NDDB

BRUCELLOSIS

An Indian perspective

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BRUCELLOSIS: AN INDIAN PERSPECTIVE

Purpose

The main aim of this communicationis to document all the studies undertaken on the incidence, geographical distribution, zoonoses and other aspects of brucellosis in India during the past three decades with an intent to develop a good understanding of the disease profile in India. It is assumed that this information would be of help in formulating a control strategy for brucellosis.

Introduction

Brucellosis, also known by a multitude of synonyms such as 'Undulant, Mediterranean, Malta, Rock, Gibraltar, Cyprus, Typho-malarial fever', Intermittent typhoid and Bang's disease (*Al Dahouk et al.,2003*) is a zoonosis which is almost invariably transmitted by direct or indirect contact with infected animals or their products. It affects people irrespective of age and sex.

It is an important human disease in many parts of the world especially in the Mediterranean countries of Europe, north and east Africa, middle east, south and central Asia and Central and South America. Several endemic areas have achieved control like France, Israel and most of Latin America. But on the other hand new foci have emerged particularly in central Asia and the situation in certain countries in the near east (eg. Syria) is rapidly worsening. (*Pappas et al., 2006*). There are only a few countries in the world that are officially free of the disease.

The disease in humans can be insidious and may be present in many atypical forms. It should be noted that even in the severe form, differential diagnosis can still be difficult.

Brucellosis in India is an important but a neglected disease. It is present in all livestock systems and the increased demand for dairy products and intensified farming practices has raised the concern of increased spread and transmission to humans.(*Smits,H.L & Kadri., 2005*)

There are six main species that cause brucellosis in livestock and humans: *B.abortus, B.suis, B.melitensis, B.neotomae, B.ovis and B.canis*.

Marine mammal brucellosis due to two new proposed brucella species (*B.cetaceae & B.pinnipediae*) represents a new zoonotic threat but pathogenicity for humans has not been clearly established.(*Godfroid et al.,2005*)

Currently *B.mellitensis* remains the principal cause of human brucellosis worldwide including India. In India, fewer than 10% of the human brucellosis cases may be clinically recognized and treated or reported. (*Mantur et al.,2007*)

The emerging challenges that need to be addressed by the medical and veterinary community in the control of brucellosis world wide are:

1. Expanding wildlife reservoir of brucellosis with a possible impact on domestic animals.
2. The emergence of *B.mellitensis* infections in cattle for which prophylactic efficacy of available vaccines has not been established.
3. Huge animal reservoir of brucella species in marine mammals for which the potential influence on humans remains unknown. (*Maurin,M., 2005*)

Animal brucellosis

Brucellosis is a disease that occurs in many animal species like sheep, goat, cattle, pig, camel, buffalo, horse, mule, donkey etc. Most infections result from ingestion of bacteria either from diseased animals or contaminated feedstuffs. Infection may also be acquired by respiratory exposure and by contamination of abraded skin and mucosal surfaces.

The table below shows the different animal species affected by brucellae species:

Host	***B.abortus***	***B.melitensis***	***B.suis***	***B.canis***	***B.ovis***
Cattle	+	+	+(rare)	-	**-**
Buffaloes	+	+	-	-	**-**
Sheep	+(rare)	+	+(possible)	-	**+**
Goats	+(rare)	+	-	-	**-**
Swine	+(rare)	+(rare)	+	-	**-**
Dogs	+	+	+(rare)	+	**-**
Camels	+(rare)	+	-	-	**-**
Horses	**+**	**+(rare)**	**+(rare)**	**-**	**-**

Source : *www.who.int*

Incidence and geographical distribution of brucellosis in India

Incidence in apparently normal herds

Many authors have reported a higher incidence of brucellosis in organized farms in India compared to unorganized farms or animals owned by individual farmers. (*Vaid et al., 1991*; *Mehra et al.*, 2000; *De et al., 1982; Sharma et al.,2003;Rathore et al.,2002).*

Relating to the incidence within organized farms, those owned by the government have been reported to have a lesser incidence compared to the privately owned ones. (*Nawathe & Bhagwat.,1984*). The prevalence also was significantly higher in Gaushalas than in organized farms. (*Sharma et al.,2007;Subhash Kachhawaha et al,2005*)

Saini et al., 1992 noted that floor space, running space, ventilation, lighting and sanitation were superior in villages where animals did not have brucellosis. Moreover a high proportion of such free animals were also fed individually.

Natural breeding transmits infection in swine and dogs and, to a lesser extent, sheep and goats. But studies in cattle and buffalo herds in India have shown a much higher prevalence (25%) in herds using artificial insemination than in those using natural service (4.3%).(*Chatterjee et al.,1985*). *Rathore et al., 2002,* has also hinted at the extensive use of AI as a probable reason for the higher incidence of brucellosis in organized farms.

