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Bovine tuberculosis: Prevalence, associated risk factors and its effect on milk production in crossbreed dairy cattle in Wolaita Sodo town, SNNPRS, Ethiopia

Gezahegn Shirmeka Hemecho and Yared Dendana Tuffa
Sidama Region Livestock and Fishery Resource Development Agency, Hawassa, Ethiopia.
Corresponding author: *shirmekagezahegn@gmail.com*

Abstract

A cross-sectional study aimed at observing the prevalence, associated risk factors and effects on the milk production of bovine tuberculosis (BTB) in crossbred dairy cattle in Wolaita Sodo town, south-central Ethiopian, was carried out from March to September, 2016 using comparative intra-dermal tuberculin (CIDT) test. Out of the total 38 dairy herds tested, 22 of them (57.9%) were found to be positive reactors for bovine tuberculosis. The disease problem was more prevalent in medium sized dairy herds (88.9%) than in small sized dairy herds (48.3%). Of the total 338 dairy animals tested, 96 dairy animals (76 cows and 20 heifers) were found to be positive reactors for CIDT test with an overall individual animal prevalence of 28.4%. The prevalence of BTB was higher (32.3%) in cows than in heifers (19.4%). The highest prevalence rate of BTB was observed in Holstein-Friesian crossbred dairy breeds of cows and heifers (31.0%) while it was found to be nil in Jersey breeds of dairy animals. Regarding to body condition score, the prevalence of the disease in thin dairy animals was observed to be 100.0% while it was (15.7%) in medium body conditioned animals. Similarly, the prevalence of bovine tuberculosis in hygienically poor conditioned farms was higher (100.0%) than medium ones (38.5%). With regard to the negative impact of the disease problem on the milk yield, BTB positive lactating cows were observed to be affected on average more than 26.7% when compared to those lactating cows which were observed to be BTB negative indicating the significant impact of the disease on the milk production. Analysis of the prevalence and associated risk factors revealed an increased incidence of bovine tuberculosis on the crossbred dairy herds and individual animals. In view of Ethiopia’s increasing involvement in livestock breed improvement endeavor, the observed high prevalence of bovine tuberculosis could be a major obstacle. Besides, the increased impact on the milk production as well as the higher prevalence of bovine tuberculosis and a high risk of acquiring the disease among the majority of the crossbred dairy cattle population emphasizes the need for paying the necessary attention towards the control of the disease.

Keywords: Bovine tuberculosis, Wolaita Sodo, Prevalence, Risk factores, CIDT test, Crossbreed, Dairy cattle

Introduction

Tuberculosis is a contact disease of both humans and a wide range of domestic and wild animals caused by Mycobacterium tuberculosis complex [1, 2]. As a public health threat, globally it causes 9.4 million cases and 1.7 million deaths annually in which Ethiopia is ranked as seventh among the world’s 22 countries with high tuberculosis burdens [3]. Bovine tuberculosis (BTB) is one of the ten most important priority diseases and ranked in global scores according to priority settings and criteria, and based on its impact on intensification of cattle production, the disease is ranked in the third level in terms of its significance [4].

Bovine tuberculosis (BTB) is caused by *Mycobacterium bovis (M. bovis)* and mainly a disease of intensification. It is also one of the contributing causes for human tuberculosis [5, 6]. Globally, the representative proportion of this disease problem in human tuberculosis is estimated to contribute a 10% - 50% share [7, 8]. BTB, also known as tuberculosis bovina, is the major Mycobacterial infection affecting mainly cattle and other domestic as well as wild animals [9]. As a disease of intensification, it occurs in extensive as well as in intensive livestock production systems of the tropics [2]. The disease has got a significant economic importance in two different livestock production systems where it appears in pulmonary and extra-pulmonary forms [10]. The pulmonary tuberculosis is typical in highly productive cattle in intensive dairy production systems whereas the extra-pulmonary one is very common in the extensive as well as nomadic animal production systems [11].

The pulmonary form of BTB is reported to be prevalent and endemic in Ethiopia [6, 11, 12]. It is one of the bottle-neck problems for cattle breed improvement which has become a priority agenda of livestock resource development of the region. Its prevalence varies depending on geographical areas, the breeds and the husbandry practices [13]. In central Ethiopia, BTB studies in crossbred dairy cattle showed prevalence varying between 3.5% and 50% [6] and an abattoir prevalence of 3.5% to 5.2%. In addition, a herd prevalence rate of 42.6% to 48.6% was found to be higher than the prevalence rate of individual animals that may indicate that the herd size can favor the transmission of BTB in intensive dairy farms in particular [14, 15]. Prevalence of the disease in traditionally kept zebu cattle varies between 0.9% - 45% based on arbitrary 4 mm. cut-off values used for interpretation [16].

In pastoral livestock settings of Boran/Oromia and Somali regions, individual animal prevalence rate of bovine tuberculosis was assessed to be 0.4% [7]. It was also reported that prevalence of 5% gross tuberculous lesion in camels slaughtered at Dire Dawa abattoir in eastern Ethiopia [17]. [18] Hiko and Agga (2011) reported 4.2% abattoir prevalence of BTB in Mojo export abattoir based on gross lesion. [16] Tschopp et.al., (2010), studied prevalence of BTB at human-livestock-wildlife-interface in Hammer woreda of South Ommo, South West of Ethiopia, and reported individual BTB prevalence in cattle as 0.8% and 3.4% with 4mm. and 2mm. arbitrary cut-off values, respectively.

The occurrence and distribution of BTB is well established in developed countries. However, information on distribution and occurrence of the disease problem is still lacking in developing countries [19]. This is also true in most parts of Ethiopia where urban intensive dairy farms are flourishing which includes Wolaita Sodo town, south-central Ethiopia. Scientific information is mandatory to make an appropriate decision of control measures. Hence, to solve this economically important disease as well as public health hazard, vigilant and continuous surveillance, assessment, information gathering and screening test and awareness creation is very important. The objectives of this study were:

- To estimate the prevalence of bovine tuberculosis in the study area
- To assess associated potential risk factors of bovine tuberculosis
- To estimate the negative impact of bovine tuberculosis on milk production

Materials and Methods

This part sets out what approaches or methods have been used to produce the desired results. The section contains the location of the study and the methodologies applied during data collection and analysis.

Description of the Study Area

This study was undertaken from March to September, 2016 in Wolaita Sodo town, south- central Ethiopia. The town is bounded by Wolaita Sodo Zuria worda, and it is the administrative capital of Wolaita zone. It is located at a distance of 380 and 150 kilometers southwest of Addis Ababa and Hawassa, respectively (figure 1). Administratively, the town is sub-divided into three sub- cities and 11 kebeles. The total surface area of Wolaita Sodo town is estimated to be 8,283 ha. According to Wolaita Sodo town urban development office 2015 data, the total human population of the town is estimated to be 173,175 (81,438 of them female). The town is situated on an elevation range of 1600-2100 m.a.s.l. with a *woina-dega* agro-ecological condition, and at a latitude and longitude range of 6.54^0N to 7.11^0N and 37.4^0E to 38.2^0E, respectively (Wolaita Sodo town, urban development office, 2015 data). The average annual rainfall and ambient temperature of the town is 1,125 mm. and 16.3^{0}C, respectively [20].

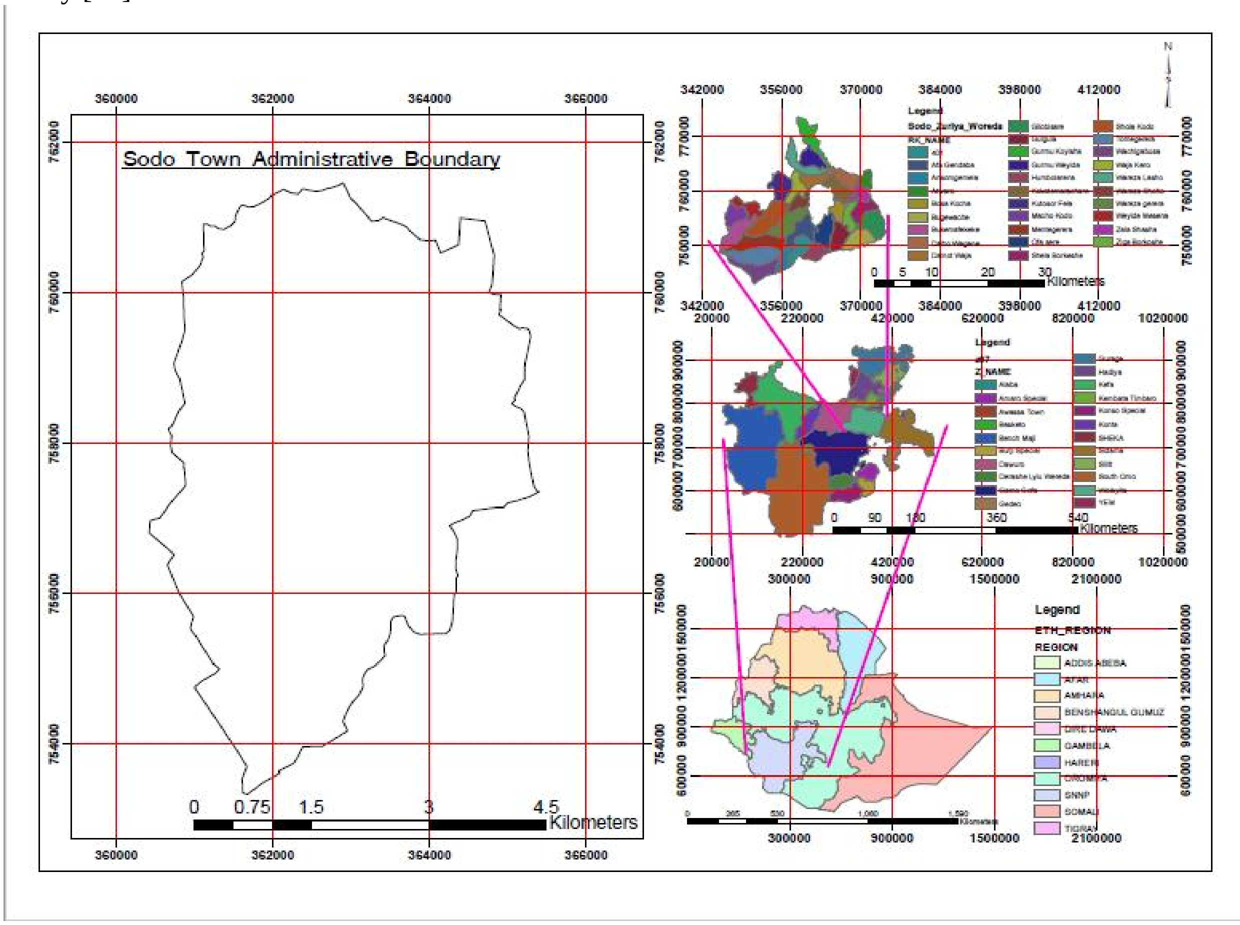

Figure 1: Administrative map of Wolaita Sodo town; Source: [21]

