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A study on tuberculosis in buffaloes: some epidemiological aspects, along with haematological and serum protein changes

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ABSTRACT

The study was conducted to ascertain the epidemiology, together with effects of bovine tuberculosis, on certain haematological parameters and serum proteins at two Livestock Experiment Stations in Pakistan. The results on prevalence of tuberculosis in buffaloes on the basis of comparative intradermal tuberculin test revealed it to be from as high as 8.48% (14/165) to as low as 2.45% (4/163) on the basis of positive reaction to bovine PPD. However, a doubtful reaction was observed in 8.58% (14/163) of buffaloes at farm 2 with low prevalence. It was also observed that the reaction to bovine or avian PPD was much stronger in buffaloes compared with indigenous cattle. The result on certain epidemiological factors studies revealed higher positive reactors of greater than 6 years of age and the majority were between 6-8 years old (P = 0.03). Results also revealed that a significantly higher number of animals had a body mass of less than 550 kg (P = 0.005), had less than three parturitions (P = 0.001) and milk production of 5-7 litres. The number of animals present at the farm, number of species, the nearby village, etc., played a significant role in the prevalence of the disease, rather than the condition of the farm. The results on haematological studies revealed a considerable decrease in RBC, while the decrease in ESR in a significantly (P = 0.05) greater number of buffaloes showed a positive or doubtful reaction to mammalian PPD. Total leukocyte count and lymphocyte percentages were higher in a considerably greater number of buffaloes. However, while changes in monocyte and eosinophil count were less significant, combined monocyte count in both positive and doubtful reactors was higher in a considerable number of buffaloes. While the results on serum proteins revealed an increase in serum total proteins and globulins in a significantly greater number of buffaloes, they had a positive reaction to mammalian PPD. A significant, positive relationship of serum total proteins with globulins in positive (r = 0.918; P = 0.0001) and doubtful reactors (r = 0.691; P = 0.0015).

Key words: bovine tuberculosis, buffaloes, epidemiology, haematology, serum proteins

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Introduction

The Office International des Epizooties classifies bovine tuberculosis as a List B disease, a disease which is considered to be of socio-economic or public health importance and of great significance to the international trade of animals and animal products (COUSINS, 2001). *Mycobacterium bovis* is a zoonotic bacteria and is the major cause of human infection in underdeveloped countries in particular (DABORN, 1995), but is not generally regarded as a significant public health hazard in the developed world. However, it constitutes the major economic problem for the agriculture trade and industries in several countries. The disease prevalence is variable in different parts of the world. The prevalence of tuberculosis in buffaloes at the Agriculture Development Cooperation Farm Rohri and Quetta, Pakistan, as reported by KHILJI (1974) was 0.53 and 5.31%, respectively. The prevalence of the disease in buffaloes within a 10 km radius around Faisalabad city, Pakistan, was reported to be 1.76% (IFRAHIM, 2001), while it was reported to be as high as 30-40% in India (GUHA and SARKAR, 1970) and 20.2% in Egypt (GUINDI et al., 1981).

The infection in bovines occurs through many causes, such as colostrum/milk to calves (EVANGELISTA and ANDA, 1996), ingestion of infected flies (POLYAKOV et al., 1994), bird droppings (HEJLICEK and TREND, 1995), aerosol (SAUTER and MORRIS, 1995), contact with each other and with other wildlife (BARLOW et al., 1997), and excreta of flies (POLYAKOV et al., 1994). It may be further mentioned that tuberculosis bacilli remain viable in the soil for up to 2 years (HUTCHINGS and HARRIS, 1997). Various risk factors responsible for development of clinical disease from a non-clinical form are reported to include calving place, group size of calves, length of keeping calves in groups, types of concentrate feed given to calves, breed, source of replacement, presence of wild animals and region (CENTINKAYA et al., 1997). It has been reported that the factors identified as possibly involved in increasing the risk of bovine tuberculosis in the Veneto region of Italy were the presence of mixed (dairy and beef) enterprises and cattle purchase (MARANGON et al., 1998). They further reported that other risk factors include herd size, housing system, summer mountain pasture and possible contact with wild animals. However, the role of contact with neighbouring cattle, presence of substandard cattle housing, movement of equipment or vehicles into farms and exposure to water supplies (rivers and streams) was suggested to be re-evaluated in the occurrence of tuberculosis.

