. A herd was denoted positive if at least one animal reacted positively to PPD injection during a single CIDT. Possible risk factors for BTB were selected using univariable random effect logistic regression analysis with farm ID as a random effect to account for clustering at the herd level. All variables having p-value <0.25 in the initial univariable analysis were further checked for co-linearity using Kruskal gamma statistics before multivariable analysis, and those variables whose gamma value ranged between −0.6 and +0.6 were considered in a multivariable logistic regression model. During multivariable random effect logistic regression analysis, all non-significant variables were removed sequentially by backward elimination where the model with the lowest Akaike Information Criterion (AIC) value was chosen as the best model. At every step during model development, the confounding effect of potential factors such as herd size and location was assessed by checking for changes in coefficient estimates, and changes >25% were considered to indicate confounding [19]. In all analyses, confidence levels were calculated at

95% and a P value < 0.05 was used for statistical significance level.

Results

Herd and Animal Level Prevalence of Tuberculosis

Out of the total 135 herds tested by single CIDT, 33 (24.4%) had one or more cattle reactive to bovine PPD at a 4mm cut-off point. The prevalence of BTB in individual herds ranged from 0% to 100%. The animal level prevalence was 14.1% (121/856) (Table 2).On the other hand, the change in skin thickness was found greater at avian PPD injection sites than at bovine PPD infection sites in 55.4% (474/856) cattle showing that these animals are positive for Mycobacterium spp other than M. tuberculosis complex.

Table 1. Herd and animal level prevalence of bovine tuberculosis in Hawassa and Yirgalem.

Herd level Prevalence				**Animal level prevalence**		
Study Area	No tested	No Positive	Prevalence (95% CI)	No tested	No Positive	Prevalence (95% CI)
Hawassa	109	18	16.5(.10-.25)	659	89	13.5(.11-16)
Yirgalem	26	15	57.7(.37-.77)	197	32	16.2(.11-.22)
Total	135	33	24.4(.17-.33)	856	121	14.1(.12-.17)

Risk Factors for Bovine Tuberculosis

About nine potential risk factors were evaluated for their effect on the presence of tuberculosis in cattle using invariable random effect logistic regression analysis.

From these, herd size, breed, parity, and production system had p < 0.25 and were thus selected for multivariable analysis (Table 3). Co-linearity was checked between variables before multivariable analyses. Accordingly, the production system was dropped from multivariable analysis due to collinearity with the breed (gamma = -0.99). The final multivariable model showed that breed was the only predictor of tuberculin reactivity in the dairy farms investigated. Accordingly, the odds of finding an animal with a positive PPD result were significantly higher among cross-bred cattle than the Zebu breed (OR = 6.9; P < 0.001). Herd size showed no significant association with BTB prevalence in multivariable analysis. However, the role of herd size as a confounder was investigated by fitting models for BTB prevalence with and without herd size included. None of the coefficients for the other variables changed substantially when herd size was excluded, so we concluded that any confounding effect of herd size was minimal.

Table 2. Univariable random effect logistic regression analysis of risk factors for bovine tuberculosis in Hawassa and Yirgalem dairy farms.

Variable	No cattle tested	NoPos	Prevalence (%)	OR	95%CI for OR	P
Location						
Hawassa	659	89	13.5	Ref		
Yirgalem	197	32	16.2	1.0	0.6-1.6	0.822
Age						
<2	56	23	14.7	Ref		
2-4	196	19	9.7	0.8	0.4-1.4	0.48
4-7	251	48	19.1	1.7	0.1-2.8	0.42
>7	253	31	12.2	1.2	0.7-2.2	0.48
Herd size						
1-5	162	6	3.7	Ref		
6-10	112	14	12.5	5.3	0.14-0.35	0.000
>10	582	101	17.35	6.4	0.73-0.89	0.009
Breed						
Local	206	5	2.4	Ref		
Cross	650	116	17.8	6.9	3.1-15.1	<0.001
Parity						
Calf& Heifer	396	45	11.4	Ref		
1-2	241	37	15.4	1.4	0.9-2.3	0.144
3-5	194	36	18.6	1.8	1.1-2.9	0.017
>5	25	3	12.0	1.1	0.3-3.7	0.926
BCS						
Good	139	16	11.5	Ref		
Moderate	694	105	15.1	1.4	0.8-2.4	0.271
Poor	23					
Pregnancy						
No	710	100	14.1	Ref		
Yes	146	21	14.4	1.3	0.8-2.1	0.226
Source						
Home	823	117	14.2	Ref		
Purchased	33	4	12.1	0.8	0.3-2.4	0.735
Production System						
Extensive	192	5	2.6	Ref		
Sem-intensive	88	11	12.5	8.3	2.9-23.5	<0.001
Intensive	576	105	18.2	9.7	3.9-24.2	0.204

Table 3. Best-fit multivariable model for risk factors associated with animal-level BTB prevalence using mixed effect logistic regression modeling with farm as random effect.