Livestock production system of the study area

Based on the intensity and type of product, the livestock production system in the study area is small and medium sized urban type of intensive and semi intensive livestock production system mainly with the intention of producing milk and milk products. There are three state owned dairy farms with an average number of 28 dairy cattle. Furthermore, the number of dairy animals in private owned dairy herds ranges from 5-16 dairy animals. The dairy herd in one of the government owned farm is for Jersey bull production purposes and the other two farms with Holstein-Friesian breeds of cattle are reared for milk production purpose. Dairy animals in private herds are mostly located in the out skirts of the town and they are reared mainly for milk and milk products. In this intensive as well as semi intensive dairy production system, the primary goal of rearing dairy cattle is for the production of milk and milk products.

Dairy farmers sell the milk produced in a contractual way for the hotels and cafes of the town. Some milk is processed locally into butter and cheese for sale and home consumption. Hence, the milk production is meant mainly for income generation purpose and for food security, especially for fulfilling the demand for protein by the family.

Study Animals

There were 157 private and 3 state owned small and medium sized dairy farms in the town and the number of dairy animals differed from herd to herd. The number of crossbred dairy cattle in government owned farms ranged from 15-28 and those from private owned dairy farms in small and medium sized herds ranged 5-26 dairy animals.

The total crossbred cattle population of the town was estimated to be 3,790 of which 2,264 (59.7%) were cows and heifers of breeding ages..The study animals in the small and medium sized herds were managed intensively as well as semi intensively. They were Holstein-Friesian and Jersey crossbred animals at different exotic blood levels, and they were reared mainly for milk production purpose. The dairy cattle breeding method used in the study area was primarily artificial insemination, and mating with improved Holstein-Friesian bulls was done sometimes.

According to Wolaita Sodo urban agricultural department 2015 data, 5,463.8 tons of milk was produced annually of which 4,082.4 (74.7%) tons was from cross-bred and 203.13 tons from local cattle breeds. This made the annual per capita consumption of milk in the town being 30.5 liters per urban dwellers. Most of the milk produced is consumed by the urban dwellers either in raw form, boiled or in the form of yoghurt, locally known as *ergo.*

Study Design

This study was an observational field study. As a study methodology, cross-sectional type of study was undertaken to determine the static nature of the disease in which the proportion or ratio of dairy herds and cattle affected by BTB was detected in the specified time of the study. Then, probability and chance of individual herds and dairy cattle from the same population having BTB at this point in time was assessed. Hence, the static nature, occurrence and frequency of the disease were being determined in the study animals.

The sampling process included processing the population at risk, study population and the sample size. The dairy farms were selected based on random sampling method. Probability sampling which allowed inferences to be used for other population was applied. Dairy cows at all reproductive stages including heifers of all breeding age in the randomly selected herds was included in the study. Heterogeneity in the study result was reduced by targeted sampling of particular sub-groups, in this case cows and heifers, within the study population.

The sampling procedure and sample size

The small and medium sized dairy herds were the primary sampling units. A herd was defined in the study as crossbred dairy cattle owned by a house hold. The list of heads of the households with the dairy herds was generated in collaboration with Wolaita Sodo town urban agricultural development office. To estimate the herd sample size, the number of herds was calculated using the formula described by Thrusfield [22], and the herds were selected randomly. The formula applied to select the small and medium sized herds is indicated below:

$$g = 1.96^2*(nV_c+P_{exp}(1-P_{exp})/nd^2$$

Where:

g = The number of clusters sampled, i.e. the dairy farms

n = Predicted average number of animals per cluster, which was estimated to be10

P = the expected BTB prevalence, which was considered to be 21% (0.21)

d = Desired absolute precision = ±0.05 (±5%)

Vc =The guessed between-cluster variance which was the guessed standard deviation (i.e., the average difference expected between an individual cluster prevalence and the overall mean cluster prevalence. The overall mean cluster variance was anticipated to be 0.54 (54.0%),and the average difference between this and the individual-cluster prevalence was guessed to be 0.09 (9%), then the between-cluster variance component was guessed to be $0.09^2 = 0.0081$.

Hence, the sampling strategy was one stage cluster sampling methodology, and the total number of herds which have been sampled was determined randomly. After sampling of the small and medium sized dairy herds randomly, all cows and heifers in the selected dairy herds were considered as sample in the study. Accordingly, a total of 38 farms (29 small and 9 medium sized dairy herds) and a total of 338 crossbred cows and heifers belonging to the randomly selected dairy herds were included in the study sample.

Estimation of the impact of BTB on milk production

In order to estimate the negative impact of bovine tuberculosis on milk production, the cows in the study animals were categorized into lactating and non-lactating ones. Since one of the objectives of the study was to estimate the negative impact of the disease on the milk production, then only lactating cows were considered for the estimation of milk yield loss. Hence, the study cows were categorized into lactating and non-lactating ones, and the average daily milk yield of each lactating cow was recorded accordingly.

Then, the average daily milk yield of the cows which were positive for BTB was compared with the average milk yield of cows which were negative for BTB cows with the help of testing for difference between the two means in which a two sample Student's t-test for the two tailed hypothesis was applied [23]. The percentage reduction of milk yield in BTB positive lactating cows was estimated by applying the formula:

$$Y = Y_1 - Y_2 = \Delta Y / Y_1 * 100\%,$$

Where:
Y = Average percentage reduction in milk yield,
Y_1 = the average daily milk yield of BTB negative lactating cows,
Y_2 = the average daily milk yield of BTB positive lactating cows,
ΔY = the actual change in milk yield (Y_1-Y_2),

Finally, the actual change in milk yield dividing by original milk yield of the BTB negative cows and the result multiplied by hundreds percentage. However, as the lactating cows in the two categories were at different lactation stages and parity, the estimation of milk production might vary to some extent.

Questionnaire survey on management and husbandry practices

The questionnaire has got six parts. These are personal information of the farm owner, general information about the farm, questions related to risk factors to bovine tuberculosis, management and husbandry practices of the dairy farms, questions related to public health risk and awareness and public health aspects as well as individual animal data recording. An enquiry was administered to willing participants. Information on farm structure and management was collected from randomly selected small and medium sized herds using a standardized questionnaire with closed and open type questions. According to Msangi [24], body condition score (BCS) of the dairy cattle was recorded generally as thin and medium (BCS = 1.0-2.0 and 2.0-3.5, respectively).

The owner or manager of each farm or the animal attendant living in the farm for more than a year was interviewed at the time of CIDT test. The hygienic and sanitary status of the farms was judged as poor and medium based on aspects such as odor, waste drainage, cleanness of floor and animals, barn ventilation and light source and animal stocking. Know-how about BTB and age of the respondents was recorded. Educational status of the herd owners and consumption habit of raw milk was recorded.

Materials Needed and the Test Procedure

This study used Comparative Intra-dermal Tuberculin (CIDT) test as it was indicated by Moentex and OIE terrestrial manual [25 &26]. The materials needed and the test procedures are indicated as follows.

Materials needed

The materials needed for comparative intra-dermal tuberculin test in the study of BTB were:

- Hypodermic tuberculin syringe of 0.5 ml. capacity (0.04mm. x 13mm., 27G1/2) with permanently attached needle to be discarded after a single use
- Avian purified protein derivative which is known as avian tuberculin
- Bovine purified protein derivative which is known as bovine tuberculin
- Calipers, shavers, scalpel handle with blades
- Absorbent cotton, denatured alcohol for disinfection purpose
- Ice boxes and ice packs
- Bull holder, OIE standard format

These materials were provided by the Wolaita Sodo regional veterinary laboratory. As a regional animal disease investigation and surveillance laboratory, its staffs has participated and cooperated in the study.

The test procedure

The standard procedure of bovine tuberculin test was conducted as it was indicated by Moentex and OIE terrestrial manual [25 & 26]. It was done as follows:

- The test animal which was going to be injected with PPD (purified protein derivative) was restrained using the bull holder
- Two separate sites of the study animal around the center of the neck was shaved using shaver
- The shaving was done on the right side of the neck of the test animal 12 cm. apart from one above the other
- The shaved sites were disinfected with denatured alcohol using absorbent cotton.