Halder & Sen., 1990 have reported that conception rate in brucella reactors were 29.5% in the first and second inseminations, 20.4% in the 3rd,6% in the 4th and 13.6% in the 5th insemination. The follow-up studies on the reactors showed that 72.3% calved normally, foetal death occurred in 4.2%, abortion occurred in 4.4%, foetal resorption in 2.2% and 5.5% were sterile.

Bhattacharya et al.,2005, have also reported a high incidence (55%) of brucellosis in aborted cows, followed by repeat breeders (24%) and cases with retention of placenta (20%).

The incidence range of brucellosis has also been reported higher in cattle than in buffaloes, whether in mixed or separate herds. *(Rao et al., 1986)*

The incidence range of brucellosis reported in various species in apparently normal herds of animals in various regions of India over the last three decades is elaborated in the tables below:

Incidence in north India

Review of incidence of brucellosis in apparently normal herds in various regions of north India										
Sl.No	Source	Location	Incidence in different species (%)							
			Cattle	Buffalo	Sheep	Goat	Pig	Camel	Equines	Region
	North India									
1	Dwivedi and Mahesh Kumar (2006)	Field	10	12	2	7				
2	Vikrant Jain et al (2006)	Field	8	7	16	7				Uttaranchal
3	Vaishali Mittal et al (2005)	Field	35	30		39				
4	Dhand et al (2005)	Field	10	13						Punjab
5	Charanjeet et al (2004)	Field	3	3	16	5				HP
6	Sharma et al (2003)								46	HP
7	Rathore et al (2002)	Field	9	2						UP
8	Grewal et al (2000)	Field			7	5				Punjab
9	Prahlad et al (1999)			21						Punjab
10	Singh et al (1998)	Field				1				UP and Punjab
11	Nagal et al(1991)	Field	4							HP
12	Chauhan et al (1986)	Field						1		Rajasthan & Haryana
13	Kapoor et al (1984)	Field				11				
14	Dubey,S.C & Mathur,P.B(1980)	Field	5	3	2	7				Rajasthan
15	Sharma et al (1979)	Field	6	5	3	6	16			UP & Delhi
16	Kulshreshtha et al (1978)	Field	9	4	1	2	1			Haryana
	Incidence range in field (%)		**3-35**	**3-30**	**2-16**	**1-39**	**1-16**	**1**	**46**	
17	Subhash Kachchawaha et al (2005)	Farm	42	26						Rajasthan
18	Puran Chand & Sharma (2004)	Farm	27							Haryana,MP & UP
19	Siingh et al (2004)	Farm	15	11						Punjab
20	Singh et al (2004)	Farm	14							Punjab
21	Singh et al (1998)	Farm				5				
22	Saini et al(1994)	Farm					17			Punjab & HP
23	Nagal et al(1991)	Farm	17							HP
24	Bandey et al (1989)	Farm			3					Kashmir
25	Bachh et al (1988)	Farm	44							Kashmir
26	Sinha,B.P & Verma,B.B(1979)	Farm							38	Punjab
	Incidence range in farms (%)		**14-44**	**11-26**	**3**	**5**	**17**		**38**	
27	Mudit Chandra et al (2005)	Abattoir				1				UP
28	Prahlad et al (1999)	Abattoir		8.1						Delhi
29	Singh et al (1998)	Abattoir				7				
30	Prahlad Kumar et al (1997)	Abattoir			50					Punjab
31	Nagal et al(1991)	Abattoir			15	25				HP
32	Kapoor et al (1985)	Abattoir /Field				6				Rajasthan
33	Kapoor et al (1984)	Abattoir				2				Rajasthan

	Incidence range in abattoir (%)			**8**	**15-50**	**1-25**				
34	Prahlad et al (1999)			11						UP
35	Prahlad Kumar et al (1997)					16				Punjab
36	Prahlad Kumar et al (1997)				33					Rajasthan
37	Prahlad Kumar et al (1997)					30				Rajasthan
38	Prahlad Kumar et al (1997)					29				UP
39	Vaid et al (1991)		2		1					HP
40	Shaw,A.A (1986)		1							Kashmir
	Incidence range in north India(%)		**3-44**	**3-30**	**2-50**	**1-39**	**1-17**	**1**	**38-46**	