Variable	OR	95% CI for OR	SE	Z	P
Breed					
Local	Ref				
Cross	6.9	3.2-15.7	0.62	2.33	0.020
Constant	0.003	0.001-0.01	0.002	-7.51	<0.001

Demographic Characteristics and Knowledge, Attitude, and Practices of Dairy Cattle Owners towards BTB Out of 122 dairy farmers interviewed, 100 (82%) were male while 22 (18%) were females. Fifty-seven (46.7%) of the respondents were 18-35 years old, 55 (45.08%) were 36-55 years while 10 (8.2%) of them aged above 55 years. Regarding their knowledge about BTB, only 2 (1.6%) respondents explained that they had heard about BTB and thus, were aware of the zoonotic importance of BTB. A total of 92 (75.4%) respondents used to drink raw milk and only 1.6% and 7.4% knew that BTB could be transmitted by consuming raw milk and raw meat, respectively. On the other hand, 45.1% of respondents had shared a house with their animals and therefore, are at risk of getting BTB from their animals due to sharing similar dwelling houses.

The awareness of the respondents regarding BTB and the transmission of BTB from cattle to man improved as the educational background of the respondents increased. As shown in Table 5 below, those respondents their educational statuses above degree were aware of BTB and its zoonotic implication 15 %(2/13) which was 1.6% of the total respondents.

Table 4. Assessment of dairy cattle owners on awareness of public health importance of BTB at study area (N = 122)

Factors	No of respondents	Category	Frequency	Percentage (%)
Knowledge about transmission of BTB through raw milk	122	Yes	2	1.6
		No	120	98.4
Knowledge about transmission of BTB through raw meat	122	Yes	9	7.4
		No	113	92.6
Habit of raw milk drinking	122	Yes	92	75.4
		No	30	24.6
Inspection of meat by Veterinarians during slaughtering	122	Yes	0	0
		No	122	100
Owners share house with cattle	122	Yes	67	45.1
		No	55	54.9

Educational Status	Illiterate	21	Yes	0	0
			No	22	
	Basic writing and reading		Yes		0
			No		
	Primary (Grade 1 to 6)	22	Yes	0	0
			No	22	
	Junior secondary (grade 7 to 8)	36	Yes	0	0
			No	36	
	Secondary (Grade 9 to 12)	19	Yes	0	0
			No	19	
	Diploma	11	Yes	0	0
			No	11	0
	Degree and above	13	Yes	2	15.4
			No	11	

Discussion

The present study aimed to investigate the animal and herd-level prevalence of BTB and the potential risk factors in indigenous Zebu and cross-bred cattle. The study revealed that the individual animal level prevalence was 14.1% (121/856)(95%CI,0.12-0.17).The present result is higher than figures reported by previous studies such as11.6%, 8.8%, 5.8% and 3% reported by Regassa *et al*. [11], Biffa *et al*. [20], Tekle *et al*. [21] and Mekonnen *et al*. [22], respectively in different years. However, prevalence higher than the current study result has also been reported by some studies from different areas of Ethiopia. For example, Regassa [9], Shitaye *et al*. [23], Tigre *et al*. [24] and Kemal *et al*. [25] have reported a prevalence of 16.2%, 18.7%, 21.4% and 30.3% and 50% respectively. The current herd level prevalence (24.4%) is lower than previous figures of 45.9% Regassa *et al*. [26], 48.7% Regassa *et al*. [11] and 38% Mekonenn *et al*. [22] reported from central Ethiopia, Hawassa city and Mekele town respectively. However, it is higher than the herd level prevalence of 15%, 20%, 12.5% and 7.4% reported by Ameni and Erkihun [27], Zeru *et al*. [28], Zuru *et al*. [29] and Alelign *et al*. [30], in Adama town, Mekele, Bahir Dar and rular villages of Gondar Zone respectively.

In the multivariable logistic regression analysis of potential risk factors, the breed was the only factor that remained significantly associated with PPD reactivity. The prevalence of BTB was significantly higher among the crossbred cattle than local indigenous. The likelihood of positivity to the PPD test was 6.9 times higher among the crossbred cattle than local cattle. This is due to cattle of Bos Taurus (European breeds) becoming stressed when they are kept in a more hot and overcrowded environment which can be expressed as a possible explanation for the high prevalence of BTB in the area [4, 31]. The result of the present study concurs with the above author's idea where we found the prevalence to be 2.4% in local breed cattle whereas 17.8% in cross-bred cattle from Holstein Friesian and local breed.