- The skin thickness of the two shaved sites was measured using calipers before tuberculin injection
- A 1 ml. of bovine and avian PPD was aspired after shaking from each vial of 5 ml. capacity using two syringes with capacity of 1 ml.
- A 0.1 ml dose of bovine and avian PPD was injected intra-dermally one after the other on the shaved sites and they was injected at the right side of the neck
- The bovine PPD as injected on the above and avian ppd was injected on the lower shaved sites uniformly in each study animal
- The results were read after 72 hours after the comparative intra-dermal tuberculin injection of bovine and avian ppd

Interpretation of the test result

The bovine intra-dermal tuberculin test result was interpreted as a size of measure of the skin fold of ppd injected site by comparing the bovine ppd injection with the complementary avian ppd injection reaction. The comparative measurement values of the injected skin test results were interpreted as follows:

Using OIE Standard cut-off value > 4mm

- Increase in skin fold thickness greater than4 mm. was taken as positive reactor for BTB,
- Increase in skin fold thickness 1 to 4 mm. was taken as inconclusive (doubtful) reactor,
- The reaction was considered to be negative for BTB if the increase in skin thickness at the bovine site of injection was less than the increase in the skin reaction at the avian site of injection,
- Increase in skin fold thickness greater than 1mm. at avian site than at the bovine site was considered as positive for *Mycobacterium avium* species,
- The reaction was considered as equal reactor if increase in skin thickness at the both sites was equal,

The bovine and avian positive reactors were obtained using the formula: (B2-B1) - (A_2-A_1) and

(A_2-A_1)- (B2-B1), Where: B_1 = Bovine ppd (purified protein derivate) injection skin site thickness before injection, A1= Avian ppd injected skin site thickness before injection, A_2= Avian ppd injected site skin thickness after 72 hours of injection, B2 = Bovine ppd injected skin site thickness after 72 hours of injection, $\Delta B = B_2 - B_1$ = change of B; $\Delta A = A_2 - A_1$ = Change of A; $\Delta B - \Delta A$= change in skin reaction.

Data Entry and Analysis

The data was entered in Microsoft excel (Microsoft Corp. Redmond, USA) and it was validated before it was being imported into SPSS version 23. The outcome of all statistical analyses was herd level and individual animal binary outcomes. A herd was considered positive if it has at least one tuberculin reactor cow or heifer.

Explanatory variables were cross-tabulated using Pearson's chi-square test. The following explanatory variables were added in the analysis: herd size, age, breed, body condition score, sanitary and hygienic conditions of the herds. The milk yield of the lactating cows which were positive for BTB was compared with the milk yield of cows which were negative for BTB cows to observe the difference between the two means in which a two sample Student's t-test for the two tailed hypothesis testing was applied.

The raw data collected was condensed and summarized with the help of tables. Moreover, summary statistical quantities such as proportions, standard errors and variance were included in the analysis. Then, the population parameter was estimated and inferred from the sample statistical quantities.

Results

Herd Level BTB Prevalence

Out of 38 CIDT tested dairy herds, 22 of them were found to be positive reactors for bovine tuberculosis (BTB), and the overall apparent herd level prevalence was observed to be 57.9% (95% CI = 42.2% - 73.6%) when using the 4 mm. arbitrary cut-off value. In subsequent comparison of small-versus-medium sized dairy herds, evidence of higher BTB exposure was detected in medium sized herds than small sized dairy herds. Accordingly, of the total 9 medium-sized dairy herds tested, 8 of them (88.9%) were found to be positive reactors for BTB, while of the total 29 small-sized dairy herds tested, 14 of them (48.3%) were found to be positive reactors for bovine tuberculosis which was found to be significantly different (P = 0.013) (Table3). Moreover, out of 37 tested herds with Holstein-Friesian breeds of dairy cattle, 22 of them were found to be positive reactors for BTB with an overall prevalence rate of 59.5%. The prevalence of BTB was found to be nil in Jersey herd and breeds of cows and heifers.

Table 1: Comparative herd prevalence of bovine tuberculosis in medium and small sized herds of dairy animals in Wolaita Sodo town

Farm size	Numbers positive	Numbers negative	Total number tested	Prevalence (%)	Chi-square value	*P*-Value
Medium sized herds	8	1	9	88.9		
Small-sized herds	14	15	29	48.3		
Total	**22**	**16**	**38**	**57.9**	**4.647**	**0.031**

Out of the total 142 cows and heifers tested in medium sized dairy herds, 64 of them (45.1%) were observed to be positive reactors of tuberculin test for bovine tuberculosis, while of the tuberculin tested 196 cows and heifers in small sized dairy herds, only 32 of them (16.3%) were observed to be positive reactors (Table 2). A significant difference was observed for the prevalence of bovine tuberculosis in medium and small farm sizes ($P < 0.05$) when using the 4 mm. arbitrary cut-off value test result (Table 2).

Table 2: Relative differences in individual animal prevalence rate for cows and heifers between medium and small sized herds of dairy animals in Wolaita Sodo town

Farm size	Number positive	Numbers negative	Total number tested	Prevalence (%)	Chi- square value	P-value
Cows and heifers in medium-sized farms	64	78	142	42.9		
Cows and heifers in small sized farms	32	164	196	15.0		
Total	**96**	**242**	**338**	**28.4**	**33.455**	**<0.05**

Individual Animal Level BTB Prevalence

A total of 338 crossbred cows and heifers from 38 randomly selected dairy herds were tested using CIDT test to assess the prevalence of bovine tuberculosis (BTB). The number of tested dairy animals in the study area was 142 animals from medium sized herds and 196 were from small sized dairy herds. 96 dairy animals (76 cows and 20 heifers) were found positive reactors for BTB. The overall apparent individual animal prevalence was observed to be 28.4% (95% CI = 23.86% - 33.43%) when using the 4 mm. standard cut-off value. Out of the total 235 dairy cows tested, 76 were positive reactors for tuberculin skin test with an overall prevalence of 32.3%, while of the total 103 heifers tested, 20 of them were found positive reactors for bovine tuberculosis with an overall prevalence of 19.4% (Table 3). There was a significant difference ($P = 0.015$) in proportion of positive dairy cattle between age group of the animals (Table 3).

Table 3: Individual animal prevalence of bovine tuberculosis in cows and heifers of study animals of dairy animals in Wolaita Sodo town

Age category	Numbers positive	Numbers negative	Number tested	Prevalence (%)	Chi-square value	P-value
Cows	76	159	235	32.3		
Heifers	20	83	103	19.4		
Total	**96**	**242**	**338**	**28.4**	**5.881**	**0.015**

BTB Associated Risk Factors

The potential risk factors associated with the occurrence of bovine tuberculosis in the study herds and animals were assessed. These included herd size, age and breed category, body condition score of the dairy cattle as well as the hygienic and sanitary conditions of the housing system of the dairy herds. Accordingly, comparison of small with medium sized dairy herds showed a higher BTB exposure in medium sized herds than small sized dairy herds.

Of the total 9 medium-sized dairy herds tested, 8 of them (88.9%) were found to be positive for BTB, while out of the total 29 small-sized dairy herds tested, 14 of them (48.3%) were found to be positive reactors for bovine tuberculosis. As an associated risk factor, herd size was found to be significantly different (P = 0.013) (Table 4). Moreover, out of 37 CIDT tested herds with Holstein-Friesian breeds of dairy cattle, 22 of them were found to be positive reactors for BTB with an overall prevalence rate of 59.5%. The prevalence of BTB was found to be nil in Jersey herd and breeds of cows and heifers.

It was observed that there was a significant difference for the occurrence of bovine tuberculosis between cows and heifers of (P = 0.015) when using the 4 mm. arbitrary cut-off value test result (Table 4).

Differences in occurrence and prevalence rate of BTB due to age category of the dairy animals were found to be one of the most important intrinsic risk factor for the occurrence of bovine tuberculosis in the study area. As an intrinsic host risk factor, the differences in age category of the dairy animals in the study area have made the occurrence of the disease problem to be more prevalent in cows than in heifers (Table 4).

Table 4: Risk factors associated with the occurrence of bovine tuberculosis in dairy cattle of Wolaita Sodo town

Associated Risk factors	Numbers positive	Numbers negative	Number tested	Prevalence (%)	Chi-square value	P-value
Herd level						
Medium sized farm	8	1	9	88.9		
Smaller sized farm	14	15	29	48.3	4.647	0.013
Individual animal level						
Medium sized farm	64	78	142	45.1		
Smaller sized farm	32	164	196	16.3	33.455	<0.050
Age						
Cows	76	159	235	32.3		
Heifers	20	83	103	19.4	5.881	0.015
Breed						
H-F*	96	214	310	31.0		
Jersey	0	28	28	0.0	12.111	<0.05
BCS**						

Thin	51	0	51	100.0		
Medium	45	242	287	15.7	151.408	<0.05
Hygiene condition						
Medium	10	16	26	38.5		
Poor	12	0	12	100.0		
Individual animal level					12.755	<0.05
Animals in medium f	34	205	239	14.2		
Animals in poor farm	62	37	99	62.6	80.642	<0.05

*-Holstein-Friesian **-Body Condition Score

Of the total 310 Holstein-Friesian cows and heifers tested, 96 of them were found positive for BTB with an overall prevalence of 31.0%. The prevalence of bovine tuberculosis was found to be nil in Jersey herd as well as breeds of cows and heifers (Table 4). There was a significant difference for the prevalence of bovine tuberculosis between herds with Holstein-Friesen and Jersey breeds of cows and heifers (P <0.05) when using the 4 mm. arbitrary cut-off value test result. As a dominant host risk factor, the differences in breed of the dairy animals in the study area have made the occurrence of the disease problem to be more prevalent in Holstein-Friesen herds and breeds of cows and heifers than that of Jersey ones.

Body condition score (BCS) of the dairy cattle was recorded generally as thin and medium (BCS = 1.0-2.0 and 2.0-3.5, respectively). Of the tested 51 thin body conditioned dairy cattle, all of them were found to be positive for bovine tuberculosis, while of the total 287 medium body conditioned dairy cattle tested, 45 of them were positive reactors. The prevalence of bovine tuberculosis in thin and medium body conditioned dairy animals was observed to be 100.00% and 15.7%, respectively (Table 4). A strong significant difference was observed for the prevalence of bovine tuberculosis between thin and medium body conditioned cows and heifers (P < 0.05) when using the 4 mm. arbitrary cut-off value test result. The significant difference due to body condition score of the dairy animals in this study was found to be one of the intrinsic host risk factors for the occurrence of bovine tuberculosis in the study area.
As an important host risk factor, the differences in body condition score of the dairy animals in the study area have made the occurrence of the disease problem to be more prevalent in thin body conditioned cows and heifers than that of medium ones. This indicates that thin cows and heifers were more affected by the disease problem than medium body conditioned cows and heifer. This is in line with the fact that animals affected by the disease problem lose their body condition gradually and become emaciated due to the chronic nature of the disease.

