International Journal of Food Microbiology 154 (2012) 113–118

Contents lists available at SciVerse ScienceDirect

International Journal of Food Microbiology

journal homepage: www.elsevier.com/locate/ijfoodmicro

Epidemiology and risk management of listeriosis in India ☆

S.B. Barbuddhe [a,*], S.V.S. Malik [b], J. Ashok Kumar [a], D.R. Kalorey [c], T. Chakraborty [d]

[a] ICAR Research Complex for Goa, Ela, Old Goa 403402, India
[b] Division of Veterinary Public Health, Indian Veterinary Research Institute, Izatnagar 243122, India
[c] Department of Microbiology and Animal Biotechnology, Nagpur Veterinary College, Maharashtra Animal and Fishery Sciences University, Nagpur 440006, India
[d] Institute of Medical Microbiology, Justus-Liebig University, 35392 Giessen, Germany

ARTICLE INFO

Available online 7 September 2011

Keywords:
Listeria monocytogenes
Listeriosis
Humans
Animals
Food
India

ABSTRACT

Listeria monocytogenes is a foodborne pathogen that can cause serious invasive illness, mainly in certain well-defined high-risk groups, including elderly and immunocompromised patients, pregnant women, newborns and infants. In India, this pathogen has been isolated from humans, animals and foods. The incidence of *Listeria* is generally comparable to those reported elsewhere in the world. In humans, maternal/neonatal listeriosis is the most common clinical form reported. Among animal populations, spontaneous abortions, subclinical mastitis, meningoencephalitis and endometritis were the commonest forms reported. The disease largely remains undiagnosed and under reported. From reported analyses of a variety of foods for *Listeria*, milk and milk products, meat and meat products, seafood and vegetables have been reported to be contaminated in India. The legal framework for microbiological safety of foods against microbes including *L. monocytogenes* is summarised. The epidemiological studies would help in understanding of the sources of infection and persistence and their risk assessment, routes of transmission, clinical forms and allow for better management of the infection.

1. Introduction

Listeriosis is an important bacterial infection, which occurs in animals and humans, and arises mainly from the ingestion of contaminated food. Listeriosis leads to septicaemia, abortion, stillbirth, perinatal infections, meningitis, gastroenteritis and meningoencephalitis, especially in immunocompromised individuals and elderly (>60 years old). The genus *Listeria* (Group 19, Bergey's Manual, 9th ed.) includes eight species, namely, *Listeria monocytogenes*, *L. ivanovii*, *L. innocua*, *L. welshimeri*, *L. seeligeri*, *L. grayi*, *L. marthii* (Graves et al., 2010) and *L. rocourtiae* (Leclercq et al., 2010). Of these, *L. monocytogenes* is an opportunistic pathogen in human beings and various animal species, whereas *L. ivanovii* mainly affects ruminants, causing abortion, only occasionally occurring in man (Guillet et al., 2010).

Our knowledge on the ecology and physiology of *L. monocytogenes* and its manifestations as the disease listeriosis has increased manifold during the past two decades. Through application of this new information to food production and processing, it has been possible to reduce the incidence of listeriosis in the industrialised countries of the world (Schlech et al., 1983; Swaminathan and Gerner-Smidt, 2007). The occurrence of listeric infections in the Indian subcontinent has been extensively reviewed by Malik et al. (2002). In India, *L. monocytogenes* strains have been isolated from the meat and milk of goats, sheep and buffaloes (Barbuddhe et al., 2000, 2002). The microorganism has been isolated from fish and fishery products (Jayasekaran et al., 1996; Karunasagar and Karunasagar, 2000; Parihar et al., 2008). Serology would be a useful tool for epidemiological studies aimed at assessing the burden of the disease and clarifying the role of animals in the epidemiology of listeriosis. However, cross reactivity with of antigens from other related bacteria has hampered the use of serology for the study of listeriosis. Advances in our understanding of the pathogenesis of listeriosis have identified many virulence factors specific for *L. monocytogenes* which could serve as antigens for serological tests. In particular, ELISA-based formats designed to detect its major virulence factor listeriolysin (LLO), have been developed for diagnosis of listeriosis in animals (Barbuddhe et al., 1999a) and humans (Barbuddhe et al., 1999b). *L. monocytogenes* has been isolated from cases of mastitis, reproductive disorders and septicaemia in animals (Shakuntala et al., 2006; Rawool et al. 2007). *L. monocytogenes* has been found to be one of the etiological factors in the causation of abortions and premature births in humans (Bhujwala, et al., 1973). Dhanashree et al. (2003) isolated *L. monocytogenes* from women with poor obstetric history.

There has been a number of food borne outbreaks of listeriosis in Europe and America (Swaminathan and Gerner-Smidt, 2007). In India, we have recorded outbreaks of listeriosis in animal populations (Rahman et al., 1985; Chand and Sadana, 1998). Nevertheless, the disease largely remains undiagnosed and under reported. This review seeks to provide an account of the occurrence of *Listeria* in humans, animals, foods and also the regulations for control of *L. monocytogenes* in India.

☆ This article was presented at the International Symposium On Problems Of Listeriosis XVII.

* Corresponding author. Tel.: +91 832 2284678; fax: +91 832 2285649.
E-mail address: barbuddhesb@yahoo.com (S.B. Barbuddhe).

0168-1605/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.ijfoodmicro.2011.08.030

2. Disease in humans

Listeriosis has been reported in sporadic and epidemic forms throughout the world, however, there are certain countries (particularly in Asia) where the disease is under reported and lack active surveillance systems (Lorber, 1997; Schlech, 2000, Siegman-Igra et al., 2000). The epidemiological data available on listeriosis in India to date is not adequate for assessing the extent of infection in human beings and animals. The disease largely remains undiagnosed and under reported, largely due to the lack of a reliable, rapid and simple diagnostic test (Barbuddhe et al., 2004) and also a lack of a mandatory notification of listeriosis. The disease has been reported in various clinical forms (Table 1).