Incidence in south India

Review of incidence of brucellosis in apparently normal herds in various regions of south India								
Sl.No	Source	Location	**Incidence in different species (%)**					Region
			Cattle	Buffalo	Sheep	Goat	Pig	
	South India							
1	Vinod et al (2006)	Field	7					Kerala
2	Sarumathi et al (2003)	Field	13					AP
3	Isloor et al (1998)	Field	1					Karnataka
4	Dessai et al (1995)	Field			5	8		Karnataka
5	Manickam,R & Mohan,M(1987)	Field	10					TN
6	Krishnappa et al (1981)	Field					6	Karnataka
7	Baby,K & Paily,E.P(1979)	Field		2				Kerala
	Incidence range in field (%)		**1-13**	**2**	**5**	**8**	**6**	
8	Vinod et al (2006)		6					
9	Isloor et al (1998)	Farm	4					Karnataka
10	Suresh et al (1993)	Farm/Field	9	11				TN
11	Reddy et al (1983)	Farm	0.4					AP
12	Reddy,P.R & Rao,P.V.R (1980)	Farm					7	AP
13	Kumar,R & Rao,C.V.N(1980)	Farm					11	TN
	Incidence range in farms (%)		**0.4-9**	**11**			**7-11**	
14	Mrunalini,N & Ramasastry,P (1999)		4	4	3	7	1	AP
15	Rao et al (1998)					7		AP
16	Sreemannarayana,O(1980)	Abattoir				2		AP
	Incidence range in south India (%)		**0.4-13**	**2-11**	**3-5**	**2-8**	**1-11**	

Incidence in eastern India

Review of incidence of brucellosis in apparently normal herds in various regions of eastern India									
Sl.No	Source	Location	Incidence in different species (%)						Region
			Cattle	Buffalo	Sheep	Goat	Pig	Mithun	
	Eastern India								
1	Hussain et al (2000)	Field	44						Assam
2	Chatterjee et al (1986)	Field	4						WB
4	Acharya,B.N & Panda,S.N(1985)	Field			5				Orissa
3	Ghosh,S.S & Verma,P.C(1985)	Field				9			Nagaland
5	De et al (1982)	Field	3						WB
	Incidence range in field (%)		**3-44**		**5**	**9**			
6	Rajkhowa et al (2005)	Farm						34	Nagaland
7	Bhattacharya et al (2005)	Farm	14	10					
8	Chakraborty et al (2000)	Farm	56						Assam
9	Barman et al (1989)	Farm	33						Assam
10	Ghosh,S.S& Nanda,S.K(1988)	Farm/field				7			Tripura
11	Ghosh,S.S& Nanda,S.K(1987)	Farm	18						Tripura
12	Chatterjee et al(1985)	Farm	21	19					WB
			4						
13	De et al (1982)	Farm	17						WB
14	Maiti et al (1980)	Farm	36						Nagaland
	Incidence range in farms (%)		**4-56**	**10-19**		**7**		**34**	
	Others								
15	Rahman et al (1996)		11						Assam
16	Rahman et al (1996)		14					15	Arunachal pradesh
17	Ahmed et al(1989)		11						Assam
18	Murti et al (1986)		3						Manipur
19	Murti et al (1986)		27						Nagaland
20	Rahman et al (1984)	Abattoir					10		Assam
21	Choudhary et al (1983)	Abattoir					5		Jharkhand
22	Mishra,K.C (1982)		7						Sikkim
	Incidence range in east India (%)		**3-56**	**10-19**	**5**	**7-9**	**5-10**	**15-34**	

Incidence in western and other regions and, country as a whole

Review of incidence of brucellosis in apparently normal herds in western,other regions,and country as a whole											
Sl.No	Source	Location	Incidence in different species (%)								Region
			Cattle	Buffalo	Sheep	Goat	Pig	Camel	Mithun	Equines	
	Western India										
1	Varasada et al (2007)	Field	4	0.5							Gujarat
2	Sharma et al (2006)	Field			15	5					Gujarat
3	Chouhan et al (2005)	Field						7			Gujarat
4	Kuralkar et al (2006)	Farm	2								Maharastra
5	Raju et al (2004)	Farm			10	23					Maharastra
6	Nawathe,D.R & Bhagawat,S.S (1984)	Farm	10								Maharastra
7	Mehra et al (2000)	Organised farm	10	11							MP
			13								
			2								
			3								
8	Mehra et al (2000)	Unorganised farm	2	9							MP
	Incidence range in western India (%)		**2-13**	**0.5-11**	**10-15**	**5-23**		**7**			
	Other regions										
9	Jai Sunder et al (2005)	Field	14			12					
10	Maqsood et al (1990)			4							
11	Savalgi et al (1987)	Farm	12	2							
12	Tongaonkar et al (1986)		6	4							
13	Rao et al (1986)	Farm	6	1							
14	Babu et al (1985)	Farm	1	0.3							
15	Sikdar,A& Rao,J.R(1985)	Field	31	8							Andamans
16	Bala,A.K & Sidhu,N.S (1982)		26								
			29								
			17								
				3							
	Incidence range in other areas (%)		**1-31**	**0.3-8**		**12**					
	Incidence range in the country (%)		**0.4-56**	**0.3-30**	**2-50**	**1-39**	**1-17**	**1-7**	**15-34**	**38-42**	

Region-wise comparison of brucellosis incidence in cattle and buffaloes in normal herds

While critically reviewing the incidence of brucellosis in apparently normal herds of cattle and buffaloes in various regions of the country from the literature available for the past three decades, it becomes obvious from the tables that, with respect to cattle, the incidence range is highest in eastern India (3-56%), followed by north (3-44%), west (2-13%) and the south (0.4-13%).