The hygienic and sanitary condition of the dairy farms was assessed in this study. This was done based on the ventilation, odor, and animal stoking density, and waste disposal, floor and animals as well as general cleanness of the dairy farms.

In subsequent comparison of dairy farms with regard to hygienic and sanitary standards as poor-versus-medium, occurrence of higher BTB exposure was detected in hygienically poor herds than medium dairy herds. Accordingly, of the total 26 dairy herds tested in sanitarily medium farms, 10 of them (38.5%) were found to be positive reactors for BTB, while of the total 12 dairy herds tested in sanitarily medium dairy herds tested, all of them (100.0%) were found to be positive reactors for bovine tuberculosis which was found to be significantly different (p <0.05) (Table 4).

Moreover, out of the total 239 tested dairy cattle in medium farm hygiene and sanitation condition, 34 of them were positive reactors for BTB, while of the 99 animals in poor farm hygiene and sanitation condition, 62 of them were found to be positive reactors. The prevalence of BTB in those farms which were hygienically and sanitarily medium standards was observed to be 14.2%, while it was observed to be 62.6% in hygienically poor farms (Table 4).

This finding signifies there was a significant difference observed for the prevalence of bovine tuberculosis between hygienically and sanitarily medium and poor standard of dairy farms and dairy cattle ($P < 0.05$) when using the 4 mm. arbitrary cut-off value test result. Hence, the significant difference due to farm hygiene condition of the dairy animals in this study was found to be one of the decisive risk factors for the occurrence of bovine tuberculosis in the study area. As a decisive environmental risk factor, the differences in farm hygiene and sanitation condition of the dairy animals in the study area have made the occurrence of the disease problem to be more prevalent in hygienically poor farms than that of medium ones. This indicates that cows and heifers in hygienically poor farms were more affected by the disease problem than those in hygienically medium farms.

The Negative Impact of BTB on Milk production

The negative impact of bovine tuberculosis on milk production was estimated by analyzing the difference between average daily milk yields of the lactating cows. Of the total 182 CIDT tested lactating cows, 58 (31.9%) of them were positive reactors for tuberculin test and the rest 124 lactating cows were non-reactive to the test. The percentage reduction of milk yield in BTB positive lactating cows was estimated by applying the formula:

$Y = Y_1 - Y_2 = \Delta Y / Y_1 * 100\%$, Where:
Y = Average percentage reduction in milk yield,
Y_1 = the average daily milk yield of BTB negative lactating cows = 15.01 liters,
Y_2 = the average daily milk yield of BTB positive lactating cows = 11.0 liters
ΔY = the actual change in milk yield which is 15.01 liters -11.0 liters= 4.01 liters. Hence,
Y = 15.01 liters - 11.0 liters/15.01 liters *100% = 4.01 liters/15.01 liters *100%, Y= 26.7%

Accordingly, the average daily milk yield (11.0 liters) of BTB positive lactating cows was less when compared with the average daily milk yield (15.01 liters) of lactating cows which were not reacting for the tuberculin test (Table 5). The average daily milk yield of BTB positive lactating cows was 26.7% less than that of BTB negative lactating cows. The difference in average daily milk yield between the two groups of lactating cows was significant ($p < 0.01$) indicating that BTB has a considerable negative impact on the milk yield of dairy cattle.

In this study, the significant difference in milk production between the test positive and the test negative dairy cattle could mainly be attributed to the negative impact of BTB on milk production. The animals affected by the disease could have a capricious appetite and lack the usual consumption of feed. Thus, progressive loss of body weight results in low body condition score of the animals. Subsequently, the animals affected by the disease gradually lose the normal physiological milk production capability. Hence, the whole dairy business as well as its value chain players is affected greatly. Furthermore, the disease affects the livelihood of the dairy herders, and could have a negative impact on the herd replacement because of its effect on the production of calves.

However, since the lactating cows in the two categories were at different parities and lactation stages, the estimation of the average daily milk yield recorded might vary to some extent. This added with other factors affecting the milk yield of dairy cows may underplay the findings of this study. Hence, further detail study has to be undertaken to estimate the rigorous negative impact of the disease on the milk production and productivity.

Table 5: Comparison of milk yield (in liters) difference of BTB positive and negative lactating dairy cows of Wolaita Sodo town

Milk yield (in liters) of BTB positive lactating cows (x_1)	f_1	x_1*f_1	Milk yield (in liters) of BTB negative lactating cows (x_2)	f_2	x_2*f_2
9	4	36	14	38	532
10	4	40	15	53	795
11	45	495	16	22	352
12	3	36	17	6	102
13	2	26	18	5	90

$n_1 = 58$
sum of $f_1 * x_1 = 638$
$Mean_1 = 11.0$
v_1 (degree of freedom) = 57
$variance_1 = 0.642$
$sd_1 = 0.682$
$P < 0.01$

$n_2 = 124$
sum of $f_2 * x_2 = 1871$
$Mean_2 = 15.01$
V_2(degree of freedom) = 123
$variance_2 = 3.565$
$sd_2 = 1.689$

Public Health Significance of BTB

All the respondents of the dairy farmers in this study answered that they and the member of their family used to consume unpasteurized or non-boiled milk as well as uncooked meat, and their contact with the dairy animals was closer than expected. 14 of the dairy owners (36.8%) responded they knew that bovine tuberculosis was a cattle disease and can be transmitted to humans through consumption of unpasteurized or non-boiled milk as well as via uncooked meat (Table 6).

Table 6: Questionnaire survey result of public health significance and assessment among dairy herd owners in Wolaita Sodo town

S/No.	Variables	Frequency (N = 38)	Percentage (%)
1	Do you and members of your family drink raw milk regularly?		
	Yes	38	100.0
	No	0	0.0
2	Do you know that bovine tuberculosis is a cattle disease?		
	Yes	14	36.8
	No	24	63.2
3	Do you know that bovine TB can be transmitted to man through raw milk/milk products consumption obtained from bovine tuberculosis infected cattle?		
	Yes	14	36.8
	No	24	63.2
4	Do you know that bovine TB can be transmitted to man through raw meat consumption obtained from bovine tuberculosis infected cattle?		0.0
	Yes	14	36.8
	No	24	63.2
5	Have any of the people living/working on your farm had TB in the last two years?		
	Yes	5	13.2
	No	33	86.8
6	If your answer for the above question is yes, did he/she drink raw milk/milk products?		
	Yes	38	100.0
	No	0	0.0

In this finding, 5 (13.2%) of the respondents working in the dairy farms have noticed clearly having some of the clinical sign of the disease in the last two years. Besides, out of the 22 CIDT test positive herds, 3 (13.6%) of them had respondents with obvious clinical signs of tuberculosis. Thus, to reduce the public health risks arising from the disease, it is imperative to strengthen dairy farmers' awareness through extension services, training and education program.

Husbandry and Management Practices of the Dairy Farms

This part encompassed personal information of the dairy farm owners. It has included information related to the dairy farms and associated risk factors to the occurrence of the disease problem. Furthermore, information regarding to the dairy farm management, husbandry practice and public health hazards of the dairy farms was included in the questionnaire survey.

Household Characteristics of the dairy farm owners

Out of the total 38 dairy herd owners assessed, 21 (55.3%) of them were females and female-headed dairy farms. Furthermore, 24 (63.3%) of the total dairy farm owners assessed were young people involved in the dairy business. 27 dairy herd owners had total household members less than five whereas 11 of the dairy farm owners had a family member ranging from 6-10. Educational status of the dairy owners was assessed and 19 of them were grade 9-12 whereas those with diplomas and above accounted 6. Six of the dairy owners were with basic writing and reading skills. None of the dairy farm owners were illiterate. As to the job status of the dairy farm owners, 17 of them were government employees, 8 of them retired ones and 13 of them were in other different job categorical positions (Table 7).

Table 7: Livelihood characteristics of dairy herd owners and/or attendants of the study area

S/No	Variables	Frequency (N = 38)	Percentage (%)
1	Sex		
	M	17	44.7
	F	21	55.3
2	Age		
	Young	24	63.2
	Adult	14	36.8
3	No. of house hold/family members		
	less than five	27	71.1
	Six to ten	11	28.9
	Greater than ten	0	0.0
4	Educational status		
	Illiterate	0	0.0
	Basic writing and reading	6	15.8
	Primary (Grade 1 to 6)	3	7.9
	Junior Secondary (grade 7 to 8)	4	10.5
	Secondary (Grade 9 to 12)	19	50.0
	Diploma	2	5.3
	Degree	2	5.3
	Above degree	2	5.3
5	Job status		
	Government employee	17	44.7
	Private employee	6	15.8
	Have /run own business	0	0.0
	Retired	8	21.1
	No job	7	18.4

Of the total 38 dairy farms assessed, 37 of them were private dairy farms. 29 of the dairy farms were small sized dairy farms with the average number of 6 dairy cattle, whereas 9 of them were medium sized dairy herds. As to the housing system, the dairy farms were all indoor types and the stall structure was found to be a tie-up one. The dairy farmers were asked how they started the dairy farm business, and 36 of the private owned farms answered that they have bought dairy cattle from other known dairy farms. 26 of the farm owners responded that they have got replacement stock from their own farm by artificial insemination (Table 8).

Table 8: General information related to the dairy farms assessed in the study

S/No.	Variables	Frequency (N = 38)	Percentage (%)
1	Ownership type of the farm		
	Private	37	97.4
	Government owned	1	2.6
	Cooperative	0	0.0
	Others (Specify)	0	0.0
2	Type of housing system		
	Indoor	38	100.0
	Outdoor	0	0.0
	None but fenced	0	0.0
	Cattle share house with the owners	0	0.0
3	Type of stall		
	Tie-up	38	100.0
	loose	0	0.0
	Both types	0	0.0
4	Farm headed by		
	Female	25	65.8
	Male	13	34.2
	Both	0	0.0
5	How did the owner start the farm business?		
	Bought the enterprise	0	0.0
	Bought cattle from other known dairy farms	2	5.3
	Bought animals from market without knowing their origin	36	94.7
	Gift	0	0.0
	Don't know	0	0.0
	Other (specify)	0	0.0
6	Breeding method applied		
	AI	36	94.7
	Improved bull	2	5.3
	AI and Improved bull	0	0.0
7	Size of the herds		
	Small	29	76.3
	Medium	9	23.7
	Large	0	0.0

The dairy farmers were asked whether they have bought any dairy animals and introduced to their farm in last two years, and 12 of them answered that they have bought and introduced to their farms.