In USA, about one-third of reported human listeriosis cases happen during pregnancy, which may result in spontaneous abortion in second–third trimester (CDC, 2005). In England and Wales, pregnancy and neonatal disease account for 10–20% of cases. Of these, 15–25% of infections lead to abortion and stillbirth (McLauchlin et al., 2004). In India, genital listeriosis is the most common clinical form reported. *L. monocytogenes* has been found to be one of the etiological factors in the causation of abortions and premature births (Bhujwala, et al., 1973). Earlier attempts (Dhawan and Dhall, 1963) failed to isolate *L. monocytogenes* from the cervix of unsuccessful pregnancy and of unhealthy cervical and vaginal discharges. However, later *L. monocytogenes* was isolated from the cervix of 14% of 150 patients with poor obstetric history i.e., past history of abortions, miscarriages, stillbirths or neonatal deaths (Krishna et al., 1966), from 3 of 100 (Bhujwala, et al., 1973), 9 of 670 women with a bad obstetric history (Bhujwala and Hingorani, 1975) and 4 of 40 women with a history of abortions (Stephen et al., 1978). Pathogenic *L. monocytogenes* were isolated from 3.3% of cases of spontaneous abortions (Kaur et al., 2007). The patients had a history of abortion in earlier pregnancy. *L. monocytogenes* has been reported as a cause of meningitis and hydrocephalus in children born of infected mothers (Gogate and Deodhar 1981). These reports highlight the importance of the pathogen as a cause of spontaneous abortions and infant mortality in this part of the world.

Isolation of *L. monocytogenes* from cultured blood taken from 3 cases, from a 4 h old infant, a one and a half month old child with congenital heart disease and digestive failure, and a one and a half year old severely malnourished child has also been described (Gupta et al., 1997). A perinephric abscess presenting as abdominal pain and caused by *L. monocytogenes* in a 5 year old malnourished child has also been reported (Gomber et al., 1998). *L. monocytogenes* was detected from one of 43 samples of cerebrospinal fluid obtained from patients with partially treated and culture-negative meningitis (Pandit et al., 2005).

A case of listeriosis, late onset type, with features like hepatosplenomegaly, lymphadenopathy, cutaneous haemorrhages and meningitis has been reported (Raghuraman and Rupnarayan, 1988). A case of meningitis caused by *L. monocytogenes* in a 17-year-old immunocompetent patient was reported. The organism was isolated from the cerebrospinal fluid and subsequent treatment with ampicillin resulted in dramatic recovery (Kalyani et al., 2006).

Perinatal listerial infection is the most common clinical syndrome caused by *L. monocytogenes* and includes abortion, stillbirth, neonatal sepsis and meningitis. Early onset neonatal listeriosis develops within 7 days and classically within 1 or 2 days of life. Aspiration of infected amniotic fluid contributes to pathogenesis, although, transplacental transmission is favoured by most authors (Klein, 2001). A case of early onset neonatal listeriosis in a full term baby presenting at 58 hr of life was reported (Srivastava et al., 2005).

Worldwide, a number of cases of spontaneous bacterial peritonitis in cirrhosis caused by *L. monocytogenes* are reported in the literature. A case spontaneous bacterial peritonitis in cirrhosis caused by *L. monocytogenes* was reported. The organism was isolated from ascitic fluid (Bashir et al., 1997) reiterating the need to be aware of this syndrome.

A significant number of patients in India have advanced renal insufficiency at initial presentation leading to an increasing use of temporary dialysis catheters. Catheter related bacteremia is a significant complication associated with its use. *L. monocytogenes* was isolated from one patient from a total of 50 cases (Nirni et al., 2002).

The incidence of listeriosis varies between 0.1 and 11.3/1,000,000 in different countries (Anon, 2004). No such estimates are available in India. There is no passive or active surveillance system for human listeriosis in India. The notification for listeriosis is not mandatory. It is now necessary to put in place such a system to have proper estimates of disease burden among population. Education of consumers, especially the high risk groups, about the risk of infection will be necessary to keep morbidity and mortality as low as possible.

Table 1
Reported sporadic cases of human listeriosis with isolation of *Listeria monocytogenes* strain in India.

Age	Sex	Year	Clinical form	References
NS (14% of 150 cases)	Female	1966	Maternal listeriosis	Krishna et al. (1966)
25, 26 and 32 years (3 of 100 cases)	Female	1972	Maternal listeriosis	Bhujwala et al. (1973)
24, 30 35 years (10% of 40 cases)	Female	1977	Maternal listeriosis	Stephen et al. (1978)
NS	Female	2002	Abortion	Dhanashree et al. (2003)
22 years	Female	2003	Maternal listeriosis	Gupta et al. (2003)
NS	Female	2006	Maternal listeriosis	Kaur et al. (2007)
NS (1.34% of 670 cases)	Female	1974	Perinatal	Bhujwala and Hingorani (1975)
Not specified		1980	Neonatal	Thomas et al. (1981)
4 h	Male	1997	Neonatal	Gupta et al. (1997)
1.5 months	Male	1997	Septicaemia	Gupta et al. (1997)
1.5 years	Male	1997	Septicaemia	Gupta et al. (1997)
58 h	Male	2005	Neonatal	Srivastava et al. (2005)
25 years	Female	1995	Pericarditis	Revathi et al. (1995)
5 years	Male	1998	Perinephric abscess	Gomber et al. (1998)
2 months	Male	1981	Meningitis	Gogate and Deodhar (1981)
2 months	Male	1988	Septicaemia	Raghuraman and Rupnarayan (1988)
17 years	Female	2006	Meningitis	Kalyani et al. 2006
20 months	Female	2009	Meningoencephalitis	Peer et al. (2010)
2 days	Male	2009	Neonatal	Mokta et al. (2010)

3. Disease in animals

A number of surveys have characterised the prevalence of the zoonotic agents in individual animals on farms or at slaughterhouse. Such studies have provided an excellent indication of the overall infection status of farmed livestock. Animals contribute to amplification and dispersal of *L. monocytogenes* into the farm environment, and the farm ecosystem maintains a high prevalence of *L. monocytogenes*, including subtypes linked to human listeriosis cases and outbreaks. In India, cases of listeriosis have been reported from animal population as sporadic as well as outbreak forms. The clinical manifestations varied with the species affected. Spontaneous abortions, subclinical

mastitis, meningoencephalitis and endometritis were the commonest forms reported (Table 2).

The first confirmed case of listeric abortion in any species of domesticated animal in India was reported by Dhanda et al. (1959) in an ewe. *L. monocytogenes* was isolated from a swab of uterine pus. In 1977–78, 111 abortions out of 800 lambings in sheep were recorded in Jammu and Kashmir (Vishwanathan and Uppal, 1981). *L. monocytogenes* serotype 4b was isolated from the stomach contents of one of 22 aborted foetuses (Vishwanathan and Uppal, 1981). Studies on migratory flocks with a history of abortions revealed *L. monocytogenes* and *L. ivanovii* from vaginal swabs of sheep and goats (Sharma et al., 1996). These flocks were maintained by keeping sheep and goats together and rearing them exclusively on grazing without feeding any concentrate. Isolation of *L. monocytogenes* and *L. ivanovii* has been reported from ewes and does in Himachal Pradesh, India (Nigam et al., 1999).