Similar observations can be made for buffaloes, with the incidence range of brucellosis being highest in the north (3-30%).The eastern region follows with an incidence range of 10-19%. The incidence range in the western and southern regions is almost comparable with 0.5-11% and 2-11% respectively.

To summarize, the incidence range of brucellosis in the country in apparently normal herds of cattle and buffaloes is recorded at 0.4-56% and 0.3-30% respectively. This does not include reports on herds with abortions and other symptoms of brucellosis which have been analyzed separately.

Published reports on brucellosis incidence in cattle and/or buffaloes were not available for Bihar, Chattisgarh, Orissa, Meghalaya and Mizoram.

Field vis-à-vis farm incidence of brucellosis in cattle and buffaloes in normal herds

While comparing the incidence range of brucellosis in cattle between field and farms (both organized and unorganized), it is clear from the tables that the greatest variation is in the east with incidence range in the field at 3-44% in field and 4-56% in farms. In the north the incidence range in field is at 3-35% and farms, 14-44%. The incidence range in farms in western India is between 2-13% with the field having an incidence of 4% (only from one report).On the contrary, as regards the south, the incidence range in the field is higher (1-13%) than the incidence recorded in farms (0.4-9%).

The published reports on incidence of brucellosis in buffaloes both in the field and farms are not adequate enough to make a comparison for all the regions. In the north, the incidence range of 3-30% and 11-26% respectively in the field and farm is recorded. Reports on

incidence available from other regions either in field or farm are very few to draw an inference but the values are invariably higher in farms.

Incidence in herds with history of abortion and other symptoms of brucellosis

A review of incidence of brucellosis in herds that exhibited symptoms like abortions, retention of placenta, still birth, mastitis, joint swelling, repeat breeding etc over the last three decades is given in the table below:

Review of incidence of brucellosis in herds with abortions and other symptoms of brucellosis										
Sl.No	**Source**	**Location**	**Incidence in different species (%)**						**Region**	**Remarks**
			Cattle	Buffalo	Sheep	Goat	Mithun	Equines		
1	Jaianandh et al (2006)	Field	11							Abortion,repeaters, ROP, pyrexia , arthritis & hygroma
2	Rathore et al (2002)	Field	40						UP	Aborted foetus culture
3	Rajeswari et al (1999)	Field	75						Andamans	3 out of 4 samples from aborted cattle was positive
4	Jeyaprakash et al (1999)	Field	15						Tamil nadu	
5	Das,A.M & Paranjape,V.L (1987)	Field		24					Maharastra	
	Incidence range in field (%)		**11-75**	**24**						
1	Anuradha and Ganesh (2006)	Farm	18							Abortion,ROP,repeatbreeding,metritis,hygroma & arthritis.
2	Gupta et al (2005)	Farm				82				Abortion
3	Bhattacharya et al (2005)	Farm	55							In aborted cows
4	Rajkhowa et al (2005)	Farm					34		Nagaland	
5	Barbuddhe et al (2004)	Farm	40						Goa	Abortion
6	Mrunalini et al (2000)	Farm				55			Andhra	
7	Chakraborty et al (2000)	Farm	68						Assam	
8	Isloor et al (1998)	Farm	17						Karnataka	
9	Das et al (1990)	Farm	38	14					Maharastra	
10	Barman et al (1989)	Farm	45						Assam	ROP,Abortion,mastitis,joint swelling and repeaters
11	Barman et al (1989)	Farm	60						Assam	Aborted cows
12	Barman et al (1989)	Farm	39						Assam	Repeaters
13	De et al (1989)	Farm	21							
14	Bachh et al (1988)	Farm	78						Kashmir	Average of reactors that aborted and repeated
15	Kulshreshtha et al (1983)	Farm			74				Haryana	Abortion& still birth
16	Oberaoi,M.S& Kwatra,M.S (1982)	Farm	4	9					Punjab	
17	Sodhi et al (1980)	Farm	15	19					Punjab	
	Incidence range in farms (%)		**17-78**	**9-24**	**74**	**55-82**	**34**			
18	Srivastava et al (1983)							40		
	Country average		**11-78**	**9-24**	**74**	**55-82**	**34**	**40**		

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A review of brucellosis in herds, both in the field and farms that exhibited symptoms like abortions, retention of placenta, still birth, mastitis, joint swelling, repeat breeding etc over the last three decades shows that the incidence range of brucellosis in cattle where abortions and other symptoms of brucellosis were seen is significantly higher (11-78%) than in buffaloes, which is 9-24%.