As evident from the preceding discussion, the prevalence of the disease varies from region to region and even from one farm to another in same locality. Countries known to be disease-free have spent years working hard through continuous monitoring and test and slaughter policies. However, in Pakistan not much work has been carried out on tuberculosis, particularly in animals. Most of the work is confined to the prevalence of tuberculosis in buffaloes, as detected by tuberculin tests. The present study was designed to investigate not only the prevalence of the disease at two Govt. livestock experimental stations, but

also on certain epidemiological factors of disease in buffaloes, along with the effects of disease on haematology and serum proteins.

Materials and methods

The study was conducted at two livestock experimental stations owned by the Government of Punjab, Pakistan. A total of 165 and 163 animals were tested at each farm, i.e., farms 1 and 2, respectively, by comparative intradermal tuberculin test at the neck region. A double cervical intradermal skin test was performed using bovine (50.000 I.U./mL) and avian (50.000 I.U./mL) PPD produced by the Instituto Zooprofilattico Sperimentale Dell'Umbria E Delle Marche, Perugia, Italy. Results were read and interpreted according to standard protocol (OIE manual of standards, 2000).

Blood samples of about 5 mL were collected in two clean glass tubes with and without EDTA for haematological studies and serum proteins determination, respectively. Haematological studies included RBC count, WBC count, haemoglobin, PCV, ESR and differential leukocyte count (BENJAMIN, 1978). Serum studies included determination of serum total proteins (OSER, 1976), albumin (VARLEY et al., 1980) and serum globulins (by subtracting albumin from total protein values). Data on some of the epidemiological factors were also collected at each farm.

Data thus obtained was subjected to analysis using Chi-square test and Pearson correlation on personal computer using SAS 6.12 computer software package (SAS, 1996).

Results

Results on prevalence of tuberculosis in buffaloes on the basis of comparative intradermal tuberculin test are presented in Table 1. Data shows prevalence of tuberculosis to be from as high as 8.48% to as low as 2.45% on the basis of positive reaction to bovine PPD. However, a doubtful reaction was also observed in almost the same number of animals at each farm. It may be mentioned here that reaction to bovine or avian PPD was much stronger in buffaloes compared with indigenous cattle (unpublished data).

Table 1. Prevalence of tuberculosis in buffaloes at various farms

	Nº of animals tested	Positive		Doubtful	
		Mammalian	Both	Mammalian	Both
Farm 1	165	14 (8.48)	-	14 (8.48)	-
Farm 2	163	4 (2.45)	14 (8.58)	4 (2.45)	3 (1.84)
Overall	328	18 (5.48)	14 (4.27)	18 (5.48)	3 (0.91)

Results of some of the epidemiological factors studied are presented in Table 2. It was observed that tuberculosis was present in significantly higher number of buffaloes of older than 6 years of age; the majority were between 6-8 years old. Results also revealed that a significantly greater number of animals had a body mass of less than 550 kg and had had less than three parturitions. It was further observed that majority had a milk production of 5-7 litres.

Table 2. Positive and/or doubtful mammalian and avian PPD reaction in buffaloes of various ages, masss, parity and milk production groups

	Mammalian PPD		Combined PPD	
	Positive	Doubtful	Positive	Doubtful
Age (years)				
<5	1 (01.88)	5 (09.43)	-	-
6-8	10 (18.86)	5 (09.43)	2 (03.77)	-
>8	7 (13.20)	8(15.04)	12 (22.64)	3 (05.66)
	P = 0.03		P = 0.008	
Mass groups (kg)				
<500	10 (18.87)	10 (18.87)	1 (01.88)	1 (01.88)
500-550	6 (11.32)	4 (07.55)	8 (15.09)	1 (01.88)
551-600	1 (01.88)	2 (03.77)	2 (03.77)	1 (01.88)
>600	1 (01.88)	2 (03.77)	3 (05.66)	-
	P = 0.005	P = 0.02	P = 0.04	
Parity				
<3	15 (28.30)	14 (26.41)	3 (05.66)	1 (01.88)
3-6	2 (03.77)	3 (05.66)	4 (07.54)	1 (01.88)
>6	1 (01.88)	1 (01.88)	7 (13.20)	1 (01.88)
	P = 0.001	P = 0.001		
Milk production (litres)				
<5	3 (05.66)	1 (01.88)	10 (18.86)	-
5.1-6	5 (09.43)	4 (07.54)	2 (03.77)	2 (03.77)
6.1-7	4 (07.54)	2 (03.77)	2 (03.77)	-
7.1 +	3 (05.66)	4 (07.54)	-	1 (01.88)
			P = 0.01	