In this study, fewer reactor animals were recorded in the younger age groups (<2yrs, P=14.7%), and reactivity to the CIDT test increased up to 4 years of age (19.1%), after which it declined. However, the variations among the different age groups were not statistically significant (p>0.05). It is possible that the infection may not become established in young animals, but as they get older, their chance of acquiring infection also increases due to the increased time of exposure. As quoted by Regassa et al. [11], Tizard [32], stated that the lower response to intra-dermal tuberculin test in older animals is due to immune depression occurring during old age or poor body condition. Moreover, Dinka and Duressa [33], quoted Pollock and Neill [34], who further argued and explained the late occurrence of Mycobacteria disease in that it can remain in a latent state for a long period in an infected animal before reactivation at an older age.

In the univariable analysis, a significantly higher prevalence of BTB was observed in dairy farms with intensive or semi-intensive management systems than those extensively managed but this was not evident (p>0.05) in the multivariable model. This is due to the confounding effect of the breed. It was noted that 98% of cattle in the intensive and sem-extensive farms were cross-bred having a higher proportion of exotic bloodlines while all of the cattle in extensive herds were local Zebu breeds.

Assessment of the level of awareness of cattle owners about BTB showed that only 2 (1.6%) of the respondents out of 122 knew that cattle can be infected by tuberculosis of heard about BTB, and 9 (7.4%) recognized that BTB can be transmitted through raw meat and 2 (1.6%) respondents knew that bovine BTB can be transmitted through raw milk. It was also identified that the majority (75.4%) respondents used to drink raw milk. Therefore, this shows that a higher number of dairy farmers had no detailed and accurate knowledge about tuberculosis and its zoonotic importance and thus, were at risk of contracting the disease from their cattle. This result is consistent with Ameni et al. [10] and Radostits et al. [35], who have also indicated that lack of understanding regarding the zoonotic effect of BTB, food consumption behavior and poor sanitary measures are among the potential risk factors of BTB to public health.

Most of the respondents prefer raw milk to treated milk due to the taste, availability, and lower price of raw milk. The study revealed that 98.4% and 92.6% of the interviewed farm owners and/or farm attendants did not know that milk and meat could be vehicles for the zoonotic transmission of BTB, respectively. The survey further indicated that 54.9% of the respondents shared the same house with their cattle. Transmission of the disease tuberculosis may be cyclical i.e. cow-to-man-to-cow [5], underlying the existence of a risk of dissemination of the pathogen among human and cattle populations. Humans attain the infection mainly by ingesting the causative agent in raw milk and its products as well as by inhaling the pathogen during close physical contact with his/her cattle, particularly at night time since in some cases they share shelters with their animals [36]. Our assessment of the knowledge of society on BTB is in line with the findings of Mohammed et al [37], Akililu *et al*. [38], Fikre *et al*. [39] and Sisay *et al*. [40].

Conclusion and Recommendations

The present study showed that BTB is prevalent both in Hawassa city and Yirgalem town dairy farms with individual animal prevalence of 14.1% and herd level prevalence of 24.4%. BTB prevalence increased significantly among cross-breed cattle and in intensive dairy farms keeping cattle with exotic bloodlines. The questionnaire survey of this study revealed that the majority of cattle owners in the area lack awareness of BTB and its public health significance. As a result, a large portion of the community had a habit of drinking raw milk and sharing the same shelter with their cattle in close contact implying the possible potential of acquiring BTB from positive animals. Thus, awareness should be created of BTB transmission and its public health significance among cattle owners and farm attendants for the effective implementation of TB control measures.

Based on the above conclusion, the following recommendations are forwarded:

- ➢ Crossbreed dairy cattle should have better management since they are more exposed to BTB infection.
- ➢ Feed for dairy cattle should be stored appropriately to avoid contamination.
- ➢ It is better to cull BTB-infected animals with an organized compensation plan as it has economic as well as epidemiological impacts on dairy production.
- ➢ New animals introduced to the farms should be tested before mixing into the herd.
- ➢ Hygiene and avoidance of contamination should be given due emphasis to prevent between-herd infections.
- ➢ Awareness creation on the zoonotic importance of BTB should be done.
- ➢ Further study on isolation and spatial distribution of causative agents should be done to see and control the transmission dynamics.

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	Subject: Veterinary Sciences
DOI:10.22192/ijarbs.2023.10.12.001	

How to cite this article:
Shunkamo Yuta. (2023). Prevalence of Bovine Tuberculosis and the Associated Risk Factors in Dairy Cattle under Different Production System in Hawassa City and Yirgalem Town, Sidama National Regional State, Ethiopia. Int. J. Adv. Res. Biol. Sci. 10(12):1-13.
DOI: http://dx.doi.org/10.22192/ijarbs.2023.10.12.001