An outbreak of abortions caused by *L. ivanovii* was reported in a flock of 254 crossbred sheep (Chand and Sadana, 1998). The isolation of *L. monocytogenes* from aborted foetuses from a cow and a buffalo has been reported (Dutta and Malik, 1981).

Listeric mastitis, which is the most stubborn and difficult to treat, results in culling of the infected animals from a herd. Although the recovery of *L. monocytogenes* has been reported from milk and milk products in India (Bhilegaonkar et al., 1997), its possible role in the causation of mastitis needs to be studied. *L. monocytogenes* and *L. ivanovii* were recovered from milk samples and faecal of mastitic cattle and buffaloes. The recovery of pathogenic *L. ivanovii* isolate from faeces of buffalo with mastitis, could serve as a probable source of listeric infection including mastitis for the other animals on the farm (Rawool et al., 2007).

L. monocytogenes was isolated from endometritis cases in buffaloes (Shah and Dholakia, 1983). Two strains of *L. monocytogenes* serotypes 1/2c and 4b were isolated from the endometrium of infertile cows (Srivastava et al., 1985). In Himachal Pradesh, *L. ivanovii* and *L. monocytogenes* were isolated from sheep and goats with endometritis (Mahajan and Katoch, 1997). The prevalence of *L. monocytogenes* and other *Listeria* spp. was found to be 4.4 and 7.4%, respectively from buffaloes with a history of reproductive disorders (Shakuntala et al., 2006). *L. ivanovii* was recovered from one of the 54 samples from the 18 ewes with reproductive disorders (Kaur et al., 2010).

L. ivanovii was isolated from 7.5, 5.56 and 14.52% goats of those aborted, mastitic and apparently healthy, respectively (Elezebeth et al., 2007). Out of the 120 samples each of feacal, nasal and vaginal swabs 5, 1.67 and 2.5% was positive for *L. ivanovii*, respectively. Out of 120 serum samples tested by listeriolysin-O based indirect ELISA, 19.16% turned out to be seropositive. The percentage of seropositivity was higher in goats those aborted (Elezebeth et al., 2007).

The disease syndrome “circling disease” in sheep and goats with sudden onset, was observed by Phadke et al. (1979) in the Maharashtra state. Three strains of *L. monocytogenes* serotype 4b were isolated from the brain of a buffalo during an investigation of an outbreak in Andhra Pradesh (Uppal et al., 1981). A rare case of listerial abortion and encephalitis was reported in a 7 year old buffalo (Patil et al., 1998).

An outbreak of listerial meningoencephalitis affecting 75 indigenous pigs was observed in a pig farm (Rahman et al., 1985). In another outbreak, circling movements with lateroventral deviation of the head, sudden ataxia and epileptic seizures among the affected pigs was reported (Dash et al., 1998). Pregnant sows aborted macerated foetuses and *L. monocytogenes* was isolated from the brain of affected animals that died after showing signs of circling (Dash et al., 1998).

An outbreak of listeriosis with neurological signs was reported in a flock of 700 broiler chickens with a history of mortality rate of 40% and a twisted neck condition with no other signs of illness (Vijayakrishna et al., 2000). During three outbreaks of encephalitis, 69 of 875 sheep were affected, with overall morbidity, mortality and case fatality rates of 7.89, 7.08 and 89.85%, respectively (Kumar et al., 2007).

Studies are lacking particularly on the extent of faecal shedding of *Listeria* and its persistence. Since *L. monocytogenes* has been identified as one of the agent causing subclinical mastitis and repeat breeding in bovines, awareness of risk factors may be used in future to develop control measures to reduce animal disease and avoid introduction of *L. monocytogenes* into the human food chain. Animal production units may represent a reservoir for *L. monocytogenes* and source for human infection via faecal contamination of food products since certain *L. monocytogenes* types carried by farm animals have been associated with human infections (Fugett et al., 2007; Esteban et al., 2009). Though eradication from the farm is highly unlikely due to the ability of *L. monocytogenes* to survive and multiply in many habitats and hosts, adequate risk management could be planned through the implementation of adequate intervention strategies.

Table 2
Reported clinical manifestations of listeriosis among animal populations in India.

Species	Clinical forms	References
Sheep, buffalo, cattle, goats, pigs, poultry	Spontaneous abortions, endometritis abortion, repeat breeding, subclinical mastitis, meningoencephalitis	Dhanda et al. (1959), Sharma et al. (1996), Shakuntala et al. (2006), Vishwanathan and Uppal (1981), Nigam et al. (1999), Shah and Dholakia (1983), Dutta and Malik (1981), Srivastava et al. (1985), Sharda et al. (1991), Mahajan and Katoch (1997), Rawool et al. (2007), Elezebeth et al. (2007), Chand and Sadana (1998), Phadke et al. (1979), Rahman et al. (1985), Dash et al. (1998), and Vijayakrishna et al. (2000)

4. Isolation from foods

L. monocytogenes is ideally distributed in the natural environment and consequently present in various animal products. *L. monocytogenes* is considered to be a ubiquitous organism occurring in both terrestrial and aquatic habitats. In India, there are few studies on the prevalence of *L. monocytogenes* in food samples described in this section, and presently no documented clusters and outbreaks of human listeriosis have been documented.

L. monocytogenes has been involved in numerous outbreaks of listeriosis occurring through consumption of milk and milk products (Flemming et al., 1985; Linnan et al., 1988; Lyytikainen et al., 2000). Contamination of raw milk with *L. monocytogenes* results from exogenous and intramammary origins. India is the largest producer of milk in the world and also has the highest number of cattle in the world. *L. monocytogenes* was also isolated from 8.1% of raw milk samples (Bhilegaonkar et al., 1997). Most of the isolates were pathogenic by mice inoculation assay (Menudier et al., 1991). No *L. monocytogenes* was isolated from pasteurised bulk milk tanks. Recovery of pathogenic *L. monocytogenes* isolates has been reported from milk of 1.56% goats (Barbuddhe et al., 2000) and 6.25% buffaloes (Barbuddhe et al., 2002). The pathogenicity of the isolates was tested by mice inoculation ad chick embryo inoculation assays. Milk samples collected from 2060 dairy cows were examined for the presence of *Listeria* species. *Listeria* spp. were isolated from 139 (6.75%) samples; 105 (5.1%) were positive for *L. monocytogenes* (Kalorey et al., 2008). The microbiological analysis of 1098 samples comprising of milk (471) and ready-to-eat indigenous milk products (627) revealed 18 isolates (eight from milk and 10 from milk products) as *L. monocytogenes* (Aurora et al., 2008).