Table 3. Some epidemiologically important observations recorded at two farms

	Species				Grazing timing	Nearby colony/ village	Farm condition	Stall feeding	
Farm	Sheep	Goat	Cattle	Buffalo				Green fodder	Dry fodder
1	2400	450	298	165	8.00 am to 2.00 pm	Yes	Good	50-70 kg/ animal/day	5 kg/100 kg body mass
2	450	-	-	163	same as above	No	Poor	50-60 kg/ animal/day	5 kg/100 kg body mass

Other information collected at farms 1 and 2 is shown in Table 3. At farm 1, buffaloes were of Nili-Ravi breed; multiple age groups were present at the farm, but young stock were in separate pens. Animals were fed together through stall feeding and grazing. Grazing is almost in same area where all age groups assemble together, i.e., milking animals, young stock and dry animals. Stall feeding is separate for each group. Each shed has a watering trough in a corner where water is available ad libitum. Housing pattern was mixed, i.e., open and semi-open. Animals were kept combined either indoors or outdoors and unchained. Direction of shed was N-S. Animals were vaccinated against FMD, HS and Rinderpest. Recently, new animals were purchased from various sources and were distributed in various sheds after tuberculin testing. Annual auction is also carried out of animals suffering from certain undiagnosed diseases and with poor response to various treatments, poor yielders or those having reproductive problems. There had been no outbreak of disease in the past six months. Only milder injuries and minor infections were reported. Other animal species were at different locations not far from the buffalo sheds. Dogs and cats were also present and moved freely through various sheds. Birds, including backyard poultry (layers), sparrows and crows also have free access to the feeding and watering areas. Flies were abundant and no control has been ever attempted to get rid of flies or to control their numbers at any shed, in milking parlours or at the milk sale point at the farm. Animals were offered canal drinking water. In the adjoining village, all kinds of domestic and non-domestic animals were kept in homes. The village (numbering roughly 1000 to 1500 houses) shares a common boundary with the farm premises.

At farm 2, instead of Rinderpest, animals were vaccinated against black quarter. The other two vaccines, including HS and FMD, were regularly used. All other practices were almost the same. Stray dogs and cats were relatively less in number and visitors were very rare at this farm. The sheds were also of similar type to those at farm 1, but in poor condition. Backyard poultry visited the farm premises less frequently. Results on haematological studies revealed a decrease in PCV and Hb in a significantly lesser number of buffaloes, while a decrease in RBC was observed in a considerable number of buffaloes. However, ESR decreased in significantly greater number of buffaloes and had a positive or doubtful reaction to mammalian PPD (Table 4). Total leukocyte count

showed higher than normal values in a considerably greater number of buffaloes (Table 4). Results on differential leukocyte count revealed higher lymphocyte and/or neutrophil count in a considerably greater number of buffaloes, while they had a positive reaction to mammalian PPD, and they also had a doubtful reaction (Table 5). However, while changes in monocyte and eosinophil count were less significant, combined monocyte count in both positive and doubtful reactors was higher in a considerable number of animals, i.e., 10 against 22 (control group; Table 5).

Table 4. Variation in red blood cell count, PCV, haemoglobin and ESR in buffaloes with positive and/or doubtful mammalian and avian PPD reaction

	Mammalian PPD		Combined PPD	
Parameters	Positive	Doubtful	Positive	Doubtful
RBC (10^6/μL)				
<5*	6 (11.32)	8 (15.09)	8 (15.09)	1 (01.88)
5-8	12 (22.64)	10 (18.86)	6 (11.32)	2 (03.77)
PCV (%)				
<26*	2 (03.77)	1 (01.88)	-	1(01.88)
26-38	16 (30.19)	17 (32.07)	14 (26.42)	2 (3.77)
	P = 0.001	P = 0.001		
Hb (g/dL)				
<9*	1 (1.89)	-	2 (3.77)	1 (1.89)
9-15	17 (32.08)	18 (33.96)	12 (22.64)	2 (3.77)
	P = 0.001		P = 0.008	
ESR (mm/hr)				
<100*	13 (24.52)	13 (24.52)	5 (09.43)	1(01.88)
100-175	5 (09.43)	5 (09.43)	7 (13.20)	1(01.88)
175-280	-	-	2 (03.77)	1(01.88)
	P = 0.05	P = 0.05		
Total Leukocyte Count (103/μL)				
<5.5*	1 (1.89)	4 (7.55)	1 (1.89)	1 (1.89)
5.5-10.5	8 (15.09)	9 (16.98)	8 (15.09)	2 (3.77)
>10.5*	9 (16.98)	5 (9.43)	5 (9.43)	-
	P = 0.04			