Other reports on brucellosis incidence

As per the annual reports of the Project Directorate on Animal Disease Monitoring and Surveillance (PD_ADMAS) the sero-prevalence of brucellosis has risen from 8.46% in 1994-2004 (10 years cumulative), to 20.89% in 2004-05 and 22.2% in 2005-06.

A country-wide study covering 23 States of India has also estimated the overall incidence of brucellosis at 1.9% in cattle and 1.8% in buffaloes. (*Isloor et al., 1998*)

In a similar study of equines covering 10 states and 2 union territories, the incidence of brucellosis was reported at 7.1% in Mules, 3.6% in donkeys and, 8.5% in horses, giving an overall average incidence of 6.4% in equines. (*Yadav et al., 1992*)

Manickam & Mohan.,1987, reported 6.34% of 331 DCS in Coimbatore district, Tamil nadu, to be positive for brucellosis when bulk milk samples were screened by milk ring test (MRT) . In another study, *Harikumar et al.,2005,* reported 14 out of 560 DCS (3.64%) in Ernakulam milk shed and 94 out of 463 DCS (19.01%) in Trivandrum milk shed, Kerala, to be positive on MRT of bulk milk samples.

Saini et al.,1992, reported 14 out of 37 villages (37.8%) to be positive for brucellosis on screening 5398 cattle and 1733 buffaloes by Rose Bengal Test (RBT) and Standard tube Agglutination Test (STAT) from 6467 households in Punjab.

Gumber et al., 2004, have also reported a village level prevalence rate of 22.5% by milk ELISA of bulk milk samples from villages in four districts of Punjab.

The individual screening tests used earlier were the Rose Bengal Test (RBT) and Standard Tube Agglutination test (STAT). These tests have been mostly replaced by the more sensitive and specific Enzyme Linked Immunosorbent Assay (ELISA) in the recent years.

Human brucellosis

Cattle, sheep, goats and pigs are the main sources of infection for humans. Transmission to humans occurs through occupational or environmental contact with infected animals or their products. Cheese made from raw milk and unpasteurised milk are the main sources of foodborne transmission. It can also be a travel associated disease. Person to person transmission is extremely rare.

B.melitensis infection is most frequently reported and causes severe disease in humans. *B.suis* has a much more restricted occurrence but can be as severe as the first. Though *B.abortus* is the most widespread cause of infection, the severity is much less than the disease caused by *B.melitensis* or *B.suis.*

Brucellosis exists in the general population in India and high clinical suspicion must be made in patients especially when there is history of animal contact or consumption of unpasteurized milk. *(Gokhale et al., 2003)*

The disease is acute in about half the cases, with an incubation period of 2-3 weeks. In the other half, the onset is insidious, with symptoms developing over a period of weeks to months from the infection.

Incidence of human brucellosis in India

Human brucellosis is a significant public health problem in India, the magnitude of which is not known. Paucity of clinico-epidemiologic data hampers control strategies. Persistence of animal reservoir, low physician awareness, poor availability of diagnostic facilities, and the non existence of regional data bases contribute towards the perpetuation of zoonosis in India. (*Handa et al., 1998*)

In India, fewer than 10% of the human cases of brucellosis may be clinically recognized and treated or reported. Screening of family members of index cases of brucellosis in an endemic area will help to pick up additional unrecognized cases. *(Mantur et al., 2007)*

In an outbreak of brucellosis reported in Kanvari village, Churu district, Rajasthan, 91.6% of 48 persons presented were positive by RBPT. (*Kalla et al., 2001)*

The reports of incidence of human brucellosis in India are elaborated in the table below:

Review of incidence of brucellosis in various human populations in India										
Sl. No	**Source**	**Vets**	**Para vets**	**Abattoir workers**	**Patients with FUO**	**Patients with fever and other symptoms**	**Occupationally exposed**	**General pop**	**Region**	**Remarks**
1	Mrunalini et al (2004)	25	23	7	12		45		AP	Farmers,shepherds and occupationally exposed.
2	Hussain et al(2004)						7		Assam	Farmers & attendant
3	Mishra et al (2003)							0.5	Bihar	
4	Kumar et al (1997)	29							Delhi	
				69						Animal Handlers
				68						Butchers
				57						Sweepers
5	Handa et al (1998)						24		North India	
6	Kadri et al (2000)				1				Kashmir	
7	Kalla et al (2000)					92			Rajasthan	Acute polyarthritis
8	Mudaliar et al (2003)						5		Maharastra	
9	Thakur,S.D & Thapliyal,D.C (2002)	17						4		
10	Ajay Kumar,V.J & Nanu,E (2005)						1	2	Kerala	
11	Hussain et al (2000)					7			Assam	Persons involved in animal husbandry
12	Mohanty et al (2000)					7			Orissa	Vets and paravets
13	Mrunalini.N & Ramasastry,P(1999)						16		AP	Vets,abattoir workers and farmers
14	Dessai et al (1995)						6		Karnataka	Vets, paravets and shepherds
15	Sharma et al (1979)							1	UP & Delhi	
16	Kulshreshtha et al (1978)						23		Haryana	Animal attendants
17	Savalgi et al (1987)						20			Farm staff
18	Kapoor et al (1985)							3	Rajasthan	
19	Rana et al (1985)	28	51						Delhi	
		40								Asst vet surgeons
20	Agasthya et al (2007)	12							Karnataka	
			41							Vet Inspectors
			31							Vet assistants
			6							Vet supervisors
							6			Group D workers
							2			Shepherds
				1						Butchers
	Incidence range (%)	**12-40**	**6-51**	**1-69**	**1-12**	**7-92**	**1-45**	**0.5-4**		