Feedstuffs and feeding regimen

The dairy animals in the study area were fed with different kinds of feedstuffs from different feed sources. All of the farm owners responded that major feedstuffs for their dairy cattle include industrial by products such as wheat bran which are locally known as *furushka and furshkelo,* crop residues from wheat, barley, teff, and maize and other crops; hay, forages of different types and homemade leftovers in different proportions. The availability of the forage feedstuff is greatly affected by seasonal differences. Forages are available for the dairy herds especially in wet seasons of the year. Unlike that of medium sized dairy herds, dairy animals of small scale dairy herds are let to graze in the vicinity of their locality.

As to feeding regimen, the supplying of the available feedstuffs is dependent on the animals' physiological state such as age and production status. More of the available feed is given to milking cows, calves and pregnant heifers. The animals in the dairy herds are mostly fed thrice a day especially early in the morning, at noon and at nightfall. Small scale dairy herds are supplemented with additional homemade feed sources such as *attela,* a residue from local alcoholic drinks known as *tella* and *katikalla* (Table 9).

Table 9: Management and husbandry practices of the dairy farms of the study area

S/No.	**Variables**	**Frequency (N = 38)**	**Percentage (%)**
1	Type of feed offered to the dairy animals		
	Concentrate (furushka and furushkello)	0	0.0
	Roughage (forage, grass, hay, crop by-product)	0	0.0
	Home leftovers /food processing wastes, organic wastes	0	0.0
	All types of feed at different proportions	38	100.0
2	Sources of feed		
	Purchasing	37	97.4
	Own farm	0	0.0
	Purchasing and own farm	1	2.6
3	Type of milking		
	Hand milking	38	100.0
	Machine milking	0	0.0
	Both types of milking	0	0.0
4	Milking frequency		
	Once a day	0	0.0
	Twice a day	38	100.0
	Thrice a day	0	0.0
5	Method of calve feeding		
	Bucket-fed	38	100.0
	Suckling	0	0.0
	Both bucket fed and suckling	0	0.0
6	Do you have farm record?		
	Yes	2	5.3
	No	36	94.7
7	If your answer for the above question is yes, what type of record do you keep?		
	Breeding	1	2.6
	Feeding	0	0.0
	Health	0	0.0
	Market	0	0.0
	All types of records	2	5.3

Housing system

The dairy animals are kept in different forms of shelters. The housing system in the study area is no more a standard stalls or barns. Only a kind of shelter is used to protect the animals against wind, rain, solar radiation and wild life. Site selection and construction designs for the shelters are no more conventional ones. Moreover, the house construction design is dependent on economic level of the herd owners. The sanitary and hygienic condition of the floor, wall and roof of the shelters are relatively medium to poor. Most of the small scale dairy herds share the common housing infrastructures with the attendants and the owners of the farm (Table 10).

Table 10: Summary result of risk factors for the occurrence of bovine tuberculosis

S/No.	**Variables**	**Frequency (N = 38)**	**Percentage (%)**
1	Hygienic and sanitary condition of the dairy house		
	Poor	12	31.6
	Medium (satisfactory condition)	26	68.4
	Good	0	0.0
	Excellent	0	0.0
2	Ventilation status of the house		
	Poor	28	73.7
	Medium (satisfactory ventilation)	10	26.3
	Good	0	0.0
	Excellent	0	0.0
3	Total number of crossbred dairy animals in the farm		
	less than 5	0	0.0
	Five to ten	29	76.3
	greater than 10	9	23.7
4	The purpose of the dairy farm		
	to produce dairy products for home consumption only	0	0.0
	to produce dairy products for market only	0	0.0
	to produce dairy products for both market and home consumption	38	100.0
5	Have you bought and introduced dairy animals to your farm in last two years?		
	Yes	12	31.6
	No	26	68.4
	I do not remember		0.0
	I do not have that	37	97.4
	Difficult to remember	1	2.6
6	To whom do you sell the milk?		
	to individual consumers	25	65.8
	to processing plant	0	0.0
	intermediate cafes	0	0.0
	to restaurants/cafeteria	13	34.2
	Others specify	0	0.0

S/No.	Variables	Frequency (N = 38)	Percentage (%)
7	How do you get replacement stock?		
	my own farm by artificial insemination	26	68.4
	Insemination by own bull	6	15.8
	Purchasing from different cattle sources	6	15.8
	Others (specify)	0	0.0
8	What type of cattle do you sell from your farm?		
	Weak and poor body condition	22	57.9
	Diseased	0	0.0
	Low productive	16	42.1
	High productive	0	0.0
	Others (Specify)	0	0.0
9	Are animals in your farm mixed with animals from other farms		
	Yes	0	0.0
	No	38	100.0
10	Have you in the last six months had any animal in your herd with chronic cough and chronic body wastage		
	Yes	23	60.5
	No	15	39.5
	I do not notice		0.0
11	Have cattle been tuberculin/PPD tested before on your farm?		
	Yes	0	0.0
	No	38	100.0

Milking, milk yield and milk consumption habits

All the milking cows both in state owned and private dairy farms were milked 2-3 times a day. The average daily milk yield per cow was estimated approximately to be 14 litters. As to the respondents, although not routine, washing of teats and udder is practiced before and after milking. It was observed during the interview that the personnel in charge of milking the cows are hygienically poor and milking utensils and the environment were not in a good hygienic condition. Calves both in government owned and private dairy farms were bucket-fed since the first weeks of calving. In most herds, the calves and cows share the same shelter.

All the dairy animals were kept for the purpose of producing income for the owners and for the purpose of fulfilling food and protein demand of the households. The producers of milk sold most of their milk to the urban hotels, cafes and individual consumers in a contractual base. Some of their milk was consumed at home for food security purposes. There was no milk processing plants in the town, and the remaining milk was processed traditionally and consumed by the households.

Recording

Only two dairy farms (one private and one government owned) responded that they have got standard farm records. The government farm used to keep all types of dairy farm records whereas only one of the private owned dairy farms kept only breeding record. In most of the private owned dairy farms, there was no standard way of recording about the daily activities undertaken in the farms. Herd breeding, health, feeding and related records were not kept properly. Management and husbandry practices of the dairy herds and individual animal records were passed from attendant to attendant mostly in oral bases. Written information was rare and the owners and attendants of the dairy herds answered the questions in a memorial way. They told the history of the farm, but very ambiguously.

Discussion

Evidence for the prevalence of bovine tuberculosis in dairy cattle has been growing in central Ethiopia since 1990's and the infection has been detected in cattle and rarely in other species of domestic animals [11, 27]. Over the years, more and more reports came up to reinforce the occurrence of the disease in different dairy cattle production systems of the country [11, 28]. However, still there is lack of information and knowledge about the actual prevalence and distribution of the disease in each dairy cattle production systems of the country.

The higher herd and individual animal prevalence rate (57.9% and 28.4%, respectively) of bovine tuberculosis observed in the current study substantiates the fact that bovine tuberculosis is one of the infectious diseases affecting the dairy cattle population in the study area. This study showed that large sized dairy herds with Holstein-Friesian breeds of cattle were more affected than small sized ones by the bovine tuberculosis. Thus, the prevalence of the disease was higher in large sized dairy herds than the small sized counterparts.

The significance difference observed for the occurrence of BTB between large sized dairy herds and small sized ones could be ascribed to the fact that as the dairy herds get more number of dairy animals, it made them more prone to the disease. This result is in line with the study findings reported by Firdessa *et al*, [29]. Besides, as the large sized dairy herds were relatively more intensified and with more input supply, it might have made them more prone to the disease problem. Since the large sized dairy herds were crowded and overstocked by more number of dairy animals, the probable occurrence of the disease in them was relatively higher and the animals in them were being more infected.

Indeed, among the different studies undertaken, the herd level prevalence rate of bovine tuberculosis ranged from 43.4% to 50% by Firdessa *et al.* [29], while the individual animal prevalence rate of BTB ranged from 3.4% in a small holder to 50% in intensive dairy production systems which have been reported in various places of the country [30, 31, 32, 33 & 34]. Hence, the large sized dairy herds necessitate more attention with regard to management and husbandry practices. Suitable housing system has to be facilitated in order to keep the appropriate dairy farm standards. Thorough follow up and care should be taken for the large sized dairy farms to protect them from further infection by the disease.

In this study, it was observed that cows were more affected than heifers by the bovine tuberculosis. Consequently, the prevalence of the test reactor dairy animals for bovine tuberculosis was higher in cows (32.3%) than in heifers (19.4%). This result was in agreement with previous studies Ameni *et al*, [31] and Regassa *et al.*, [6] and may be explained by the chronic nature of the disease and long exposure to the causative agent over longer times.

The significance difference for the occurrence of BTB between cows and heifers could be attributed to the fact that as the dairy cows get older, it makes them more susceptible to the diseasedue to their immunity decrement and their resistance to the disease gets poorer than when it is compared to that of heifers. Moreover, the cows in the dairy farms have relatively longer exposure time to the affected animals and probably could have contracted the causative agent of the disease. Besides, some physiological stress factors such as pregnancy and lactation as well as low body condition score might have made cows more susceptible to the disease than heifers. Hence, the cows need more attention with regard to management and husbandry practices of the dairy farms. Adequate and balanced feed have to be supplied in order to keep the appropriate body condition score of them. Thorough follow up and care should be taken for the dairy farms and cows to protect them from further infection by the disease.

Breed of the study animals were observed to be the potential associated risk factor which enhanced the occurrence of BTB in the dairy cattle. The prevalence rate of BTB was observed to be higher in Holstein-Friesian crossbred dairy cattle than Jersey crossbreds of cattle. This can be attributed to the fact that the high yielding capability and the relatively more susceptible nature of Holstein-Friesian dairy cattle to diseases such as BTB than the Jersey breeds of cattle. Besides, the Jersey breeds of dairy cattle were kept relatively in a better public-owned way of dairy farm management system.