Values of control group: RBC = 6.26 ± 0.98; PCV = 31.5 ± 6.2; Hb = 11.87 ± 2.25; ESR = 138 ± 35; TEC: 8.0 ± 2.5

Table 5. Variation in differential leukocyte count in buffaloes with positive and/or doubtful mammalian and avian PPD reaction

Percent	Mammalian PPD		Combined PPD	
	Positive	Doubtful	Positive	Doubtful
Lymphocytes				
<43*	3 (5.66)	3 (5.66)	-	-
43-55	8 (15.09)	9 (16.98)	2 (3.77)	-
<55*	7 (13.21)	6 (11.32)	12 (22.64)	3 (5.66)
			P = 0.008	
Neutrophils				
<30*	4 (7.55)	6 (11.32)	8 (15.09)	1 (1.89)
30-45	5 (9.43)	5 (9.43)	6 (11.32)	2 (3.77)
<45*	9 (16.98)	7 (13.21)	-	-
Monocytes				
<1.5*	3 (5.66)	1 (1.89)	-	-
1.5-5.0	12 (22.64)	10 (18.87)	9 (16.98)	3 (5.66)
<5*	3 (5.66)	7 (13.21)	5 (9.43)	-
	P = 0.01	P = 0.03		
Eosinophils				
<1.5*	3 (5.66)	6 (11.32)	6 (11.32)	-
1.5-4.5	15 (28.30)	12 (22.64)	7 (13.21)	2 (3.77)
<4.5*	-	-	1 (1.89)	1 (1.89)
	P = 0.005			

Values of control group: Lymphocytes = 48 ± 5; Neutrophils = 38 ± 4; Eosinophils = 3 ± 1.5; Monocytes = 3.0 ± 1.5

Results on serum proteins revealed an increase in serum total proteins and globulins in a considerably greater number of buffaloes, while they had a positive reaction to mammalian PPD (Table 6). Increase in serum albumin was also observed in almost half of the buffaloes than among those which had normal values among positive animals (Table 6).

Table 6. Variation in serum proteins in buffaloes with positive and/or doubtful mammalian and avian PPD reaction

	Mammalian PPD		Combined PPD	
g/100 mL	Positive	Doubtful	Positive	Doubtful
Total Proteins (g/100 mL)				
5-8	11 (20.75)	15 (28.30)	11 (20.75)	3 (5.66)
<8**	7 (13.21)	3 (5.66)	3 (5.66)	-
		P = 0.005	P = 0.03	
Albumin (g/100 mL)				
2.1-4.5	13 (24.53)	15 (28.30)	13 (24.53)	3 (5.66)
<4.5*	5 (9.43)	3 (5.66)	1 (1.89)	-
	P = 0.05	P = 0.005	P = 0.001	
Globulins (g/100 mL)				
1-3.5	11 (20.75)	12 (22.64)	8 (15.09)	3 (5.66)
<3.5*	7 (13.21)	6 (11.32)	6 (11.32)	-

Values of Control group: Total Proteins = 6.21 ± 2.3; Albumin = 3.34 ± 1.23; Globulins = 2.19 ± 1.21

Correlation

A significant positive relationship of serum total proteins with globulins (r = 0.918; P = 0.0001) in tuberculin positive buffaloes and also in doubtful reactors (r = 0.691; P = 0.0015). A significant inverse relationship between monocyte percentage with total leukocyte (r = -0.599; P = 0.008) was observed in tuberculin doubtful reactors. A significant positive relationship of serum total proteins with globulins (r = 0.618; P = 0.018) and a significant inverse relationship of total leukocyte count with monocyte percentage (r = -0.543; P = 0.04) was also observed in positive reactors to both avian and mammalian PPDs. Such a relationship could not be found in control buffaloes.