* – Fever of unknown origin

Symptoms of human brucellosis reported in India

Brucellosis may often be unsuspected because of its varied clinical manifestations and may be a more important cause of fever than previously considered (*Mathai et al., 1996*). There are about 27 symptoms affecting almost all the systems that have been noticed in patients with brucellosis. However, at times, seropositive patients may remain asymptomatic. (*Handa et al.,1998*)

The various symptoms of human brucellosis reported in India have been summarized in the table below:

Various manifestations of brucellosis in humans reported in India		
S.No	**Symptoms**	**Source**
1	**Neurobrucellosis:** (a) Meningoencephalitis (b) Myelitis leading to spastic paraparesis (c) Polyradiculoneuropathy@ (d) Polyneuroradiculomyeloencephalopathy.	Kochar et al., 2000.
2	(a) Acute polyarthritis (b) Low grade fever of 1-2 weeks.	Kalla et al., 2001.
3	(a) Spondylitis (b) Sacroiliitis	Gokhale et al., 2003.
4	(a) Persistent fever (b) Joint pain (mainly knee) (c) Back ache (d) Involuntary movements of limbs. (e) Burning sensation of feet. (f) Pityriasis alba $ (g) **Neurobrucellosis**: Chorea#, peripheral neuritis & meningitis (h) Skin lesions (i) Carditis	Mantur et al., 2004.
5	(a) Arthritis (b) Abortion (c) Genito- urinary infection	Mudaliar et al., 2003.
6	Persistent fever	Deepak et al., 2003.
7	Pneumonia	Singh et al., 2005.
8	Endocarditis	Purwar et al., 2006.

@ - Radiculoneuropathy is not a specific condition, but rather a description of a problem in which one or more nerves (polyradiculoneuropathy) are affected and do not work properly. The nerve or nerves may be inflamed, "pinched," lack blood flow, or may be affected

by a disease that is destroying it in part or totally. This can result in pain, weakness, numbness, or difficulty in controlling specific muscles.

$ - Pityriasis alba is a common skin condition mostly occurring in children and usually seen as dry, fine scaled, pale patches on their faces.

- Chorea is an abnormal involuntary movement disorder causing quick movements of the feet or hands.

The cure rate of brucellosis is very high if diagnosed properly and the prescribed treatment regimen administered. (*Kochar et al., 2000*)

Brucellosis control in some countries

Dedicated disease control programmes have controlled the disease in most of Europe, Australia, New Zealand, Canada, Israel, Jordan and Latin America. The disease control scenarios in some countries are described in brief below:

Poland

National eradication programme of bovine brucellosis in Poland reduced the prevalence of the disease below 0.5%. (*Seroka and Seroka., 1993*)

Greece

In Greece, vaccination of young animals (3-6 month old) sheep and goats with Rev 1 vaccine for 15 years decreased abortions in both sheep and goats as well as reduced the incidence in humans. After vaccinations were stopped in 1994, the prevalence in animals and humans quickly increased. The human incidence decreased after an emergency mass vaccination programme was taken up for young and adult animals with Rev 1 in 1998. It was also observed that the decrease in human incidence was not linear but decreased only when vaccination coverage of animals was above 30%. (*Minas et al., 2004*).

Czech Republic

Kouba., 2003, described a depopulation policy applied on farms and ranches affected with brucellosis in the Czech Republic with a view of totally eradicating the disease by a fixed deadline wherein breeding on diseased farms and ranches were temporarily discontinued and infected herds were replaced by healthy cattle from brucellosis free regions. Adopting such a method, eradication was achieved within a span of 5 years, without reducing the cattle population, rate of cattle production, or the income of farmers.