The incidence of contaminated milk samples varies among countries, being 1.2% in Denmark (Jensen et al., 1996), 3.62% in Spain (Gaya et al., 1998) and 3.48% as calculated by Ryser and Marth (1991) in the USA. The variation in the number of *Listeria* spp. from different studies carried out could also be due to the diverse isolation and enumeration methods.

In India, recovery of *L. monocytogenes* isolates has been reported from meats of 6.66% to 7.08% goats (Barbuddhe et al., 2000; Rekha et al., 2006), 7.4% sheep (Barbuddhe et al., 2000), and 3.07% to 6% buffalo meat samples (Bramhabhatt and Anjaria, 1993; Barbuddhe et al., 2002). *L. monocytogenes* was isolated from 8.l% poultry meat samples (Barbuddhe et al., 2003).

The organism has been isolated from fish and fishery products from different parts of the world and interestingly the incidence rate reported from tropical fish is rather low (Karunasagar and Karunasagar, 2000). In India, only a few surveys have been conducted to assess the presence of *Listeria* sp. in seafoods (Table 3). Jeyasekaran et al. (1996) reported higher occurrence of *L. monocytogenes*, 12.1% in fresh shell fishes and 17.2% in fresh fin fishes from tropical seafood from India. Dhanashree et al. (2003) isolated *L. innocua* in 30.8% and *L. monocytogenes* in 1.3% of fresh raw fish samples from Mangalore, India. Earlier reports from India suggested the absence of *L. monocytogenes* in fishes (Fuchs and Surendran, 1989; Karunasagar et al., 1992; Manoj et al., 1991). The incidence of *Listeria* species in the seafood of markets in Goa, India was studied. Twenty eight of 115 seafood samples were positive for *Listeria* spp. and in 10 samples *L. monocytogenes* was detected. *L. innocua* was the most common *Listeria* species recovered and was detected in 18 samples (Parihar et al., 2008).

A total of 200 samples (muscles and viscera, 100 of each) of fresh water fish, walking catfish (*Clarias batrachus*) were screened for *Listeria* spp. A total of 39 isolates of *Listeria* spp. were recovered. Of these 26 (67%), 8 (21%), 3 (8%) and 2 (5%) were *L. monocytogenes*, *L. seeligeri*, *L. grayi* and *L. welshimeri*, respectively (Jallewar et al., 2007).

Various studies confirm the view of *Listeria* as a frequent contaminant in food products, and India is no exception. The occurrence of *L. monocytogenes* is summarised in Table 3. Although we have not experienced documented listeriosis outbreaks, it is important to be aware of this possibility. There is a need for further vigilance as the total amount of fresh food products and ready-to-eat foods is increasing in India, and because of the common practice of eating unheated fresh vegetables and salads among both children and adults, as well as the potential risk of eating raw or undercooked meat. More studies are needed to establish microbiological criteria to *L. monocytogenes* for foods and later a bioindicator or hygiene criteria on the presence of *Listeria* spp.

5. Framework of food safety regulations in India

Limits of microbiological parameters including *L. monocytogenes* for processed food products are specified in respective Indian Standards. As far as microbiological criteria are concerned Indian Standards are elaborate. The Bureau of Indian Standards (BIS) has formulated standards on test methods for detection and enumeration of pathogenic microorganisms in food and specifications for ingredients used in media for microbiological work. BIS has also a formulated code of hygienic conditions for various food industries. BIS has adopted Codex, HACCP and Food Hygiene guidelines in the Indian Standards.

The Bureau of Indian standards has adopted the methods for detection and enumeration of *L. monocytogenes* from foods as ISO 11290 Part 1 and Part 2 (1996) equivalent to IS 14988 Parts 1 and 2 (2001) in India (Anon, 2001, 2002; Scotter et al., 2001a, 2001b).

In India, microbial food safety is being enforced through various regulatory mechanisms such as the Prevention of Food Adulteration (PFA) Act, 1955; Quality control orders issued under the Essential Commodities Act, 1955 such as Fruit Product Order (FPO), 1955, Meat Food Products Order (MFPO), 1973, Milk and Milk Product Order (MMPO), 1992 and the Agricultural Produce (Grading & Marking) Act, 1937.

Prevention of Food Adulteration (PFA) Rules, 1956 (First Amendment, Rules, 2010) specifies microbiological requirements for pathogens such as *L. monocytogenes* in foods (Table 4) commonly involved in food-borne diseases, such as sea food, milk and milk products, meat and meat products. As per these rules, *L. monocytogenes* should be absent in 25 g of frozen mutton, goat, beef and buffalo meat, and cheese/processed cheese other than hard cheese. The rules and tests are routinely applied in India.

6. Microbiological surveillance

A database of *Listeria* strains isolated in India from various sources, Indian *Listeria* Culture Database (ILCD) has been established (Jangam et al., 2010, Barbuddhe et al., 2010; http://www.icargoa.res.in/ilcd). The database provides visualisation of geographical source of the strain, its lineage, serotype, source of isolation (animal/human), year of isolation, phenotypic and genotypic characteristics as well as antibiotic sensitivity patterns. This is an interactive web-based database and permits data exchange between laboratories electronically. The web interface of ILCD allows users with no special programming background or bioinformatics experience to examine the results. ILCD is expected to be helpful to molecular epidemiologists and those interested in research on *Listeria* (Jangam et al., 2010).

7. Conclusions and perspective

L. monocytogenes has been detected in human, animals and foods in India. In humans, genital listeriosis is the most common clinical form reported. The clinical manifestations are diverse and varied with the species affected. Spontaneous abortions, subclinical mastitis, meningoencephalitis and endometritis were the commonest forms reported among animal populations.

In India, no reference laboratory for listeriosis currently exists. There have been major global advances in the understanding of the epidemiology, taxonomy, detection of listeriae in foods and animals, and also of the molecular determinants of virulence in this bacterium. In India, the existence of listeriosis has been recorded in man and animals from time to time. However, clinical diagnosis of *L. monocytogenes* infections is inadequate owing to its complex immunopathological aspects and varied clinical forms and is hampered by the lack of simple tests based on immune diagnostics and limited implementation of robust detection methods in microbiological laboratories. The feasibility and efficacy of potential intervention strategies need to be defined.