The increased prevalence of BTB in Holstein-Friesian crossbred cattle compared with Jersey crossbred cattle has been previously documented by Firdesa *et al*. [29]. The finding of increased prevalence of the disease in Holstein-Friesian crossbred cattle was also reported elsewhere by Ayele*et al*. [35]. This underpins the need for strict follow up to prevent and control the disease problem in the genetically improved and crossbred dairy cattle. However, Fetene and Kebede [36] reported that the absence of significant prevalence difference among the aforementioned dairy cattle breeds. Due to lack of consistency and conclusive evidence on breed effect, management-related factors have been attributed to variation in BTB prevalence rather than the breed itself [11, 37].

The association of bovine tuberculosis to the type of breed of dairy cattle in this study is strong and this has earlier been suggested by Ameni *et al.* [38] in different parts of central Ethiopia where the highest prevalence proportion was reported in exotic and crossbred dairy cattle than local zebu ones. Indeed, there is an evidence of low prevalence rate of bovine tuberculosis in intensively and semi intensively managed exotic and crossbred dairy cattle [5, 10, 31]. However, this does not underestimate the role of breed effect as an intrinsic risk factor which could have an important impact on the occurrence of the disease problem.

In this study, the frequency and occurrence of CIDT test positive reactor dairy cattle was significantly increased in animals which were recorded as poor body conditioned cattle. This explains body condition of dairy animals to be one of the possible potential risk factors for the occurrence of bovine tuberculosis [7]. Pertinent to this risk factor, reports are available that disclosed the influence of this intrinsic risk factor which influences the infection dynamics of the disease in dairy cattle population [5, 17]. In fact, there are evidences of high prevalence rate of bovine tuberculosis in poor body conditioned dairy cattle [5, 10, 31]. However, this does not underrate the effect of several intrinsic and extrinsic factors such as level of nutrition and availability of feed, the animals' age, breed and some chronic diseases which affect the body condition score of dairy cattle other than BTB.

Another risk factor that has shown to contribute for increased frequency of positive reactors for CIDT test among the study herds and individual animals was the hygienic and sanitary standards. Herds and individual animals in poor hygienic and sanitary standards of the farms were more affected than those in medium farm hygiene and sanitation conditions. Since the dairy farms in hygienically poor farms were less ventilated and the circulation of clean and fresh air was not enough, the occurrence of the disease was observed to be more prevalent.

This can be attributed to the fact that the poor hygienic and sanitary standards of the dairy farms could have enhanced the multiplication of the causative agent of BTB. As the dairy herds get sanitarily poor, the floor of the house becomes moist and shady which favors the multiplication of the causative agent *(M. bovis)* of the disease problem. This, in turn, facilitates further contamination of apparently healthy dairy animals in the herd. Hence, further transmission of the disease occurs and animals in the dairy farm get infected and diseased.

This finding is in line with the finding of Ameni *et al.* [5]who has reported cattle husbandry and management in Ethiopia was a predominant factor for affecting the pathology of bovine tuberculosis. In fact, this study could have produced a stronger evidence for the association of this extrinsic risk factor to the occurrence of the disease problem.

The prevalence and associated potential risk factor findings of bovine tuberculosis in this study among the dairy herds and individual animals is a strong evidence that is needed for prevention and control intervention for dairy cattle and for their surroundings. However, it should be noted that the effects of the aforesaid potential risk factors which are associated with the occurrence of the disease are varied in different dairy cattle production systems, and other possible risk factors associated which have to be presumed.

The impact of bovine tuberculosis on milk production was estimated by analyzing the average daily milk yield of 182 lactating cows which were tested using CIDT. Of the total 184 lactating cows tested, 58 (31.9%) of them were positive reactors for tuberculin skin test. Accordingly, the average daily milk yield (11.0 liters) of BTB positive lactating cows was less when compared with the average daily milk yield (15.01 liters) of lactating cows which were not reacting for the tuberculin test. Hence, the average daily milk yield of BTB positive lactating cows was less by 26.7% than that of BTB negative lactating cows. The difference in milk yield between the two groups of lactating cows was significantly different ($p < 0.01$) indicating that BTB has a considerable negative impact on the milk yield of dairy animals. However, since the lactating cows in the two categories were at different lactation stages, parity and different body condition scores, the estimation of average daily milk yield might vary to some extent.

The economic importance of bovine tuberculosis has been established in many developed countries. However, in Ethiopia, the economic impact of BTB on cattle productivity and milk production is not yet well documented or studied [11]. Only few abattoir meat inspection surveillances have shown that the condemnation rate of the total or partial carcass and organs. With this respect, it is reported that 0.024% to 31.2% of a total condemnation and a partial condemnation rate of 16.4% resulted in significant economic losses [11, 39, 40].

With regard to public health risk and awareness about the disease, all the respondents of the dairy farmers in this study answered that they themselves and the member of their family used to consume unpasteurized or non-boiled milk as well as uncooked meat, and their contact with the dairy animals was closer than expected. Out of the 38 dairy owners, 14 (36.8%) of them responded they knew that bovine tuberculosis is a cattle disease and can be transmitted to humans through consumption of unpasteurized or non-boiled milk as well as via uncooked meat. Moreover, 5 (13.2%) of the CIDT respondents working in the farm have noticed clearly having some of the clinical sign of the disease in the last two years. Besides, out of the 22 CIDT test positive herds,3 (13.6%) of them had respondents with obvious clinical signs of tuberculosis.

The observed clinical signs of TB in this study comprised all forms of the disease and no differentiation was made between *M. bovis* and *M. tuberculosis.* Considering the relatively higher percentage of the apparent clinical signs of the pulmonary tuberculosis, it is plausible that *M. bovis* might play a substantial role. The farmers' consumption habits for raw milk and meat in this study have shown the public health importance as of the other findings in Ethiopia [41]. In comparison to Regassa et al. [34] and Ameni and Erkihun [42], a positive relationship was found between having PPD-positive cattle and clinical signs of the disease in human cases of TB. This can be attributed to the fact that dairy herders and dairy cattle often shared the same house, and this enhanced the transmission of the disease between them. However, conclusive statements on the zoonotic significance and potential public health hazard of BTB require bacteriologically confirmed *M. bovis* in human TB cases.

Therefore, the herd and individual animal prevalence rate findings, associated potential risk factors, its impact on the milk production and the public health significance of BTB in the study area explicitly warrant the need for more intensive investigation on static and dynamic nature and additional possible risk factors of the disease in the dairy cattle population.

The socio-economic characteristics of this study has depicted information related to the dairy farm husbandry practice such as feeding, health and recording aspects of the dairy farms to infer the findings with associated risk factors for the occurrence of the disease problem.

In this study, it was observed that 65.8% of the dairy herders were found to be either females or female-headed dairy farms. In contrast, Belay and Janssens [43] from Jimma reported that 75.9% of the respondents were males which were also in agreement with the reports presented by Azage [44] and Yitaye [45] who reported that in Addis Ababa and northwest of Ethiopia, there were more male-headed households than female headed ones. Furthermore, 63.2% of the total dairy farm owners assessed was observed to be young people involved in the dairy business. Besides, Haile [46] reported that dairying created an estimated 224.5 persons per 1000 liters of milk in the year 2004 in Ethiopia. Staal et al. [47] also estimated that the urban/peri-urban dairy production system creates annually 4.4 million person days of work or 16, 400 fulltime jobs, while the small-scale mixed farming systems created 166 million person days of work, equivalent to 553,500 full-time job. This was evidential that the dairy sector is becoming one of the choices of entrepreneurs for the creation of job and employment especially by small holder dairy producers and their families. This indicated that the involvement of younger people in the dairy development activities.

71.1% of the dairy herd owners had total household members less than five whereas 28.9% of the dairy farm owners had a family member ranging from 6-10. This finding was in line with that of Belay and Janssens [43] who have reported from Jimma that the average family size of the respondents of 54 dairy farmers was 6.02±2.52 members. However, the average family size in the present study was observed to be lower than the finding of Asaminew and Eyasu [48] that showed the mean family size in Bahir Dar and Mecha districts was 8.2 and 7.2 persons, respectively.

The assessment of the educational status of the dairy owners showed that out of 38 herders, half of them were grade 9-12 whereas those with diplomas and above accounted only 6 (15.8%).The rest of the dairy owners were with basic writing and reading skills. None of the dairy farm owners were observed to be illiterate. Belay and Janssens [43] in Jimma reported that of the total 54 households interviewed, 42.9% had college and university education, and the findings of the present study was lower than the former one. However, it was comparable to the findings of Teferee [49] who reported in Addis Ababa milk shed; of the total respondents of the dairy herd owners 24% of them had college and university education.

As to the job status of the dairy farm owners, 44.7% of them were observed to be government employees. In addition, 21.1% of the dairy farm owners were found to be retired, and the rest 13 of them were in other different job categorical positions. Of the total assessed farms, 37 of them were private dairy farms and the rest one was state owned one. It is possible to conclude that the majority of the dairy herds in the study area were private owned dairy farms. Besides, 29 of the dairy farms observed were small sized dairy farms with the average number of 6 dairy cattle, whereas 9 of them were medium sized dairy herds. Comparable to this, Fikre [50] reported the average herd size per farm was 6.5 (range 2–24) and 9.9 (range 3–32) for the urban dairy production system and mixed crop livestock production systems, respectively, while the average number of cows per farm in the aforementioned dairy production systems was 3.1 (range 2–10) and 3.2 (range 2–8), respectively. This also indicated that the number of small sized dairy farms were relatively higher than the medium sized ones in the study area.

With regard to the housing system, the dairy farms in the study area were all indoor types and the stall structure was found to be a tie-up one. Out of the total 37 private owned dairy farms questioned, 91.4% of them responded that they have bought dairy cattle from other known dairy farms and established the dairy business. Moreover, 94.7% of the farm owners responded that they have got replacement stock from their own farm by artificial insemination (AI) breeding technique. In contrast to this finding, Fikre [50] reported that approximately 36% of the farms in the mixed crop livestock production systems of Sellale and Holeta, Oromia region, used bull service only, while 40% of the farms in small holder urban dairy production systems used AI service only. The report of the current study showed that AI breeding method is becoming more popular than bull mating due to the advantages of the former over the latter one.

