

## Review Article

# MYCOPLASMAS OF ZONOTIC SIGNIFICANCE

D.N.GARG\*

Former Dean and Addl. Director Research  
College of Veterinary Sciences  
C.C.S. Haryana Agricultural University  
Hisar-125 004, Haryana, India

## 1. INTRODUCTION

Mycoplasmas are smallest and wall-less prokaryotes capable of self-replication, taxonomically, belong to class Mollicutes (meaning soft skin). The term 'Mollicutes' or 'Mycoplasma' is now used interchangeably to denote any species included in the four orders, five families, eight genera and about 200 species of mollicutes. However, in this article the term 'mycoplasma' and 'acholeplasma' are used to describe members of the genera *Mycoplasma* and *Acholeplasma*, respectively. Many mollicutes cause significant diseases in man, animals and plants. The importance of mycoplasmas in human and animal infections has accentuated with recent reporting of instances of human infections with animal mycoplasmas and *vice-versa* leading to recognition of zoonotic mycoplasmoses. The slow reporting of zoonotic mycoplasmoses can be attributed mainly to difficulty in measuring zoonotic potential of mycoplasmoses as in some other diseases *viz.* multiple sclerosis, rheumatoid arthritis, leukemia, atherosclerosis, chronic fatigue syndrome, CJD, Crohn's colitis *etc.* In this paper, an attempt has been made to collect and collate the available literature in order to provide the current status of possible zoonotic mycoplasmas and mycoplasmoses.

### 1.1 CONCEPT OF ZONOTIC MYCOPLASMOSES

Zoonotic mycoplasmoses may best be defined as sharing of mycoplasma infections, which are naturally transmitted between vertebrate animals and man. This kind of sharing occurs under natural conditions permitting bidirectional movement of mycoplasmas and is not based on experimental evidence of occurrence.

Mycoplasma infections are zoonotic; man acting as mycoplasma reservoir for animals is **zooanthroponotic mycoplasmosis**; animals acting as reservoir for human mycoplasma is **anthropozoonotic mycoplasmosis** and, the inter-transferable mycoplasma between man and animals and vice-versa are referred as **amphizoonotic mycoplasmosis**. The concept of zoonotic mycoplasmosis is new and, so far, eight species in the genus *Mycoplasma* (family *Mycoplasmataceae*) and two species of the genus *Acholeplasma* (family *Acholeplasmataceae*) can be claimed as zoonotic. No other mollicutes including ureaplasma, aneroplasma and asteroplasma have been recorded as zoonotic.

---

\*Correspondence address: H.N. 227-P, Sector-15A, Hisar-125 001, Haryana, India  
Mobile: 098960 12864, Email: dng2660@yahoo.in

## 2. ZOOANTHROPOZOONOTIC MYCOLASMAS

In humans, mycoplasmas, acholeplasmas and ureaplasmas are mucosal associated, residing predominantly in the respiratory and urogenital tract. Till now, 13 species in the genus *Mycoplasma*, 2 in the genus *Acholeplasma* and 1 in the genus *Ureaplasma* have been isolated from humans. Out of these only 2 *Mycoplasma* species viz. *M. pneumoniae*, *M. salivarium* have been recorded as zoonthropozoonotic, which are mentioned briefly.

### 2.1 *Mycoplasma pneumoniae* ( Type strain: ATCC 15531, NCTC 10119 )

*Mycoplasma pneumoniae* was first identified and described in the early 1960s. Primary site of colonization of *M. pneumoniae* is oropharynx and is pathogenic to humans. The pneumonia is designated 'primary atypical' to distinguish it from ' typical' pneumonia due to *Streptococcus pneumoniae*, the pneumococcus. A detailed definition of epidemiology of *M. pneumoniae* disease has emerged ( Lind and Bentzon, 1988 ). Attack rate is low and disease spreads slowly in communities with close contact among their members. Transmission by droplets require a rather high inoculum unless the host is immunocompromised.

A zoonotic outbreak of *M. pneumoniae* infection in a class of a Budapest secondary school has been reported (Mikola *et al.*, 1997). Thirty students became feverish and upper respiratory tract catarrh. When 2 were hospitalized with pneumonia, a mycoplasma infection was confirmed by cold agglutination test. Their classroom contained a terrarium with hamsters, from which *M. pneumoniae* was isolated.

### 2.2 *Mycoplasma salivarium* ( Type strain: ATCC 23064, NCTC 10113 )

*Mycoplasma salivarium* exists as commensal organisms in the oropharynx of human and nonhuman primates. Pathogenicity of *M. salivarium* is not known. However, isolation of the organism with a significantly higher incidence from the gingival sulci of individuals with periodontal disease (87%) than in persons with healthy periodentium (32%) has stimulated interest in its possible role in periodontal pathology (Engel and Kenny, 1970; Forest, 1979). Also it is the predominant mycoplasma species in dental plaques. Likewise, this organism has been identified as a causative agent of septic arthritis in hypogammaglobulinaemia ( So *et al.*, 1983 ).

