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Review on Occurrence and Economic Importance of Bovine Tuberculosis in Ethiopia

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Abstract: Ethiopia is one of the nations that possess the largest livestock population in the African continent with an estimated 56.7 million cattle, 29.3 million sheep, 29.1 million goats and 9.86million equines, 1.2 million camels and 56.7 million chickens. The vast majority of the national herd is of indigenous zebu cattle maintained in rural areas under extensive husbandry systems. In contrast to the huge livestock resource, the livestock productivity is, however, found to be very low. The major biological and socio-economic factors attributing to low productivity include low genetic potential and performance, poor nutrition (in quality and quantity terms), the prevailing of different diseases, traditional way of husbandry systems and inadequate skilled manpower, among others. Ethiopia is one of the African countries where tuberculosis is wide spread in both humans and cattle and the endemic nature of tuberculosis in humans and cattle has long been documented. Mycobacterium bovis is an intracellular, non-motile, facultative, weakly Grampositive acid-fast bacillus that belongs to the Mycobacterium tuberculosis complex. The pathogen affects all age groups of susceptible hosts of domestic, wild animals and human. In cattle, Bovine tuberculosis is one of the endemic chronic diseases of cattle that have long been recorded in Ethiopia. Bovine tuberculosis is widely distributed around the world with significant economic impact on the livestock production sector. In Ethiopia, cattle breeds, age, sex, body condition score and herd size, management condition, geographical origin, consumption of raw milk and close contact to livestock are most commonly identified risk factors for the spread of Mycobaterium bovis. The actual prevalence rate of bovine tuberculosis (BTB) at a national level is yet unknown. Detection of BTB in Ethiopia is carried out most commonly on the basis of tuberculin skin testing, abattoir meat inspection and very rarely on bacteriological techniques. Recently undertaken studies indicated the prevalence rate of BTB with a range of 3.4% (in smallholder production system) to 50% (in intensive dairy productions) and a range of 3.5% to 5.2% in slaughter houses in various places of the country. BTB in cattle remains to be a great concern due to the susceptibility of humans to the disease. Although, the disease represents a potential health hazard to all susceptible hosts, the economic effects of the disease are not well studied. With the exception of a few attempts like the condemnation of carcass and organs during meat inspection, culling of infected animals in some government owned farms and pasteurization of milk, effective disease control strategies do not yet established in our country.

Key words: Bovine · Ethiopia · Mycobacterium · Occurrence · Tuberculosis · Risk Factors

INTRODUCTION

A close interaction between animals and humans primarily contributes to the transmission of infectious zoonotic diseases between them [1]. Bovine tuberculosis is a common zoonotic disease caused by Mycobacterium bovis which affects a wide range of animals and humans [2, 3]. Cattle-based tuberculosis has become a significant infectious disease that spread between species. Bovine tuberculosis is widely distributed around the world with a significant economic impact on the livestock production sector [4-6].

BTB is an infectious disease caused principally by Mycobacterium (M.) bovis, which is a member of the Mycobacterium tuberculosis complex (MTC). Although cattle are susceptible to M. bouis infection and are the preferred host for M. bouis, the disease has been reported in many other domesticated animals, wildlife and humans

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[7- 9] . Aerosol exposure to M. bouis is believed to be the most frequent mode of transmission in cattle, but infection by ingestion has also been reported previously [10]. Human beings can also acquire the infection either by inhalation or ingestion [11, 12]. Thus, BTB is a disease of major socio-economic importance, with an impact of loss in animal productivity and international trade of animals and animal products [12].

Mycobaterium bovis (*M. bovis*) is an intracellular, non-motile, facultative, weakly Gram-positive acid-fast bacillus. The MTBC sub-group also comprises *M. tuberculosis*, *M. africanum*, *M. canettii*, *M. pinnipedii*, *M. microti* and *M. caprae* that are generally regarded as host adapted but with the ability to spill over into other species. Mycobaterium bovis is the primary cause of bovine tuberculosis (BTB). *M. tuberculosis*, *M. africanum*, *M. caprae* and *M. canettii* are human pathogens. *M. caprae* which causes infection in goats has been initially classified as subspecies of *M. bovis* but was recently recognized as a species on its own. *M. microti* affects rodents and *M. pinnipedii* have been isolated from seals [13]. Mycobaterium bovis has an exceptionally wide range of mammalian hosts and affects all age groups of susceptible hosts of domestic, wild animals and humans [13]. Cattle are the most common maintenance host for M. bovis infection from which transmission can occur to wildlife, or people animals [14].