All of the dairy animals in the study area were kept in indoor types of housing system. The finding of the present study was comparable with that of Belay and Janssens [43] who showed that 100% of the dairy farmers in Jimma provided closed houses for their dairy cattle. Besides, the findings of Emebet and Zeleke [51] showed that the major floor structure of cattle shed was hardened soil in Dire Dawa, eastern Ethiopia. Moreover, the housing system in the study area was no more a standard stalls or barns. The entire stall observed was tie-up kind in design and construction. Only a kind of closed shelter was used to protect the animals against wind, rain, solar radiation and wild life. Site selection and construction designs for the shelters were no more conventional ones. Moreover, the house construction design was dependent on economic level of the herd owners. The sanitary and hygienic condition of the floor, wall and roof of the shelters were relatively medium to poor. The animals in most farms were kept in poor ventilated and crowded sheds. This was comparable with the findings of Belay and Janssens [43] who observed that due to lack of space, disposal of manure posed a difficult problem. Except in a very few dairy farms, animal shelters used in the study area could be characterized as sub-standard in hygiene for production of quality milk. In addition, most of the small scale dairy herds share the common housing infrastructures with the attendants and the owners of the farm.

All of the farm owners responded that major feedstuffs for their dairy cattle included industrial by products such as wheat bran which were locally known as *furushka and furshkelo.* Crop residues from wheat, barley, teff, and maize and other crops were known to be other sources of feedstuffs for dairy cattle. This observation was comparable with that of Yilma and Amha [52] who concluded that the feeding method for dairy cattle in small holder dairy production systems was supplemented with natural grass hay, crop residues such as straws and chaffs of cereals and pulps, and agro-industrial by-products mostly from the flour/oil industries and brewery residues. Contrary to this, dairy producers in the study area didn’t cultivate improved forage crops such as elephant grass, oats, vetch and alfalfa to supplement grazing due to scarcity of land.

Hence, hay, forages of different types and homemade leftovers in different proportions were fed to the dairy animals. 97.4% of the respondents in the dairy farms answered that the source of feedstuffs for their dairy cattle was by purchasing from the available sources. As reported by SNV [53], the concentrate feeds are mainly used by urban dairies. The availability of the forage feedstuff was greatly affected by seasonal differences. Forages were sufficient for the dairy herds especially in wet seasons of the year. Unlike that of medium sized dairy herds, dairy cattle in small scale herds were let to graze in the vicinity of their locality.

As to feeding regimen, the supplying of the available feedstuffs is dependent on the animals' physiological state such as age and production status. More of the available feed is given to milking cows, calves and pregnant cows and heifers. The animals in the dairy herds are mostly fed thrice a day especially early in the morning, at noon and at nightfall. Small sized dairy herds were supplemented with additional homemade feed sources such as *attela,* a residue from local alcoholic drinks known as *tella* and *katikalla.* According to Mekasha [54], atella and pulp hulls were utilized by 80 and 47 percent of the dairy production in the urban dairy farmers, respectively. However, it was reported by the same author that atella had high crude protein (20 percent) and organic matter (97 percent) content.

All the dairy herders applied hand milking techniques and milking cows both in state owned and private farms were milked 2-3 times a day. This finding was in line with the reports of Belay and Janssens (2015) who indicated that out of 54 dairy farmers questioned in Jimma practiced hand milking with twice (88.9%), thrice (7.4%) and once (3.7%) milking frequency per day. Furthermore, once and thrice per day milking frequency was also reported by Sintayehu et al. [55] in Shashemene - Dilla urban dairy production area, South Ethiopia. The average daily milk yield per cow was estimated approximately to be 14 litters. It was observed during the interview that the personnel in charge of milking the cows were hygienically poor and milking utensils and the environment were not in a good hygienic condition. All the calves both in state owned and private dairy farms were bucket-fed since the first weeks of calving.

All the dairy animals were kept for the purpose of producing income for the owners and for the purpose of fulfilling food and protein demand of the households. The milk produced was sold to the hotels, cafes and individual consumers in a contractual base. Some of the milk product was consumed at home for food security purposes. There was no milk processing plants in the town and the remaining milk was processed traditionally and consumed by the household.

Out of the 38 dairy herds, only two dairy farms (one private and one government owned) responded that they have got standard farm records. The state owned dairy farm used to keep all types of dairy farm records whereas only one of the private owned dairy farms kept only breeding/ artificial insemination record. In the rest of the private owned dairy farms, there was no standard record about the milk production activities which has been undertaken in the farms. Herd breeding, health, feeding and related information was not kept properly.

The aforementioned recording fact was in agreement with the findings of Fikre [50] from Oromia region, central highlands of the country that farm data-recording systems at the smallholder dairy production level were either totally absent or incomplete, so it is usually difficult to get reliable data with which to evaluate the performance of smallholder cattle. In the present study, all the routine management and husbandry practices of the dairy herds and individual animal records were passed from attendant to attendant mostly in oral bases. Written and documented information was rare and the owners and attendants of the dairy herds answered the questions in a memorial way. Most of the dairy herd owners narrated the history of their farm, but very ambiguously.

Conclusion and Recommendations

Bovine tuberculosis is known to occur in high producing crossbred dairy cattle in semi-intensive and intensive livestock production systems. The comparative intra-dermal tuberculin (CIDT) test result of this study revealed the prevalence of bovine tuberculosis infection in dairy herds and individual animals of Wolaita Sodo town to be 57.9% and 28.4%, respectively. Herd size, age, breed and body condition score of dairy animals as well as farm hygienic and sanitation conditions were found to be the most important intrinsic and environmental risk factors associated with the occurrence of bovine tuberculosis. The negative impact of bovine tuberculosis on the yield and quality of milk was observed to be significantly different. The average daily milk yield of lactating cows which were found positive reactors for bovine tuberculosis skin test was observed to be 26.7% times less than that of non-reactor lactating cows. Bovine tuberculosis infection causes milk productivity losses to livestock owners and decreases the value chain of milk and milk products.

Based on above conclusion the following recommendations are forwarded.

- ✓ Creating awareness on BTB transmission and its public health significance to cattle owners and farm attendants for effective implementation of TB control measures.
- ✓ Based on a proper strategy, regular tuberculin skin testing of dairy cattle should be continued, test and slaughter policy should be designed and it is equally important to take strict control and quarantine measures during the movement and importation of dairy animals and animal products.
- ✓ The detail static nature of bovine tuberculosis is not well studied and its dynamic characteristics are not fully understood in the study area, and needs further investigation.

References

1. Berg S., Firdessa R., Habtamu M., Gadissa E., Mengistu A., Yamua I., Ameni G., Verdermier M., Robertson B.D., Smith N.H., Engers H., Young D., Hewinson R.G., Asseffa A.and Gordon S.V. 2009. The burdon of mycobacterial disease in Ethiopian cattle, implications for public health, PLoS ONE, 4, (4), 5068
2. Seifert.S.H.1996. Tropical Animal Health CTA, ACP-EU, Kluwber academic publishers, London, , 548 pp
3. WHO (World Health Organization). 2014. Global tuberculosis control surveillance, Planning and Financing, WHO Report, Country Profile, Ethiopia, 83–8, Geneva, Switzerland,
4. LMP (Ethiopia Livestock Master Plan), 2015.Roadmaps for the growth and transformation, a contribution to the Growth and Transformation Plan II (2015-2020), developed by the LMP team for the Ministry of Agriculture, Livestock Resources Development Sector, August 2015
5. Ameni G., Schelling E., Hattendorf J., Young D., Asseffa A. and Zinsstag J. 2009. Risk factors of bovine tuberculosis in cattle in rural livestock production systems of Ethiopia, Preventive veterinary medicine, 89, (3-4), 205-211
6. Regassa A., Tassew A., Amenu K., Megersa B., Abunna F., Mekibib B., Marcotty T. and Ameni G. 2010. Across-sectional study on bovine tuberculosis in Hawassa town and its surroundings, Southern Ethiopia, Tropical Animal Health and Production, 42, (5), 1039
7. Balako G. D. 2013. PhD thesis on: Mycobacteria and Zoonoses among Pastoralists and their livestock in South-East Ethiopia
8. Palmer M.Y. and Waters W.R. 2006. Advances in bovine tuberculosis diagnosis and pathogenesis, what policy makers need to know, veterinary microbiology, 112, 181-190
9. Smith N.H., Gordon S.V., de la Rua-Domenich, R, Cliften-Haddley, R.S,. and Hewinson R.G. 2006. Bottlenecks and broomsticks, the molecular evolution of *M. bovis*, Nat. Rev Microbiology, 4, 670-681
10. Regassa A., Medhin G. and Ameni G. 2008. Bovine tuberculosis is more prevalent in cattle owned by farmers with active tuberculosis in central Ethiopia, the veterinary journal, 178, 119-125.
11. Shitaye J.E., Tsegaye W., TsegayeandPavlik I. 2007. Bovine tuberculosis infection in animal and in human population in Ethiopia: a review, Veterinarini Medicina, 52, 8, 317-332
12. Demelash B., Inangolet F. O., Oloya J., Asseged B., Badasso M., Yilkal A. and Skjerve E. 2009. Prevalence of bovine tuberculosis in Ethiopian slaughter cattle based on post-mortem examination, Tropical Animal Health and Production, 41, (5), 755-765
13. Ameni G., Schelling E., Hattendorf J., Young D., Asseffa A. and Zinsstag J. 2010. Field evaluation of the efficacy of *Mycobacterium bovis* Bacillus Calmette Guerin against bovine tuberculosis in neonatal calves in Ethiopia, Clinical and Vaccine Immunology, 17, 1533-1538