Discussion

The prevalence of tuberculosis on the basis of positive reaction to bovine PPD varied from 8.48 to 2.45% at the two farms studied, with an overall prevalence of 5.48% in Nili-Ravi breed of buffalo. Earlier, 6.72% in 1969 (BARYA, 1969), 7.3% in 1989 (AMIN, 1989), 4.37% in 1992 (AKHTER et al., 1992), 1.7% prevalence in 2001 (IFRAHIM, 2001) and 6.91% in 2003 has been reported from Pakistan in different locations of the country. Another study in 1974, conducted in Quetta, Pakistan, reported a very low prevalence of

tuberculosis (0.53%) (KHILJI, 1974). However, other studies conducted on buffaloes in different parts of the world reported variable prevalence. In India, in 1969, it was reported to be 6.39% (LALL et al., 1969) and in 1976, 4.37% (JOSHI et al., 1976), 20.2% in Egypt (GUINDI et al., 1975), 8.0% in Australian buffaloes (McCOOL and TABRETT, 1979), and 0.3 to 8.22 % in feral buffaloes from different localities (HEIN and TOMASOVIC, 1981). A few studies have reported prevalence in double figures. However, prevalence varies considerably from year to year and from different localities in each country. As the disease is of zoonotic importance, the prevalence therefore has to be monitored continuously at each location in every country.

Various epidemiological factors studied revealed that prevalence was higher in buffaloes of around 6 years of age, of those with body mass of less than 550 kg and which had had less than three calves. Milk production in the majority of the positive reactors was 5-7 litres against an average milk production of 8-10 litres per day at the farm. Earlier, in cattle it has been reported that susceptibility to *M. bovis* infection increased with age. It has further been reported that the cattle were more frequently affected than heifers and bulls or calves (BONSU et al., 2000; KAZWALA et al., 2001). Another study reported the occurrence of disease to be greater in animals of more than 5 years of age (GUINDI et al., 1981). It can be deduced from the results of the present study, and from those of previous reports, that as the animal ages the chances of becoming infected increases, due to the fact that it had lived for longer period at the farm premises which might have had an infectious agent. Secondly, as the animal increases in age its production potential also increases, which does have some stress on an animal's body, and also that it had given birth to a considerable number of young ones, which also adds to stress. Hence, the animal succumbs to active disease given such stress factors. The lower body mass in these animals as observed during the present study suggests that these animals were suffering some stress, which may also include nutritional factors, although decrease in body mass due to tuberculosis itself is not altogether ruled out. Further, that feeding practices at farms were such that all animals in a shed were fed in a single manger with about 20-30 animals at a time, with weaker animals having less chance of feeding, and where dominant animals usually take the major nutritional share. The same has been noticed at the grazing fields, where weaker animals are pushed to poor grass fields. It is unlikely that the mass of these animals decreased only due to disease, but it may also be a factor. Lower milk production in these animals may be due to nutritional reasons in addition to disease stress.

The prevalence of tuberculin positive reactors at farm 1 was high compared with farm 2 and at farm 1, sheep, goat, cattle and buffalo were present, against sheep and buffalo at farm 2. Further, that farm 1 was adjacent to a village numbering about 1000 houses and where almost every house keeps milking animals: goat, sheep, buffalo or cow. Also, farm 1 was frequently visited by people from the village for different reasons, including purchase of cheap milk. It was also observed that farm 1 had frequent visitors from various

other places, including veterinary health care workers and farmers, as this is a model farm and experimental station. All these factors did not exist at farm 2. Grazing practices at the two farms were similar. The only differentiating factors were: the condition of the sheds, milking parlours, mangers, side walls and practice of whitewashing were poor at farm 2. Hence, it can be deduced that the prevalence of disease at farm 1 was higher due to the above mentioned factors, and that conditions at the farm were not important in the occurrence of the disease. Results showed that multiple species at a farm, nearby village, flies, etc., increased the risk of disease, while substandard housing also played a role at farm 2, although low in magnitude. These results confirmed the earlier findings of various workers on the factors responsible for increasing risk of disease (GRIFFIN et al., 1993; GRIFFIN et al., 1996; MARANGON et al., 1998; MUNROE et al., 1999). It has previously been emphasized in a report that reduction in susceptibility to *M. bovis* can be achieved through management. However, it has been suggested that considerable further research is required (PHILLIPS et al., 2002).