*M. salivarium*, usually confined to humans or other primates, was repeatedly isolated from nasal and pharyngeal secretions of swine (Erickson *et al.*, 1988). It has also been isolated from the tonsils of 3 horses (Poland and Lemcke, 1978). *Mycoplasma salivarium* is neither a true equine nor porcine mycoplasma and thus might have been acquired by them from their environmental companion. No further report came on this account.

#### *Comment*

*Mycoplasma pneumoniae* organisms are usually confined to humans, which is the only natural host of *M. pneumoniae*. *Mycoplasma salivarium* is a common parasitic inhabitant of the oropharynx of human and nonhuman primates. The isolation reports of *M. pneumoniae* from hamsters in the reported zoonotic outbreak (Mikola *et al.*, 1997) and *M. salivarium* from horses (Poland and Lemcke, 1978) and swine (Erickson *et al.*, 1988) were preliminary. Whether these were zoonthropozoonotic was not proved conclusively.

### 3. ANTHROPOZOONOTIC MYCOLASMAS

Numerous mycoplasmas are known to exist as animal pathogens (Ross, 1993), opportunist and as nonpathogenic. However, only a few, as described briefly below, have taken a zoonotic route.

#### 3.1 *Mycoplasma arthritidis* ( Type strain: ATCC 19611, NCTC 10162 )

*Mycoplasma arthritidis* is a common pathogen of laboratory and wild rats causing purulent polyarthritis, sometimes occurring as localized outbreaks in stocks of laboratory rats. Also, isolated repeatedly from apparently healthy rats.

Between 1948 and 1965, several mycoplasma strains were isolated from human urogenital tract and synovial tissues in laboratories at widely diverse geographical locations. These organisms did not relate to other known human mycoplasmas but were designated as *M. hominis* type 2. Later these strains were reclassified as *M. arthritidis* (Lemcke, 1965). The justification of this reclassification was subsequently confirmed by nucleic acid homology, by enzyme analysis and by examination of electrophoretic patterns of the cell proteins of these strains. No subsequent isolates of the organism from human tissues have been reported and no adequate role in human disease has been documented.

#### *Comment*

*Mycoplasma arthritidis* is causative agent of chronic proliferative arthritis of rodents and possess superantigen called MAM (*M. arthritidis* mitogen). It is the only mycoplasma species which has been demonstrated to induce differentiation of mouse lymphocytes into cytotoxic / suppressor effector cells. Arthritogenic potential of some mycoplasmas led to speculations concerning their role in human rheumatoid arthritis. Besides, the earlier isolations of *M. arthritidis* from synovial tissues, numerous other investigations over the past 4 decades have either failed to isolate mycoplasmas or have resulted in inconsistent findings.

#### 3.2 *Mycoplasma canis* ( Type strain: ATCC 19525, NCTC 10146 )

*Mycoplasma canis* is found as a common parasitic inhabitant of the mucous membrane of upper respiratory tract, conjunctivae and genitals of dogs. It has also been isolated occasionally from nonhuman primates.

Several strains of *M. canis* were isolated from the oropharynx of members of a family at the time when their dog had an acute respiratory disease infection. (Armstrong *et al.*,1971). Although one member of the family was taking immunosuppressant, the pathogenic role of *M. canis* in human disease was neither established nor the dynamics of zoonotic transfer of *M. canis* studied.

#### *Comment*

Pathogenicity of *M. canis* is not known under natural and experimental conditions. Experimentally, a strain isolated from the pericardium of a dog did not produce any

lesion in dogs and small rodents. Thus, the zoonotic transfer of *M. canis* may be regarded as of no public health significance.

### **3.3 *Mycoplasma bovis* ( Type strain: ATCC 25523, NCTC 10131 )**

*Mycoplasma bovis* is a potential bovine pathogen causing mastitis, pneumonia, arthritis and genital disorders (Pfutzner and Sachse, 1996). Once established in a herd, the organism persists and may become endemic; producing mastitis in dairy herd. Madoff *et al.* (1979) have reported the isolation of *M. bovis* from sputum of a woman with lobar pneumonia.

#### *Comment*

The significance of frequent isolations of *M. bovis* from respiratory tract of cattle with respiratory disease is yet to be resolved though the incidence of pneumonia due to *M. bovis* can be as high as 100 % ( Pfutzner, 1990). *Mycoplasma bovis* infection may spread by aerosol, which may be a logic way of its transmission to human in the case reported by Madoff *et al.* (1979). The possibility of transfer of *M. bovis* via consumption of infected bovine-milk is an another possibility as this organism appears more invasive and may cause septicaemia.

### **3.4 *Mycoplasma arginini* ( Type strain: ATCC 23838, NCTC 10129 )**

*Mycoplasma arginini* is a mammalian parasite with an apparently wide host range. It is found with a high frequency in the respiratory tract and less frequently in the conjunctivae and genital tract of sheep, goats and cattle. Occasionally, isolations have also been reported from pigs, horses, dogs, domestic and wild cats. It is also frequently isolated from bovine serum used in tissue culture.