The BTB is a chronic contagious debilitating disease of animals associated with progressive weakness/emaciation and tubercle (granuloma) formation, mainly confined to respiratory system (primarily in the lungs) and occasionally in other organs [15]. The infection to bovine can occur through the colostrum/milk to calves, ingestion of feed contaminated with feces of infected animals, aerosol, contact with each other and other wildlife [15]. The causative agent of tuberculosis (Mycobacterium) can remain viable in the environment/soil for about two years [16]. Various risk factors responsible for the occurrence of disease include calving site, herd size, the length of time calves kept in groups, the breed, the source of replacement, presence of wild animals and the region in which they are kept, presence of mixed (dairy and beef) production, age, housing systems [17].

Ethiopia is ranked top in the list of African countries with large livestock populations and it has been contributing considerable portion to the economy of the country. The 2012/13 livestock survey estimated the total number of cattle, sheep and goat population in the country to be 54 million, 25.5 million and 24 million, respectively. And Amhara Regional State owns 13.8 million cattle, 8.8 million sheep and 5.1 million goats [18]. About 98.9% of the total cattle populations in the country were local breeds and the remaining were hybrid (0.94%) and exotic (0.11 %) breeds. Among a total of 3.4 million cattle population aged _'.S.3-10 years, 12.5% were used for milk production [18]. Even though the livelihood of the people in Ethiopia is extremely dependent on livestock, several constraints including feed shortage, poor genetic performance and diseases prevalence are limiting the livestock production and productivity. Prevalence data on BTB infection in Africa is scarce. There is, however, sufficient evidence to indicate that disease is widely distributed in almost all African countries and even is found at high prevalence in some animal populations [19]. However, in the tropical countries including Ethiopia, BTB has been found to affect a higher proportion of exotic breeds than local zebus [20-22]. Thus BTB is still a great concern in many developing countries and Ethiopia is one of those where BTB is considered as prevalent disease in cattle populations. Its zoonotic implication has also significantly indicated an increasing trend to be of public health hazards [21, 23]. So, the objectives of this seminar paper are to review available literatures on the status of bovine tuberculosis in Ethiopia. Therefore, the objective of this paper was to highlight the occurrence of bovine tuberculosis in Ethiopia.

Etiology: Bovine tuberculosis is a chronic bacterial disease in animals and humans and is a major infectious disease among cattle, other domesticated animals and certain wildlife populations in a medium number of countries [11, 24]. Although cattle are considered to be the main hosts of *Mycobacterium bovis* (*M. bovis),* isolations have been made from many other livestock and wildlife species and transmission to humans constitutes a public health problem [19, 25]. Aerosol exposure to *M. bovis* is considered to be the most frequent route of infection of cattle, but infection by ingestion of a contaminated material also occurs [26].

In addition, a new species, *M. bovis* sub-species caprae, previously classified as *M. tuberculosis* sub-species caprae has been identified as a cause of infection in humans, goats, cattle, deer and swine [27].

Bovine tuberculosis is mainly caused by *M. bovis* of which cattle are the maintenance hosts. The organism is a Gram positive, acid-fast bacterium in the *M. tuberculosis* complex of the family Mycobacteriaceae [28].

Taxonomically, Mycobacteria are classified under the order Actinomycetales, which includes among others the genera Mycobacterium, Rhodocccus and Nocardia. *Mycobacteria* are aerobic, non-motile, non-spore forming, straight or slightly curved roads 1.5 to 4 micro meter long and 0.3 to 0.5 micro meter wide [29]. Their cell wall contains a high content of lipids which once stained with carbol fuchsin, cannot be decolorized by acid alcohol: thus the name 'acid fast bacteria' [29]. Therefore, the criterion of inclusion in to this genus is: acid fastness, presence of mycolic acids containing between 60 and 90 carbon atoms and a G+C mole between 61% - 71% [30].

Occurrence: All species, including humans and age groups are susceptible to *M. bovis,* with cattle, goats and pigs most susceptible and sheep and horses showing a high natural resistance [31]. In developed countries that have had rigorous tuberculosis (TB) control programs in place for many years, tuberculosis in animals is now a rarity, with occasional severe outbreaks occurring in a small group of herds. The presence of the disease is usually signaled by detection in carcasses at abattoirs [32].