Among haematological parameters, a decrease in RBC and ESR was observed in a considerable and significantly greater number of buffaloes, respectively. However, an increase in TLC, lymphocyte and or neutrophils was observed in considerably greater number of buffaloes which had a positive reaction to tuberculin compared with values in control. An appreciable drop in RBC count (AMIN et al., 1990; RAO et al., 1992; KUMAR et al., 1994) has already been reported. However, a drop in haemoglobin (AMIN et al., 1990; RAO et al., 1992; KUMAR et al., 1994) and PCV (KUMAR et al., 1994) was not observed in the present study, which may be a result of species difference as most of the mentioned studies were conducted in cattle. These changes in buffaloes were not significant. The result in bison of a slight increase in blood monocyte and lymphocyte (MILLER et al., 1989) correlated well with those in buffaloes observed during present study. Leukopenia with lymphopenia were not observed in a significant number of buffaloes, as has been reported earlier in peracute to acute form of the disease (LEPPER et al., 1977) as there were no such signs of acute or peracute disease in these animals. However, the results of ESR were contrary to earlier findings (AMIN et al., 1990) where an increase in ESR has been reported. However, another study reported ESR to be of no value in cattle, unlike in humans in the diagnosis of the disease. Present results, however, suggest its diagnostic significance in buffaloes. In buffaloes, ESR is normally quite high. It may be possible that ambient temperature together with other unknown factors played some role in the decrease of ESR, as the study was conducted in the summer season and blood samples were transported long distances involving about 3 to 4 hours' travel. However, samples from control animals also accompanied samples from tuberculosis-positive animals. Animals were also vaccinated at both farms about 1-1 2 months earlier, as well as control animals. It is suggested that further studies are needed before declaring the usefulness of ESR in buffaloes. Among serum proteins studied, a rise in serum globulins was observed in a

considerable number of animals, which also contributed to a rise in serum total proteins. Although gamma globulins were not determined, it appears to be the increase in gamma globulins which caused the rise in serum globulins in these buffaloes.

Conclusions

It can be concluded from the present study that the number of species at the farm, the nearby village, frequent visitors, wild/stray animals at farm, backyard poultry and other management practices all have a significant association with the occurrence of tuberculosis in buffaloes, and that buffaloes of around 6 years of age contract the disease and show positive reaction to PPDs. There also appears to be some association of tuberculosis with RBC number, ESR, total leukocyte count, lymphocyte and monocyte percentage, together with serum globulins.

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SAŽETAK

Istraživanje je provedeno na dvjema životinjskim pokusnim postajama u Pakistanu, da bi se ustanovila epidemiologija goveđe tuberkuloze zajedno s učincima na određene hematološke pokazatelje i serumske bjelančevine. Rezultati proširenosti tuberkuloze u bivola, na osnovi pozitivne reakcije na goveđi PPD u kožnom tuberkulinskom testu, pokazali su da se njezina prisutnost kreće od visokih 8,48% (14/165) do niskih 2,45% (4/163). Međutim, sumnjive su reakcije uočene u 8,58% (14/163) bivola na dvjema farmama s niskom prevalencijom. Također je uočeno da je reakcija na goveđi ili ptičji PPD puno jača u bivola nego u domaćih goveda. Rezultati istraživanja epidemioloških čimbenika pokazuju da je najviše pozitivnih reaktora bilo u skupini starijih od šest godina, a većina njih bila je u dobi između 6 i 8 godina (P = 0,03). Rezultati također pokazuju da je značajno veći broj životinja imao tjelesnu masu manju od 550 kg (P = 0,005), manje od tri porođaja (P = 0,001) i proizvodnju mlijeka od 5 do 7 litara. Broj životinja na farmi, broj vrsta, obližnje selo itd., imali su veću ulogu u učestalost bolesti nego uvjeti na farmi. Rezultati hematoloških istraživanja pokazuju znatan pad broja crvenih krvnih stanica, dok je pad ESR-a uočen u značajno (P = 0,05) većeg broja bivola s pozitivnim ili sumnjivim reakcijama na PPD sisavaca. Ukupan broj leukocita i postotak limfocita bili su povišeni u većeg broja bivola. Međutim, dok su promjene u broju monocita i eozinofila bile manje značajne, ukupan broj monocita u pozitivnih i sumnjivih reaktora bio je viši u znatnog broja bivola. Rezultati pretraga serumskih bjelančevina otkrivaju porast ukupnih serumskih bjelančevina i globulina u značajno većeg broja bivola koji su pozitivno reagirali na PPD sisavaca. Ustanovljena je značajna pozitivna korelacija između ukupnih serumskih bjelančevina i globulina u pozitivnih reaktora (r = 0,918; P = 0,001) i sumnjivih reaktora (r = 0,691; P = 0,0015).

Ključne riječi: goveđa tuberkuloza, bivoli, epidemiologija, hematologija, serumske bjelančevine