AH, Group, NDDB, Anand

Malaysia

Palaniswamy et al have reported that after embarking on a National Brucellosis Control and Eradication Programme (NBCEP) in 1978, the national reactor rate in cattle for brucellosis in Malaysia decreased from 8.7% in 1980 to 0.43% in 1993. The reactor rate again increased dramatically in 1998 in cattle raised in plantations after this farming system (integration of cattle with oil palm plantations) gained popularity. Exploring the reasons for such a dramatic increase in brucellosis incidence, they had made some important observations:

1. The rapidly increasing demand for cattle was met by influx from other areas/ countries (eg.Thailand) where brucellosis was endemic.
2. Infected animals have slipped into the country before enforcement of the disease control protocols.
3. Cattle that are 'incubating' and latent carriers are overlooked in the control protocols.
4. Since NBCEP was progressing well in government and small holder level, vaccination was not encouraged nor permitted and this facilitated rapid spread.
5. Delayed culling of reactors contributed significantly to high infection rates.

The recommendations given by them to control the disease were as follows:

1. Individual animals to be identified.
2. Testing for brucellosis to be made compulsory and a responsibility of the owner.
3. All free herds /farms should maintain their status through annual testing.
4. Infected herds should be imposed with movement restrictions in addition to strict disease control procedures as outlined for infected herds.
5. Strong legislation to be formulated and enforced.
6. A test and slaughter strategy alone would not be able to contain the disease as the rate of disease transmission is much higher than the rate of removal of infected cattle since susceptible animals are continuously challenged through latent carriers.
7. Vaccination is therefore necessary to protect susceptible cattle.
8. A market cattle testing system to be formulated.
9. All cattle and buffaloes sent for slaughter need to be identified with the specific farm/herd of origin.
10. Sufficient compensation funds must be made available to support the whole programme.

United Kingdom (UK)

Free calf vaccination in the UK started in 1962 followed by a compulsory eradication programme which commenced in 1971.The disease was controlled by 1981 after which calfhood vaccination was stopped. There are very few cases reported since then.

The following components of brucellosis surveillance continue to be vital and have proved effective in identifying suspected and confirmed brucellosis incursions:

- Import controls and certification.
- Exporting country alerts of brucellosis breakdowns in exporting herds.
- Post-import testing.
- Post-calving testing.
- Abortion reporting and investigations.

The national brucellosis surveillance programme in the UK presently comprises of monthly bulk milk testing of all dairy herds and blood testing of beef breeding herds every two years.

During 2005, bulk milk testing was carried out on 16,862 dairy herds and herd blood testing was carried out on 30,485 beef-breeding herds (approximately 1 million blood samples from beef breeding cattle are collected and tested each year – there are nearly four times as many beef breeding herds as dairy herds). The number of abortion investigations carried out was 7,968. (*www.defra.gov.uk*)

United States of America (USA)

Brucellosis once affected more than 10 percent of the cattle herds in the USA. An investment of 3.5 billion USD has reduced the brucellosis infected herds from 1,24,000 in 1957 to 40 in 1996. (*Richey and Harrell., 1997*)

India

There is no organized and effective control programme in India though population surveys of the disease have been taken up in many States. (*Renukaradhya et al., 2002*). In the event of a disease control programme being formulated, the following need to be kept in view while strategizing:

- Individual animals to be identified.
- Strong legislation to be formulated and enforced.
- Brucellosis testing to be made compulsory and a responsibility of the owner.
- All free herds /farms should maintain their status through periodic testing.
- Infected herds should be imposed with movement restrictions in addition to strict disease control procedures as outlined for infected herds.
- Vaccination is necessary to protect susceptible cattle as the rate of disease transmission is usually much higher than the rate of removal of infected cattle since susceptible animals are continuously challenged through latent carriers.
- A market cattle testing system to be formulated.
- Delayed culling of reactors could contribute significantly to high infection rates.
- All animals sent for slaughter need to be identified with the specific farm/herd of origin.
- Sufficient compensation funds must be made available to support the whole programme.

Office International des Epizooties (OIE) criteria

For a country or zone to be free from bovine brucellosis

- Bovine brucellosis or any suspicion thereof is notifiable.
- The entire cattle population is under official veterinary control and the rate of brucella infection has been ascertained not to exceed 0.2% of the cattle herds.
- The serological tests for bovine brucellosis are periodically conducted in each herd, with or without the ring test.
- No animal has been vaccinated against bovine brucellosis for at least the past 3 years.
- All reactors are slaughtered.
- Animals introduced come from herds officially free / free from bovine brucellosis or animals which have not been vaccinated and which, prior to entry were isolated and subjected to serological tests with negative results on two occasions, with an interval of 30 days between each test.

For a herd to be officially free from bovine brucellosis

- It is under official veterinary control.
- Contains no animal which has been vaccinated against bovine brucellosis for at least the past 3 years.
- It only contains animals which have not shown evidence of brucellosis during the past six months and all suspect cases have been subjected to necessary laboratory investigations.
- All cattle over one year of age are subjected to serological tests with negative results on two occasions, at an interval of 12 months between each test.
- Animals introduced come from herds officially free from bovine brucellosis or animals which have not been vaccinated and which showed negative results to serological tests 30 days prior to entry into the herd.