Risk Factors: The major risk factors affecting the occurrence of BTB are environmental, host and pathogen risk factors. Housing predisposes to the disease, as does high stocking intensity and a medium number of animals on a farm so the disease is more common and serious where these forms of husbandry are practiced [33]. The closer the animals are in contact, the greater is the chance that the disease will be transmitted [29]. In spite of the low overall incidence in countries where cattle are at pasture all the year round, individual herds with 60-70% morbidity may be encountered [34].

Zebu (*Bos indicus)* type of cattle is thought to be much more resistant to tuberculosis than European cattle [35]. The effect of the disease on these cattle are much less severe but under intensive feedlot conditions, a morbidity rate of 60% and a depression of weight gain can be experienced in tuberculous Zebu cattle [32]. The causative organism is moderately resistant to heat, desiccation and many disinfectants. It is readily destroyed by direct sunlight unless it is in a moist environment. In warm, moist, protected positions, it may remain viable for weeks [36].

Source of Infection and Transmission: As to source of infection, infected cattle are the main source of infection for other cattle. Cattle in the early stages of the disease, before any lesions are visible, may also excrete viable mycobacteria in nasal and tracheal mucus [31]. Inhalation is the almost invariable portal of entry in housed cattle and even in those at pasture it is considered to be the principal mode of transmission [36-54].

Diagnosis, Clinical Symptoms and Treatment: Bovine tuberculosis cannot be diagnosed simply because of its clinical symptoms and the symptoms of the disease are similar with some other livestock diseases. Treatment of BTB is not effective and the drug used is furthermore excreted with the milk and after termination of the treatment the disease may recur.

Diagnosis: The diagnosis of bovine tuberculosis is not that easy and simple because of its clinical findings. For eradication of BTB on a herd bay her basis, the tuberculin test is applied [31]. The inspection of the carcass of slaughtered animal as an identification technique will give enough indications to ensure the diagnosis. Besides, it is easy to demonstrate the characteristic acid-fast, slender rods in their typical position microscopically with Ziehl-Neelson staining in impression smears from caseous tubercles of affected organs or lymph nodes [27]. The fastidious cultural isolation and identification of the pathogen or the transmission of tissue from affected organs to guinea-pigs will only be required in exceptional case [27].

Clinical Symptoms: Although signs referable to localization in a particular organ usually attract attention to the possible occurrence of tuberculosis, some general signs are also evident [31]. Some cows with extensive miliary tubercular lesions are clinically normal but in most cases progressive emaciation associated with other signs occur and should arouse suspicion of tuberculosis [31]. A capricious appetite and fluctuating temperature are also commonly associated with the disease [37]. The hair coat may be rough or sleek. Affected animals tend to become more docile and sluggish but the eyes remain bright and alert. These general signs often become more pronounced after calving [32].

Treatment: The risk of shedding organisms, hazards to humans and potential for drug resistance make treatment controversial [31] and, in some countries, it may be illegal. Antimicrobial treatment has been attempted in some species of animals, but the treatment must be long term

and clinical improvement can occur without bacteriological cure. In many cases, the pathogens will not be eliminated from the organisms [31].

The tuberculous process will only be encapsulated and the chronic stage of the disease stabilized. Thus, treated animals will remain carriers and excrete the pathogen. Furthermore, the drug is excreted with the milk and after termination of treatment the disease may recur [31]. Because of the progress being made in the treatment of human tuberculosis with some drugs, the treatment of animals with tuberculosis has undergone some examination and claims have been made for the efficiency of long-term oral medication with both as treatment and as prophylaxis [31].

Public Health Significance: Bovine tuberculosis is a chronic bacterial disease of cattle that occasionally affects other species of mammals []. This disease is a significant public health hazard that can spread to humans, typically by the inhalation of aerosols or the ingestion of unpasteurized milk. In developed countries, eradication programs have reduced or eliminated tuberculosis in cattle and human disease is now rare; however, reservoirs in wildlife can make complete eradication difficult [26]. The current increasing incidence of tuberculosis in humans, particularly in immune-compromised humans, has given a renewed interest in the zoonotic importance of *M. bovis,* especially in developing countries [43] and the ease and frequency of the spread of tuberculosis from animals to humans in an uncontrolled environment makes this an important zoonosis. *M. bovis* can be responsible for 5 to 10% of human tuberculosis with higher rates in children in some areas [43].