14. Ameni G., Asseffa A., Engers H., Young D., Gordon S., Hewinson G. and Vordermier M. 2007b. High prevalence and increased severity pathology of bovine tuberculosis in Holstein compared to zebu breeds under field cattle husbandry in central Ethiopia, clinical and vaccine immunology, 14,(10), 1356-1361
15. Shitaye J.E., Getahun B., Alemayehu T., Skoric M., TremlF., Fictum P., Vrbas V. and Pavlik I. 2006. A prevalence study of bovine tuberculosis by using abattoir meat inspection and tuberculin skin testing data, histopathological and IS*6110* PCR examination of tissues with tuberculous lesions in cattle in Ethiopia, Veterinarni Medicina, 51,512–552
16. Tschopp R., Schelling E., Hattendorf J., Asseffa A. and Zinsstag J. 2009. Risk factors of bovine tuberculosis in cattle in rural livestock production systems of Ethiopia, Preventive veterinary medicine, 89, 4, 205-211
17. Mammo G., Kassaye A., Sanni M. and Ameni G. 2009. Across sectional study of camel tuberculosis in Ethiopia, Bulletin of Animal Health and Production in Africa, 57
18. Hiko A. and Agga G.E. 2011. First time detection of mycobacterium species from goats in Ethiopia, Tropical Animal Health and Production, 43, 133-139
19. Pollock J.M. and Neill S.D. 2002. *Mycobacterium bovis* infection and tuberculosis in cattle, Vet. Journal, 163, 115-127
20. Wolaita Sodo town agricultural office, 2015, livestock census data
21. Wolaita Sodo town urban development office, 2015 data
22. Thrusfield M. 2007. Veterinary Epidemiology, 3rd Edition, Veterinary Clinical Studies, Royal (Dick) School of Veterinary Studies, University of Edinburgh, Blackwell Science, Oxford, England, 610 pp
23. Jerrold H. Z. 2010. Biostatistical Analysis, Department of Biological Sciences, Northern Illinois University, Pearson Prentice Hall,Pearson Education Upper Saddle River, New Jersey, United States of America, Fifth Edition, PP 947
24. Msangi, B.S.J., Bryant M.J., Kavana P.Y., Msanga Y.N. and Kizima, J.B. 1999. Body condition measurements as a management tool for cross-bred dairy cattle at a smallholder farm condition. In: Proceedings of the 26th Scientific Conference of the Tanzanian Society of Animal Production, Arusha, 1997
25. *Mantoux C. www://https://en.wikipedia.org/wiki/Mantoux_test*,*The Mantoux test or Mendel*-Mantoux test (also known as the Mantoux screening test, tuberculin sensitivity test, Pirquet test, or PPD test for purified protein derivate)/accessed on 18 October 2015
26. *OIE 2009. terrestrial manual,* http://www.oie.int/fileadmin/Home/fr/Health_standards/tahm/2.04.07_BOVINE_TB.pdf*/accessed on 20 September2016/*
27. Regassa A.1999. Preliminary study on bovine tuberculosis in Wolait Sodo, South Ethiopia, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University, Debre-Zeit, Ethiopia.
28. Zinsstag J., Kazwala R. R., Cadmus I. and Ayanwale L. 2006a. *Mycobacterium bovis* in Africa, In: Thoen C.O., Steele J.H. and Gilsdorf M.F. 2006. *Mycobacterium bovis* Infection in Animals and Humans, 2nd ed. Blackwell Publishing Professional, Ames, Iowa, USA, 199–210
29. Firdessa R., Berg S., Hailu E., Schelling E. and Gumi B. 2013. Mycobacterial Lineages Causing Pulmonary and Extra-pulmonary tuberculosis in Ethiopia, Emerging Infectious Diseases In press, 10, 32, 45-68
30. Ameni G. and Wudie A. 2003. Preliminary study on bovine tuberculosis in Nazareth municipality abattoir of central Ethiopia, Bulletin of Animal Health and Production in Africa, 51, 125–132
31. Ameni G., Bonet P. and Tibbo M. 2003a. A cross sectional study of bovine tuberculosis in selected dairy farms, in Ethiopia, the international journal of applied research in veterinary medicine, 1 (4), 85-89
32. Asseged B., Lübke-Becker A., Lemma E., Taddele K. and Britton S. 2000. Bovine TB, a cross-sectional and epidemiological study in and around Addis Ababa, Bull Animal health and Production in Africa, 48,71-80
33. Firdessa R., Tschopp R., Alehegne W., Melaku S., Elena H., Girume E., Teklu K., Lawrence Y., Martin V., R. Glyn H., Douglas Y., Stephen V. G., Mesfin S., Abraham A. and Stefan B. 2012. High Prevalence of Bovine Tuberculosis in Dairy Cattle in Central Ethiopia: Implications for the Dairy Industry

and Public Health, research article, PLoS ONE Journal, 7, 12

34. Regassa, A., 2005. Study on Mycobacterium bovis in animals and human in and around Fiche, North Shewa Zone, Ethiopia. [MSc. Thesis.] Faculty of Veterinary Medicine, Addis Ababa University, Debre-Zeit, Ethiopia, 58 pp.
35. Ayele W.Y., Neill S.D., Zinsstag J., Weiss M. G. and Pavlik I. 2004. Bovine tuberculosis, An old disease but a new threat to Africa, The International Journal of Tuberculosis and Lung Disease, 8, 924-937
36. Fetene T. and Kebede N. 2009. Bovine tuberculosis of cattle in three districts of North-Western Ethiopia, Tropical Animal Health and Production, 41, (2), 273-277
37. Ameni, G., A. Aseffa, H. Engers, D. Young, S. Gordon, G. Hewinson and M. Vordermeier, 2007. High prevalence and increased severity of pathology of bovine tuberculosis in Holsteins compared to zebu breeds under field cattle husbandry in central Ethiopia. Clinical and Vaccine Immunology 14: 1356-1361.
38. Ameni G., Schelling E., Hattendorf J., Young D., Asseffa A. and Zinsstag J. 2011. *Mycobacterium tuberculosis* infection in grazing cattle in central Ethiopia, Vet. Journal, 188, 359-361
39. Abel M. 1989. Survey of abattoir meat inspection data in Dire Dawa abattoir, Annual Report, Dire Dawa, Eastern, Ethiopia
40. Gezahegne L. 1991. Economical aspect of condemned organs and parts due to cystycercosis, hydatidosis, fasciolosis and tuberculosis, Analysis report, Ministry of Agriculture, Addis Ababa, Ethiopia
41. Ameni, G., P. Bonnet, M. A. Tibbo, 2003. A cross-sectional study of bovine tuberculosis in selected dairy farms in Ethiopia. The International Journal of Applied Research in Veterinary Medicine, 1(4): 85-97
42. Ameni G. and Erkihun A. 2007a. Bovine tuberculosis on small scale dairy farms in Adama town, central Ethiopia, farmers' awareness of the disease, Revue Scientific Et, Technique, (IOE), 26, (3), 711-719
43. Belay D. and Geert. P.J. Janssens. 2015. Assessment of Dairy Farmers' Hygienic Milking Practices and Awareness of Cattle and Milk-Borne Zoonoses in Jimma, Ethiopia, Food Science and Quality Management, 45, 114-121
44. Azage T. 2004. Urban livestock production and gender in Addis Ababa, Urban Agriculture Magazine, number 12. Proc. 14th Annual Conference of the Ethiopian Society of Animal production (ESAP). September 5-7, 2006. Addis Ababa, Ethiopia
45. Yitaye A., Zollitsch W., Wurzinger M. and Azage T. 2008. Characterization and analysis of the urban and peri-urban dairy production systems in the North-western Ethiopian highlands. A thesis submitted to BOKU – University of Natural Resources and Applied Life Sciences, Vienna, Austria for the award of Doctor Rerum anturalium technicarum (Doctor of Natural and Technical Sciences), Vienna, October 2008
46. Haile G.2009. The impact of global economic and financial crisis on the Ethiopian dairy industry. Impact of the global economic crisis on least developed countries' (LDCs) productive capacities and trade prospects, Threats and opportunities, Least 64 Developed Countries Ministerial Conference, UNIDO, 3-4 December 2009, Vienna International Center, Austria.
47. Staal S., Nin.Pratt A. and Jabbar M. A. 2008. Dairy development for the resource poor. Part 1: A comparison of dairy policies in South Asia and East Africa, FAO pro-poor livestock policy initiative, Rome, Italy and ILRI, Nairobi, Keny
48. Asaminew T and Eyasu, S. 2009. Smallholder dairy system and emergency of dairy cooperatives in Bahir dar Zuria and Mecha Woredas, northern, Ethiopia. World Journal of Dairy and Food Sciences 4, 2, 185-192
49. Teferee M. 2003. A study on Urban Agriculture, The case of small-scale dairy farming in selected areas of Addis Ababa, MA. Thesis, Addis Ababa University
50. Fikre Lobago, 2007. Reproductive and Lactation Performance of Dairy Cattle in the Oromia Central Highlands of Ethiopia with Special Emphasis on the Pregnancy Period. Doctoral thesis.
51. Emebet M. and Zeleke M. Z. 2008. Characteristics and constraints of crossbred dairy cattle production in lowland areas of Eastern Ethiopia
52. Yilma Z., G.B., Emmanuelle and S. Ameha. 2011. A Review of the Ethiopian Dairy Sector. Ed. Rudolf Fombad, Food and

Agriculture Organization of the United Nations (FAO), Sub Regional Office for Eastern Africa (FAO), Addis Ababa, Ethiopia, pp 81

53. SNV.2006. Developing a Market Led Strategy for the Ethiopian Dairy Industry, by Technoserve Kenya, Nairobi, Kenya. pp 43
54. Mekasha Y. 1999. Impact of feed resources on productive and reproductive performance of dairy cows in the Addis Ababa milk shed, School of Graduate Studies, Alemaya University of Agriculture, Ethiopia (MSc thesis)
55. Sintayehu Y, Fekadu B, Azage T and Berhanu GM (2008). Dairy production, processing and marketing systems of Shashemene–Dilla area, South Ethiopia. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 9, ILRI (International Livestock Research Institute), Nairobi, Kenya. pp 62

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