The role of *L. monocytogenes* and *L. ivanovii* in abortion and other reproductive disorders needs to be elucidated. Also their role in other disease conditions and the status of listeriosis in organised farms where intensive husbandry practices have been implemented need to be studied. Studies are also lacking on determination of the carrier state of *L. monocytogenes* in healthy and diarrhoeic humans and animals. Also, little information on the overall resistance of *Listeria* to antibiotics and detergents is presently available. Indeed, it is necessary to implement a monitoring system to test any animals showing clinical manifestations of listeriosis.

Table 3
Reported isolations of *Listeria monocytogenes* from foods in India.

Sample/ product	Prevalence (%)	References
Milk and milk products	1–23	Bhilegaonkar et al. (1997), Barbuddhe et al. (2000, 2002), Kalorey et al. (2008) and Parihar et al. (2007)
Meat (beef, chevon)	2–5	Barbuddhe et al. (2002) and Bhanu Rekha et al. (2006)
Poultry meat	8–14	Barbuddhe et al. (2003) and Gunjal et al. (2007)
Fresh water fish	13	Jallewar et al. (2007)
Seafood	0 to 17	Fuchs and Surendran (1989), Manoj et al. (1991), Karunasagar et al. (1992), Jeyasekaran et al. (1996), Dhanashree et al. (2003), Moharem et al. (2007), and Parihar et al. (2007)

Table 4
Microbiological requirements for *L. monocytogenes* in foods in India as per Prevention of Food Adulteration (PFA) Rules, 1956 (First Amendment, Rules, 2010).

Food product	Requirement
Frozen mutton, goat, beef and buffalo meat, and cheese/processed cheese other than hard cheese	Absent in 25 g
Ice cream/frozen dessert/milk lolly/ice candy/ dried ice cream mix	Absent in 1 g
Cheese/processed	Cheese other than hard cheese: absent in 25 g
Evaporated milk	Absent in 1 g
Sweetened condensed milk	Absent in 1 g
Butter	Absent in 1 g
Butter oil/butter fat and ghee	Absent in 1 g
Yoghurt/dahi	Absent in 1 g
Milk powder/cream powder	Absent in 1 g
Edible casein products	Absent in 1 g
UHT milk/UHT flavoured milk	Absent in 1 g
Pasteurised milk	Absent in 1 g
Sterilised milk/sterilised flavoured milk	Absent in 1 g
Khoya/channa/paneer	Absent in 1 g
Chakka/srikhand	Absent in 1 g

India has surfeit of laws regulating the food safety and other activities of food industry. In order to give a boost to the food industry the need of the hour is to harmonise not only the various food laws but also the agencies. One national food safety code should be implemented, which should cover all aspects of Indian food safety under a unified system. Education of consumers, especially the high risk groups, about the risk of infection will be necessary to keep morbidity and mortality as low as possible.

The epidemiological studies would help in better understanding of the sources of infection and their risk assessment, routes of transmission, clinical forms and better management of the infection. Until now, there was no passive or active surveillance system for human listeriosis in India. Recently, the Indian Council of Agricultural Research has initiated an outreach programme on listeriosis for active surveillance. Such a system will help in deriving proper estimates of disease burden among animal and human populations.

Acknowledgements

The authors are thankful to the Director, ICAR Research Complex for Goa for providing the necessary facilities for studies reported herein. The research work is supported by grants from Department of Biotechnology, Government of India (BT/IN/FRG/01/SBB/2008) to SBB.

References

Anon, 2001. IS 14988 (Part 1):2001/ ISO 11290-1:1996 Microbiology of Food and Animal Feeding Stuffs — Horizontal Method for Detection and Enumeration of *Listeria monocytogenes*: Part 1 Detection Method. Bureau of Indian Standards, New Delhi, Indcbeia.

Anon, 2002. IS 14988 (Part 2):2001/ ISO 11290–2:1996 Microbiology of Food and Animal Feeding Stuffs — Horizontal Method for Detection and Enumeration of *Listeria monocytogenes*: Part 2 Enumeration Method. Bureau of Indian Standards, New Delhi, India.

Anonymous, 2004. Microbiological Risk Assessment Series, No. 5, Technical Report. WHO, Rome.

Aurora, R., Prakash, A., Prakash, S., Rawool, D.B., Barbuddhe, S.B., 2008. Comparison of PI-PLC based assays and PCR along with *in-vivo* pathogenicity tests for rapid detection of pathogenic *Listeria monocytogenes*. Food Control 19, 641–647.

Barbuddhe, S.B., Malik, S.V.S., Kumar, P., 1999a. High seropositivity against anti-listeriolysin O in humans. Annals of Tropical Medicine and Parasitology 93, 537–539.

Barbuddhe, S.B., Malik, S.V.S., Bhatnagar, S., Gupta, L.K., 1999b. Cytotoxic T-cell, delayed type hypersensitive and anti-listeriolysin O responses in experimental bovine listeriosis. Veterinary Microbiology 64, 333–341.

Barbuddhe, S.B., Malik, S.V.S., Bhilegaonkar, K.N., Prahlad, K., Gupta, L.K., 2000. Isolation of *Listeria monocytogenes* and anti-listeriolysin O detection in sheep and goats. Small Ruminant Research 38, 151–155.

Barbuddhe, S.B., Chaudhari, S.P., Malik, S.V.S., 2002. The occurrence of pathogenic *Listeria monocytogenes* and antibodies against listeriolysin O in buffaloes. Journal of Veterinary Medicine B 49, 181–184.

Barbuddhe, S.B., Swain, B.K., Chakurkar, E.B., Sundaram, R.N.S., 2003. Microbial quality of poultry meat with special reference to *Listeria monocytogenes*. Indian Journal of Poultry Science 38, 305–307.

Barbuddhe, S.B., Malik, S.V.S., Rawool, D.B., 2004. *Listeria monocytogenes* and listeriosis in India: current status. Abstract 158, XI International Symposium on Problems of Listeriosis, September 12–15, 2004, Uppsala, Sweden.

Barbuddhe, S.B., Malik, S.V.S., Ashok Kumar, J., Kalorey, D.R., Kurkure, N.V., Rawool, D.B., Swain, B.K., Korikanthimath, V.S., Chakraborty, T., 2010. Foodborne listeriosis in India: an update. Abstract C/O/25, XII International Symposium on Problems of Listeriosis, May 5–8, 2010, Porto, Portugal.

Bashir, S., Mir, T., Khan, F.A., 1997. *Listeria monocytogenes* peritonitis; an ever-increasing problem: a case report a review of literature. JK Practioner 4, 192–193.