Control and Eradication: Control in a herd rests on the removal of the infected animals, preventing the spread of infection and avoidance of further introduction of the disease [31]. Eradication of bovine tuberculosis has been virtually achieved in many developed countries. The methods used have depended on a number of factors but ultimately the *test and slaughter* policy has been the only one by which effective eradication had been achieved [43-49].

Bovine Tuberculosis in Ethiopia: Ethiopia is one among the nations that possesses the largest livestock population in the African continent with an estimated 56.7 million cattle, 29.3 million sheep, 29.1 million goats and 9.86million equines, 1.2 million camels and 56.7 million chicken [18]. In contrast to the huge livestock resource, the livestock productivity is, however, found to be very low. The major biological and socio-economical factors attributing to the low productivity includes the low genetic potential and performance, poor nutrition (in quality and quantity terms), the prevailing of different diseases, traditional way of husbandry systems and inadequate skilled manpower among others [18].

Ethiopia is one of the African countries where BTB is considered as protruding disease in animals [49]. Bovine tuberculosis is considered as one of the major livestock diseases that results in high morbidity and mortality [49]. However, still there is lack of knowledge about the actual prevalence and distribution of the disease at a national level. Despite this, the economic impacts and zoonotic importance of the BTB infection are either notwell studied or documented[49].

Among the recently undertaken studies, the prevalence rate of BTB ranges from 3.4% in a small holder production system to 50% in intensive dairy productions has been reported in various places of the country [21, 33, 50, 51]. Exotic breeds were found to be more susceptible than cross and local breeds to *M. bovis* with manifestation of high incidence and prevalence rates in Ethiopia [21-23]. A herd prevalence rate of 42.6% to 48.6% was found to be higher than the prevalence rate of individual animals (7.9% to 18.7%), that may indicate that the herd size can favour the transmission of BTB in intensive dairy farms in particular [52].

Animal Production Systems and Bovine Tuberculosis: The livestock production systems in the country basically falls into three categories according to the mode of animal husbandry and/or the production system, as well as the use of livestock products. These production systems include [53, 54].

Integrated Extensive And/or Pastoral Production System: From the very few undertaken studies, in an integrated extensive production system in the highlands, the prevalence rates of BTB ranging from 3.4% Regassa [23] to 22.6% Tadele [55] have been reported.

Among these few conducted studies the prevalence rates of BTB of 5.1% Teshome [56], 4.2% Gemta [57] and 16.2% Regassa [23], have been reported.

Unlike other production systems, better prevalence studies have been undertaken and frequently incidences and higher prevalence rates of BTB have been observed. Based on the undertaken tuberculin skin tests, in different intensive dairy farms, a prevalence rate of 24.3% to 65.8% [22] and 18.7% [52] have been reported.

Table 1: Prevalence of bovine tuberculosis detected by tuberculin skin taste by traditionally managed extensive production system

	No of cattle			
Area of study	Tested	Positive	%	Reference
Assella	281	25	8.9	[56]
Debre-birhan	76	11	14.5	[55]
Kombolcha	53	12	22.6	[55]
Dessie	34	4	11.8	[55]
West-wellega	353	12	3.4	[23]
North shewa	1041	169	16.2	[23]
Total	1838	233	12.9	

Small holder production system

Table 2: Prevalence of bovine tuberculosis in small holder dairy farms based on tuberculin test.

	No of cattle			
Area	Tested	Positive	%	Reference
Holleta	381	25	6.4	[56]
Selale	1528	18	5.1	[56]
Wolayta-sodo	416	59	14.2	[23]
Fiche	235	31	4.2	[57]
Wuchale-jida	263	60	7.9	[47]
Assella	514	18	3.5	[58]
Addis Ababa	473	61	12.9	[49]
Total	4818	332	6.9	

Intensive Production System

Table 3: Prevalence of bovine tuberculosis detected by tuberculin skin test in intensive dairy farms

	No of cattle			
Area of study	Tested	Positive	%	Reference
Addis Ababa	2098	392	18.7	[52]
Ambo	133	37	27.8	[22]
Asella	281	23	8.2	[49]
Debre-Birhan	51	3	5.9	[55]
Debre-Zeit	788	234	29.7	[21]
Debre-Zeit	281	185	65.8	[22]
Dessie	121	89	73.6	[47]
Holleta	70	17	24.3	[47]
Kombolcha	197	96	48.7	[55]
Mojo	493	338	68.6	[56]
Repi	481	310	64.4	[59]
Sebeta	37	4	10.8	[22]
Sellale	44	3	6.8	[22]
Ziway	205	56	27.3	[47]

Meat Inspection at Slaughterhouses: In Ethiopia the routine abattoir inspection involves visual examination and palpation of intact organs like the liver and kidney as well as palpation and incision of the head, lung and other lymph nodes [60]. During observation of the miliary tuberculous lesions in various parts of the carcass (lung, intestine, liver and multiple lymph nodes), the whole carcass is condemned, while condemnation of organs is undertaken if localised tuberculous lesions are observed in parenchymatous organs and their associated lymph nodes [60].