For a herd to be free from bovine brucellosis

- It is under official veterinary control.
- It is subjected to either vaccination or non-vaccination regime.
- Vaccination must be carried out in female cattle between 3 and 6 months of age and must be identified with a permanent mark.

AH, Group, NDDB, Anand

- All cattle over one year of age are subjected to serological tests with negative results on two occasions, at an interval of 12 months between each test.
- Animals introduced come from herd/country/zone officially free / free from bovine brucellosis or animals which prior to entry into the herd were isolated and subjected to serological tests with negative results on two occasions, with an interval of 30 days between each test. (Source: *www.oie.int*)

NDDB initiatives in brucellosis control

Milk ring test (MRT) popularisation

NDDB continues to facilitate many cooperative milk unions to carry out milk ring test (MRT) of bulk milk samples from their village milk cooperative societies in order to identify infected villages.

MRT of bulk milk samples from 560 milk societies in Ernakulam Milk Union and 463 milk societies in Trivandrum Milk Union identified 14 (3.64%) and 94 (19.01%) milk societies respectively as positive for brucella infection. (*Hari Kumar et al.*, 2005). This information was then shared with the Kerala State Animal Husbandry Department which then carried out a State-wide screening of milk samples by MRT. All technical assistance for preparation of the project for the State-wide screening and training of around 50 veterinarians and an equal number of paraveterinary staff working in laboratories was provided by NDDB.

Brucella Strain 19 (S 19) vaccine popularisation

NDDB continues to facilitate the dairy cooperatives to carry out vaccination of female calves between 4-8 months of age with 'Bruvax', a freeze dried S 19 vaccine manufactured by IIL. Cooperative milk unions all over India reported vaccination of 8957 female calves with S 19 vaccine in 2004-05 which increased significantly to 61483 during 2005-06 and 125161 in 2006-07.

Brucella Strain RB 51 vaccine experimentation

Strain RB 51 vaccine can be used without inducing antibody titres that interfere with serodiagnosis and is reported to give 100% protection against field strain *B.abortus* induced abortion in cattle which have been vaccinated at least 1 year before mating to an infected bull. Vaccination with S19 under similar conditions was less

effective than with RB 51 (*Lord et al.,1998*). Vaccination with a reduced dose of RB 51 also protects adults against abortion or infection caused by exposure to virulent *B.abortus* during subsequent pregnancy. (*Olsen C.,2000*). This vaccine has also been approved by Office International des Epizooties (OIE) as a substitute for S 19 vaccine. It is also less hazardous to humans than S 19 vaccine if accidental inoculation occurs. NDDB is in the process of testing the efficacy of RB 51 vaccine in the field.

Tests /reagents available for diagnosis of brucellosis in India

Sl. no	Test/Antigen	Available at
1	Rose Bengal Test (RBT) antigen	1. Indian Veterinary Research Institute (IVRI), Izatnagar, UP. 2. Some State Institutes of Animal Health and Veterinary Biologicals (IAH & VB)
2	Milk Ring Test (MRT)antigen	-Do-
3	Serum Agglutination Test (SAT) antigen	-Do-
4	Serum ELISA kits	Project Directorate on Animal Disease Monitoring and Surveillance (PD_ADMAS), Bangalore.
5	Milk ELISA Kits	-Do-
6	Serum ELISA testing	(1) Centre for Animal Disease Research and Diagnosis (CADRAD), Izatnagar, UP. (2) State Regional Disease Diagnostic Laboratories (RDDL) (3) Indian Immunologicals Limited (IIL), Hyderabad. (Uses imported kits)
7	PCR testing	(1) IIL (2) PD_ADMAS

Note: List is not comprehensive.

Economics of control

Reports are few on the economic losses of brucellosis in India. Some reports on the same for other countries where control programmes have been successfully implemented are available.

Kouba., 2003 had estimated the annual losses due to brucellosis in the Czech republic at around 20 million USD. Around 32.4% of the veterinarians also tested positive. The cumulative benefit /eradication ratio was estimated to be 7:1, 10 years after eradication of the

disease. He also mentioned that by the year 2000, eradication had averted losses of approximately 700 million USD and saved more than 2000 people from becoming infected.

In another scenario of 52% reduction of brucella transmission achieved by mass vaccination, the intervention costs were estimated at 8.3 million USD and overall benefit was 26.6 million USD giving an average benefit-cost of 3.2 for the control programme. *(Roth et al.,2003)*

For the brucellosis control programme implemented in Mongolia, *Roth et al., 2001*, estimated the benefit cost ratio for the society as a whole at 4.14, for the health sector at 7.56 and agricultural sector at 3.72.

Richey and Harrell., 1997 have reported that losses in the USA would have been in excess of 800 million USD annually due to reduced supplies of meat and milk if a brucellosis control programme was not in place.

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