Bhilegaonkar, K.N., Kulshreshtha, S.B., Kapoor, K.N., Kumar, A., Agarwal, R.K., Singh, B.R., 1997. Isolation of *Listeria monocytogenes* from milk. Journal of Food Science and Technology 34, 248–250.

Bhujwala, R.A., Hingorani, V., 1975. Perinatal listeriosis: a bacteriological and serological study. The Indian Journal of Medical Research 63, 1503–1508.

Bhujwala, R.A., Hingorani, V., Chandra, R.K., 1973. Genital listeriosis in Delhi: a pilot study. The Indian Journal of Medical Research 61, 1284–1287.

Bramhabhatt, M.N., Anjaria, J.M., 1993. Analysis of market meats for possible contamination with *Listeria*. The Indian Journal of Animal Sciences 63, 687.

CDC, 2005. Preliminary FoodNet data on the incidence of infection with pathogens transmitted commonly through food in 10 Sites, United States, 2004. Morbidity Mortality Weekly Record 54, 352–356.

Chand, P., Sadana, J.R., 1998. Outbreak of *Listeria ivanovii* abortion in sheep in India. The Veterinary Record 145, 83–84.

Dash, P.K., Malik, S.V.S., Sharma, A.K., Paul, S., 1998. Management of circling syndrome in pigs. Indian Journal of Comparative Microbiology Immunology and Infectious Diseases 19, 102–103.

Dhanashree, B., Otta, S.K., Karunasagar, I., Goebel, W., Karunasagar, I., 2003. Incidence of *Listeria* spp. in clinical and food samples in Mangalore, India. Food Microbiology 20, 447–453.

Dhanda, M.R., Lall, J.M., Seth, R.N., Chandrasekhariah, P., 1959. A case of listeric abortion in an ewe with a smallscale survey of the incidence of agglutinins of *Listeria* in the sera of sheep. The Indian Veterinary Journal 36, 113–124.

Dhawan, K., Dhall, S.R., 1963. Role of listerial infections of the genital tract the causation of repeated abortions of chronic vaginal discharges. Journal of Obstetrics and Gynaecology of India 13, 499–503.

Dutta, P.K., Malik, B.S., 1981. Isolation and characterization of *Listeria monocytogenes* from animals and human beings. The Indian Journal of Animal Sciences 51, 1045–1052.

Elezebeth, G., Malik, S.V.S., Chaudhari, S.P., Barbuddhe, S.B., 2007. The occurrence of *Listeria* species and antibodies against listeriolysin-O in naturally infected goats. Small Ruminant Research 67, 173–178.

Esteban, J.I., Oporto, B., Gorka, A., Juste, R.A., Hurtado, A., 2009. Faecal shedding and strain diversity of *Listeria monocytogenes* in healthy ruminants and swine in Northern Spain. BMC Veterinary Research 5, 2.

Flemming, D.W., Cochi, S.L., Mackonald, K.L., Brondum, J., Hayes, P.S., Plikaytis, B.D., Holmes, M.B., Audurier, A., Broome, C.V., Reingold, A.L., 1985. Pasteurised milk as a vehicle of infection in an outbreak of listeriosis. The New England Journal of Medicine 312, 404–407.

Fuchs, R.S., Surendran, P.K., 1989. Incidence of *Listeria* in tropical fish and fishery products. Letters in Applied Microbiology 9, 49–51.

Fugett, E.B., Schoonmaker-Bopp, D., Dumas, N.B., Corby, J., Wiedmann, M., 2007. Pulsed-field gel electrophoresis (PFGE) analysis of temporally matched *Listeria monocytogenes* isolates from human clinical cases, foods, ruminant farms, and urban and natural environments reveals source-associated as well as widely distributed PFGE types. Journal of Clinical Microbiology 45, 865–873.

Gaya, P., Sanchez, J., Medina, M., Nunez, M., 1998. Incidence of *Listeria monocytogenes* and other *Listeria* species in raw milk produced in Spain. Food Microbiology 15, 551–555.

Gogate, A.A., Deodhar, L.P., 1981. Meningitis due to *Listeria monocytogenes*: (a case report). Journal of Postgraduate Medicine 27, 240–242.

Gomber, S., Revathi, G., Krishna, A., Gupta, A., 1998. Perinephric abscess (presenting as abdominal pain) due to *Listeria monocytogenes*. Annals of Tropical Paediatrics 18, 61–62.

Graves, L.M., Helsel, L.O., Steigerwalt, A.G., Morey, R.E., Daneshvar, M.I., Roof, S.E., Orsi, R.H., Fortes, E.D., Milillo, S.R., Den Bakker, H.C., Wiedmann, M., Swaminathan, B., Sauders, B.D., 2010. *Listeria marthii sp. nov.*, isolated from the natural environment, Finger Lakes National Forest. International Journal of Systematic and Evolutionary Microbiology 60, 1280–1288.

Guillet, C., Join-Lambert, O., Le Monnier, A., Leclercq, A., Mechaï, F., Mamzer-Bruneel, M.F., Bielecka, M.K., Scortti, M., Disson, O., Berche, P., Vazquez-Boland, J., Lortholary, O., Lecuit, M., 2010. Human listeriosis caused by *Listeria ivanovii*. Emerging Infectious Diseases 16, 136–138.

Gunjal, P.S., Kalorey, D.R., Barbuddhe, S.B., Motiani, R.K., Kurkure, N.V., 2007. PCR analysis of *Listeria monocytogenes* isolated from raw poultry meat. Abstract P-15, XVI International Symposium on Problems of Listeriosis, 20–23 March, 2007, Savannah, Georgia, USA.

Gupta, R., Chandra, R.K., Hingorani, V., 1997. Listeriosis: an opportunistic infection. Indian Paediatrics 34, 732–734.

Gupta, V., Gautam, V., Mehta, N., Kumari, I., Joshi, R.M., 2003. Listeriosis in second trimester of pregnancy: case report from India. Japanese Journal of Infectious Diseases 56, 60–61.

Jallewar, P.K., Kalorey, D.R., Kurkure, N.V., Pande, V.V., Barbuddhe, S.B., 2007. Genotypic characterization of *Listeria* spp. isolated from fresh water fish. International Journal of Food Microbiology 114, 120–123.

Jangam, A.K., Barbuddhe, S.B., Kalekar, S., Rodrigues, J., Chopade, N.A., Hain, T., Chakraborty, T., 2010. ILCD: an interactive *Listeria* culture diversity knowledgebase. Abstract E/P 179, XVII International Symposium on Problems of Listeriosis, May 5–8, 2010, Porto, Portugal.