Detectionof Tuberculous Lesions at Slaughter Houses: Detection of tuberculous lesions in slaughterhouses takes place by observation of the visible tuberculous lesions in infected cattle; however, the level of the quality of such practices mayvary from place to place and/or abattoir to abattoir in the country. The very few studies in Ethiopia have indicated that not all cattle infected with *M. bovis* have visible tuberculous lesions at slaughter [39, 51]. This may limit the sensitivity of this detection technique at abattoirs, although detection of tuberculous lesions through abattoir inspection is so far the common procedure in Ethiopia. Among the undertaken abattoir studies, prevalence rates of7.96% Regassa [23], 5.2% Ameni *et al.* [47], 4.5% Teklu *et al*. [39] and 3.5% Shitaye *et al*. [52], have been reported in different abattoirs in the country (Table 4). The infection rate in cattle has been found to differ greatly from place to place, especially in slaughterhouses recorded as having a low prevalence of the infection. This difference is most probably linked to the type of the production system [52].

Economic Importance of Bovine Tuberculosis: Animal tuberculosis is a disease of high economic relevance within the context of livestock farming as it directly affects animal productivity. The disease considerably reduces milk and meat production of infected animal and affect animal reproduction as well as it reduce pulling power in traditional farming system [15]. Tuberculosis has also an economical and financial burden to society human health costs. The disease become is an obstacle to socio-economic development; 75% of people affected by TB are within the economically productive age group of 15-54 years. This may have a negative influence on the national economy [62].

Recently, Zinsstag *et al*. [63], reviewed the economic effects of BTB on cattle productivity, the burden of disease in different settings and at different stages of public health development and the trans-sectoral (Public health, Agricultural, Environment) economic analysis of BTB control. However, in Ethiopia, the economic impact of BTB on cattle productivity, BTB control programmes and other related economic effects of the disease are not yet well documented or studied. Few abattoir meat inspection surveillances have shown the condemnation rate of the total or partial carcass and organs.

Tables 4: Prevalence of bovine tuberculosis detected by abattoir meat inspection in cattle.

City abattoirs	Examined	Positive	%	Reference
Addis Ababa	984	34	3.46	[52]
Debre-Zeit	3934	7	0.18	[60]
Dire-Dawa	7453	4	0.05	[60]
Gonder	12525	3	0.02	[60]
Hossana	751	34	4.53	[39]
Kombolcha	57965	265	0.46	[50]
Makele	39875	730	1.83	[60]
Nazareth	1125	58	5.16	[61]
Wolaita-Sodo	402	32	7.96	[23]
Wondo-Genet	38303	207	0.54	[60]
Total	246611	1517	0.62	

Lately Gezahegne [64], demonstrated that from 1.2 million slaughtered cattle in eight export abattoirs had an estimated cost of more than 600, 000 ETB during a respective time, resulted due to condemned carcasses and organs. Asseged *et al.* [51], demonstrated that, based on the ten years retrospective analysis of the detection of BTB lesions in the Addis Ababa abattoir, there was a cause of 0.024% for whole carcass condemnation. Recently, Shitaye *et al*. [52], indicated that, in both Addis Ababa and Debre-Zeit abattoirs tuberculous lesions that, causes condemnation of carcasses and/or organs have also been found to be highly significant economically.

Zoonotic Importance of Bovine Tuberculosis in Ethiopia: In Sub- Saharan Africa, nearly 2 million tuberculosis cases in humans occur each year; yet it is unknown what role BTB plays in the rising epidemic of tuberculosis fostered by *HIV/AIDS* [43]. A varying portion of pulmonary tuberculosis cases are considered to occur, however, almost all cases of the non-pulmonary type of tuberculosis in humans has been caused due to BTB [65]. BTB in the human population mainly takes place through drinking raw milk and occur in the extra-pulmonary form in the cervical lymphadenitis form in particular [65].