Jayasekaran, G., Karunasagar, I., Karunasagar, I., 1996. Incidence of *Listeria* sp. in tropical fish. International Journal of Food Microbiology 31, 333–340.

Jensen, N.E., Aarestrup, F.M., Jensen, J., Wegener, H.C., 1996. *Listeria monocytogenes* in bovine mastitis. Possible implication for human health. International Journal of Food Microbiology 32, 209–216.

Kalorey, D.R., Kurkure, N.V., Warke, S.R., Rawool, D.B., Barbuddhe, S.B., 2008. *Listeria* species in bovine raw milk: a large survey of Central India. Food Control 19, 109–112.

Kalyani, M., Rajesh, P.K., Srikanth, P., Mallika, M., 2006. *Listeria monocytogenes* — a case report. Sri Ramchandra Journal of Medicine 1, 45–46.

Karunasagar, I., Karunasagar, I., 2000. *Listeria* in tropical fish and fishery products. International Journal of Food Microbiology 62, 177–181.

Karunasagar, I., Segar, K., Karunasagar, I., Goebel, W., 1992. Incidence of *Listeria* species in tropical seafoods. *Listeria* 1992. Abstract 155, XI International Symposium on Problems of Listeriosis, 11–14 May 1992, Copenhagen.

Kaur, S., Malik, S.V.S., Vaidya, V.M., Barbuddhe, S.B., 2007. *Listeria monocytogenes* in spontaneous abortions in humans and its detection by multiplex PCR. Journal of Applied Microbiology 103, 1889–1896.

Kaur, S., Malik, S.V.S., Bhilegaonkar, K.N., Vaidya, V.M., Barbuddhe, S.B., 2010. Use of a phospholipase-C assay, in vivo pathogenicity assays and PCR in assessing the virulence of *Listeria* spp. The Veterinary Journal 184, 366–370.

Klein, O.J., 2001. Bacterial sepsis and meningitis, In: Remington, S.J., Klein, O.J. (Eds.), Infectious Diseases of the Fetus and Newborn Infant, fifth ed. W.B. Saunders Company, Philadelphia, pp. 943–984.

Krishna, U., Desai, M.W., Daftary, V.G., 1966. Listeriosis: a clinico-bacteriological study. Journal of Obstetrics and Gynecology of India 16, 304–310.

Kumar, H., Singh, B.B., Bal, M.S., Kaur, K., Singh, R., Sidhu, P.K., Sandhu, K.S., 2007. Pathological and epidemiological investigations into listerial encephalitis in sheep. Small Ruminant Research 71, 293–297.

Leclercq, A., Clermont, D., Bizet, C., Grimont, P.A., Le Flèche-Matéos, A., Roche, S.M., Buchrieser, C., Cadet-Daniel, V., Le Monnier, A., Lecuit, M., Allerberger, F., 2010. *Listeria rocourtiae* sp. nov. International Journal of Systematic and Evolutionary Microbiology 60, 2210–2214.

Linnan, M.J., Nascola, L., Lou, X.D., Goulet, V., May, S., Salminen, C., Hird, D.W., Yonekura, M.L., Hayes, P., Weaver, R., 1988. Epidemic listeriosis associated with Mexican style cheese. The New England Journal of Medicine 319, 823–824.

Lorber, B., 1997. Listeriosis. Clinical Infectious Diseases 24, 1–9.

Lyytikainen, O., Autio, T., Maijala, R., Ruutu, P., Honkanen-Buzalski, T., Miettinen, M., Hatakka, M., Mikkola, J., Anttila, V.J., Johansson, T., Rantala, L., Aalto, T., Korkeala, H., Siitonen, A., 2000. An outbreak of *Listeria monocytogenes* serotype 3a infections from butter in Finland. The Journal of Infectious Diseases 181, 1838–1841.

Mahajan, A.K., Katoch, R.C., 1997. Aerobic microflora associated with endometritis in sheep and goats. The Indian Journal of Animal Sciences 67, 290–291.

Malik, S.V.S., Barbuddhe, S.B., Chaudhari, S.P., 2002. Listeric infections in humans and animals in Indian subcontinent: a review. Tropical Animal Health and Production 34, 359–381.

Manoj, Y.B., Rosalind, G.M., Karunasagar, I., Karunasagar, I., 1991. *Listeria* in fish and fish handling areas, Mangalore, India. Asian Fishery Science 4, 119–122.

McLauchlin, J., Mitchell, R.T., Smerdon, W.J., Jewell, K., 2004. *Listeria monocytogenes* and listeriosis: a review of hazard characterisation for use in microbiological risk assessment of foods. International Journal of Food Microbiology 92, 15–33.

Menudier, A., Bosiraud, C., Nicolas, J.A., 1991. Virulence of *Listeria monocytogenes* serovars and *Listeria* sp. in experimental infection in mice. Journal of Food Protection 54, 917–921.

Moharem, A.S., Charith Raj, A.P., Janardhana, G.R., 2007. Incidence of *Listeria species* in seafood products of Mysore, India. Journal of Food Safety 27, 362–372.

Mokta, K.K., Kanga, A.K., Kaushal, R.K., 2010. Neonatal listeriosis: a case report from sub-Himalayas. Indian Journal of Medical Microbiology 28, 385–387.

Nigam, P., Katoch, R.C., Sharma, M., Verma, S., 1999. Investigations on listeriosis associated with reproductive disorders of domestic animals in Himachal Pradesh. The Indian Journal of Animal Sciences 69, 171–173.

Nirni, S.S., Shukla, S.N., Shah, P.M., Patel, K.M., Anand, A.S., Parikh, B.J., Talati, S., Shah, S.A., Parekh, B.B., Panchal, H.P., Patel, A., Shah, B.A., Sharma, J.B., Tyagu, S., 2002. Study of various types of central venous catheters with respect to their complications. Indian Journal of Medicine and Pediatric Oncology 23, 21–24.

Pandit, L., Kumar, S., Karunasagar, I., Karunasagar, I., 2005. Diagnosis of partially treated culture-negative bacterial meningitis using 16S rRNA universal primers and restriction endonuclease digestion. Journal of Medical Microbiology 54, 539–542.

Parihar, V.S., Barbuddhe, S.B., Chakurkar, E.B., Danielson-Tham, M.-L., Tham, W., 2007. Isolation of *Listeria* species from farm bulk milk at the receiving dairy plant and cervico-vaginal samples from dairy cows. Indian Journal of Comparative Microbiology, Immunology and Infectious Diseases 28, 53–55.

Parihar, V.S., Barbuddhe, S.B., Danielsson-Tham, M.L., Tham, W., 2008. Isolation and characterization of *Listeria* species from tropical seafood. Food Control 19, 566–569.

Patil, N.A., Udupa, K.G., Kasaralikar, V.R., Prasanna, Kumar S., Rao, D.G.K., Barbuddhe, S.B., 1998. Listerial abortion and encephalitis in a buffalo. Buffalo Bulletin 17, 43.

Peer, M.A., Nasir, R.A., Kakru, D.K., Fomda, B.A., Wani, M.A., Hakeem, Q.N., 2010. *Listeria monocytogenes* meningoencephalitis in an immunocompetent, previously healthy 20-month old female child. Indian Journal of Medical Microbiology 28, 169–171.

Phadke, S.P., Bhagwat, S.V., Kapsikar, R.N., Gheveri, S.D., 1979. Listeriosis in sheep and goats in Maharashtra. The Indian Veterinary Journal 56, 634–637.

Raghuraman, T.S., Rupnarayan, R., 1988. Listeriosis. Medical Journal of Armed Forces, India 44, 245–246.

Rahman, T., Sarma, D.K., Goswami, B.K., Upadhyaya, T.N., Choudhary, B., 1985. Occurrence of listerial meningoencephalitis in pigs. The Indian Veterinary Journal 62, 7–9.

Rawool, D.B., Malik, S.V.S., Shakuntala, I., Sahare, A.M., Barbuddhe, S.B., 2007. Detection of multiple virulence associated genes in pathogenic *Listeria monocytogenes* from bovines with mastitis. International Journal of Food Microbiology 113, 201–207.

Rekha, V.B., Malik, S.V.S., Chaudhari, S.P., Barbuddhe, S.B., 2006. Listeriolysin O-based diagnosis of *Listeria monocytogenes* infection in experimentally and naturally infected goats. Small Ruminant Research 66, 70–75.

Revathi, G., Suneja, A., Talwar, V., Aggarwal, N., 1995. Fatal pericarditis due to *Listeria monocytogenes*. European Journal of Clinical Microbiology and Infectious Diseases 14, 254–255.

Ryser, E.T., Marth, E.H., 1991. *Listeria*, Listeriosis and Food Safety. Marcel Dekker, Inc, New York.

Schlech III, W.F., 2000. Foodborne listeriosis. Clinical Infectious Diseases 31, 770–775.

Schlech III, W.F., Lavigne, P.M., Bortolussi, R.A., Allen, A.C., Haldane, E.V., Wort, A.J., Hightower, A.W., Johnson, S.E., King, S.H., Nicholls, E.S., Broome, C.V., 1983. Epidemic listeriosis—evidence for transmission by food. The New England Journal of Medicine 308, 203–206.

Scotter, S.L., Langton, S., Lombard, B., Schulten, S., Nagelkerke, N., In't Veld, P.H., Rollier, P., Lahellec, C., 2001a. Validation of ISO method 11290 part 1 — detection of *Listeria monocytogenes* in foods. International Journal of Food Microbiology 64, 295–306.

Scotter, S.L., Langton, S., Lombard, B., Lahellec, C., Schulten, S., Nagelkerke, N., In't Veld, P.H., Rollier, P., 2001b. Validation of ISO method 11290 part 2 — enumeration of *Listeria monocytogenes* in foods. International Journal of Food Microbiology 70, 121–129.

Shah, N.M., Dholakia, P.M., 1983. Microflora of the cervicovaginal mucus of Surti buffaloes and their drug resistance pattern. The Indian Journal of Animal Sciences 53, 147–150.

Shakuntala, I., Malik, S.V.S., Barbuddhe, S.B., Rawool, D.B., 2006. Isolation of Isolation of *Listeria monocytogenes* from buffaloes with reproductive disorders and its confirmation by polymerase chain reaction. Veterinary Microbiology 117, 229–234.

Sharda, R., Moghe, M.N., Tanwani, S.K., 1991. Antibiotic sensitivity pattern of bacteria isolated from repeat breeding animals. Indian Veterinary Journal 68, 197–200.

Sharma, M., Batta, M.K., Katoch, R.C., Asrani, R.K., Nagal, K.B., Joshi, V.B., Sharma, M., 1996. *Listeria monocytogenes* abortions among migratory sheep and goats in Himachal Pradesh. The Indian Journal of Animal Sciences 66, 1117–1119.

Siegman-Igra, Y., Levin, R., Weinberger, M., Golan, Y., Schwartz, D., Samra, Z., Konigsberger, H., Yinnon, A., Rahav, G., Keller, N., Bisharat, N., Karpuch, J., Finkelstein, R., Alkan, M., Landau, Z., Novilov, J., Hassin, D., Rudnicki, C., Kitzes, R., Ovadia, S., Shimoni, Z., Lang, R., Shohat, T., 2000. *Listeria monocytogenes* infection in Israel and review of cases worldwide. Emerging Infectious Diseases 8, 305–310.

Srivastava, N.C., Gupta, S.K., Uppal, P.K., 1985. *Listeria monocytogenes* infection in infertile cows. The Indian Veterinary Journal 62, 545–547.

Srivastava, S., Sen, M.R., Kumar, A., Anuprabha, S., 2005. Neonatal listeriosis. Indian Journal of Pediatrics 72, 1059–1060.

Stephen, S., Indrani, R., Achyutha Rao, K.N., Padma Rao, A., 1978. Listeriosis and human abortions — including a review of literature. Journal of Obstetrics and Gynecology of India 28, 497–501.

Swaminathan, B., Gerner-Smidt, P., 2007. The epidemiology of human listeriosis. Microbes and Infection 9, 1236–1243.

Thomas, A., Verma, I.C., Singh, M., Bhujwala, R.A., 1981. Study of neonatal listeriosis in North India. The Indian Journal of Medical Research 73, 28–32.

Uppal, P.K., Srivastava, N.C., Kumar, A.A., Rao, S.H., 1981. Isolation of *Listeria monocytogenes* form neurological disturbances in buffalo. Indian Journal of Comparative Microbiology Immunology and Infectious Diseases 2, 16–18.

Vijayakrishna, S., Venkata Reddy, T., Varalakshmi, K., Subramanyam, K.V., 2000. Listeriosis in broiler chicken. The Indian Veterinary Journal 77, 285–286.

Vishwanathan, K.R., Uppal, P.K., 1981. Isolation of *Listeria* from sheep. Journal of Remount and Veterinary Corps 20, 127–130.