The proportion of which BTB contributes to the total of tuberculosis cases in humans depends on the prevalence of the disease in cattle, socioeconomic conditions, consumer habits, practiced food hygiene and medical prophylaxis measures. In countries where BTB in cattle is still highly prevalent, pasteurization is not widely practiced and/or milk hygiene is insufficient, usually estimated to be about 10% to 15% of human tuberculosis is considered to be caused by BTB [66].

In rural areas of Ethiopia, most people drink raw milk and do have extremely close attachment with cattle (such as sharing shelter) which intensifies the transmission and spread of BTB. Kiros [21], demonstrated that out of 7, 138 human patients with tuberculosis, 38.4% were found with extra-pulmonary tuberculosis and the proportion of patients with extra-pulmonary tuberculosis was significant in patients who have close contact with cattle and in those who frequently used to drink raw milk in particular.

Regassa [23], demonstrated the association of *M. tuberculosis* and *M. bovis* in causing tuberculosis between humans and cattle. The cattle owned by tuberculous patients had a higher prevalence (24.3%) than cattle owned by non-tuberculous owners with 8.6%. The author also noted that 73.8% and 16.7% of 42 human isolates were identified as *M. tuberculosis* and *M. bovis* and from cattle isolates 18.1% and 45.5% of 11 were found to be *M. tuberculosis* and *M. bovis* species, respectively. This showed that the role of *M. bovis* in causing human tuberculosis seemed to be significantly important. On the other hand, in Ethiopia, consuming raw meat is a welcome tradition, thus meat may also remain to be another area of concern or threat to be a source of BTB infection [23].

CONCLUSION AND RECOMMENDATIONS

Bovine tuberculosis is a chronic bacterial disease of animals and humans characterized by the formation of granulomatous lesion in different organs. The causative agent of this disease is *M.bovis* and is a significant zoonotic disease. Wherever milk and dairy products are consumed without heat treatment, the disease is an important zoonosis. In Ethiopia, the endemic nature of infection due to *M. bovis* has long been confirmed. Even though the disease is endemic in Ethiopia, there is great gap in information on the prevalence of the disease at the national level. The prevalence rate of tuberculosis in livestock varies among different production system and is much higher on intensive dairy farms.

Based on these conclusions, the following recommendations are forwarded:

- Identification of animals: Before embarking on any control program it is essential that all dairy farms (because of high prevalence) should be registered and that all dairy cattle older than six months of age are identified with permanent marks, at least tagged with ear tags. At present, tagging is practiced in intensive dairy farms, but it does not yet cover all dairy farms, smallholders in particular.

- Improvement of management and hygienic practices: In most parts of Ethiopia, animals are kept near dwellings and maintained under very poor management and hygienic status, thus increasing the risk of acquiring infection for animals and humans as well. Therefore, creating awareness among the people, to meet the standard hygienic requirement and to improve husbandry practices is of paramount importance. In intensive dairy farms, building of the new premises needs to be done according to designs appropriate to dairy farms taking into account space per-cow, proper manure disposal, good ventilation and lighting systems. Pasteurisation of milk and milk products should be done as routine practice most notably in rural communities.
- Legislation: For enabling enforcement of control measures, there is a need for a legislation that makes it obligatory to register dairy farms and to notify the veterinary personnel about any animal purchase, sales or transfer of farms. These measures can be gradually expanded to the traditional integrated extensive farm systems. Test-and- slaughter policy should be designed and started as a major control measure to avert the spreading of the BTB infection.
- Insurance of dairy farms: Although this principle is not yet familiarized; however, insuring dairy farms may encourage owners to cull their infected cattle after testing for BTB and other economically important contagious diseases.
- Sound testing and meat inspection: Based on a proper strategy, regular tuberculin skin testing should be continued in large with significant efforts in all animal production systems nationwide. Similarly, routine abattoir meat inspection procedures have to be made for the detection of tuberculosis lesions and special attention has to be given while a large number of animals are examined in particular. The result can be upgraded when Ziehl- Neelsen staining is simultaneously used. There is also the need to have the qualified veterinary staff at the slaughterhouses so that quality data can be generated for effective control measures. It is equally important to take strict control and quarantine measures during the importation of animals and animal products.
- Establishment of areas and/or farms free of BTB: A bi-annual testing program could be introduced to establish a "provisional disease free status in some herds/farms or areas". Under this scheme a herd with a negative result in two successive tests could be declared provisionally free from BTB. If this strategy is started, it should then be strengthened with a frequent follow up to make sure that these farms are not re-infected.

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