A septicaemic infection caused by *M. arginini* in a patient with advanced Hodgkin's disease and marked immunodeficiency emphasizes the potentially heightened risk to immunocompromised hosts with mollicutes of both human and nonhuman organisms (Yechouron *et al.*,1992). This organism was repeatedly isolated from the blood and bronchial washings of a patient during the course of the disease. *M. arginini*, commonly found in a variety of species of large animals, was thought to have been acquired by the patient during his work as a slaughter-house employee.

Prayson *et al.* (2008) have recently reported isolation of *M.arginini* from an unusual case of deep infection of open femur fracture in a 56-year hunter; organisms identified at CDC, Georgia after extensive DNA testing. The hunter had an attack of African lion causing crushing bite leading to open femur fracture and after some time bone culture was found positive for *M.arginini*. Authors put the theory that the lion had fed on goat prior to the attack on hunter resulting in deep tissue inoculation of *M. arginini*.

#### *Comment*

Evidence that *M. arginini* is pathogenic for animals and man are yet to be presented. However, the circumstantial evidence in the cases reported so far (Yechouron *et al.*1992; Prayson *et al.*, 2008) suggests the zoonotic transfer and pathogenic role of *M. arginini*.

### 3.5 *Mycoplasma felis* ( Type strain: ATCC 23391 , NCTC 10160 )

*Mycoplasma felis* is a common parasitic inhabitant of the upper respiratory and lower genital tract of asymptomatic and diseased cats. Strains related to *M. felis* have also been isolated frequently from tonsils and other regions of respiratory tract of healthy and diseased horses.

*Mycoplasma felis* is associated with conjunctivitis in cats, being isolated significantly more frequently from the conjunctivae of diseased cats than in the convalescent or healthy cats.

Bonilla *et al.* (1997) described first documented case of *M. felis* infection in a women who had common variable immune deficiency and who presented with septic arthritis of the left hip and right knee. *Mycoplasma felis* was isolated from both the joints. She has been exposed to cat before the diagnosis of *M. felis* septic arthritis was made.

#### *Comment*

Evidences so far that the *M. felis* is pathogenic are inconclusive though conjunctivitis can be experimentally induced in cats. Prevalence of *M. felis* in oligoarthritis patients exposed to cats, the possible role of *M. felis* as arthritogenic agent and the routes as well as risk of transmission is under investigation.

### 3.6 *Mycoplasma edwardii* ( Type strain: ATCC 23462 , NCTC 10132 )

*M. edwardii* is frequently found in the upper respiratory and urogenital tracts of male and female dogs. It has also been isolated from shrews. *M.edwardii* is recently reported from septicaemic infection in a patient with advanced acquired immuno-deficiency syndrome (AIDS). Baseman and Tully (1997) have reported this as a personal communication by M.KYork.

#### *Comment*

It's pathogenicity is not known although occasionally isolated from pneumonic lungs of dogs, and recently has been reported from an advanced case of AIDS.

### 3.7 *Mycoplasma sp.* (Strain M 7806 )

McCabe *et al.* (1987) described a mycoplasma infection on the hands of a veterinarian. acquired through a cat-bite The infection resulted in severe soft tissue cellulitis with tissue destruction sufficient to require a tendon graft. The organism (strain M 7806) was identified as an unclassified, glucose-fermenting *Mycoplasma* species. Although other serologically related strains were later isolated from the oropharynx of feline, the organism has remained unclassified.

#### *Comment*

This unclassified strain of *Mycoplasma* has never been isolated subsequently either from human or animals. Therefore, no comment can be offered about its pathogenic, epidemiologic and zoonotic potential.

#### 4. AMPHIZOONOTIC ACHOLEPLASMAS

Currently, 13 species of *Acholeplasma* exist in nature, which are apparent parasites of vertebrate hosts. Only two species viz. *A. laidlawii* and *A. oculi*, are commonly isolated from diseased sites of various animals and humans. These are described briefly.

##### 4.1 *Acholeplasma laidlawii* ( Type strain: ATCC 23206, NCTC 10116 )

*Acholeplasma laidlawii* was originally isolated from sewage, manure, humus and soil but its designation as true saprophyte was challenged later by its occurrence in mammals and birds. It is frequently recovered from oral cavity, respiratory and genital tract secretions, eye, lymphnodes, semen and serum. Its pathogenicity has not been well established, although some strains are lethal for chicken embryos. A limited number of *A. laidlawii* strains have been isolated from oral cavity (Razin *et al.*, 1964) and from flora of human burns (Markham and Markham, 1969).

##### *Comment*

As *A. laidlawii* is abundantly isolated from a wide variety of syndrome in man and animals, it looks like a perfect example of amphizoonosis; being freely transmitted between man and animals. A fresh look to *A. laidlawii* is required for its possible potential role when it is found associated with diseased hosts.

##### 4.2 *Acholeplasma oculi* ( Type strain: ATCC 27350, NCTC 10150 )

*Acholeplasma oculi* has been isolated from conjunctivae of goats with keratoconjunctivitis, nasal secretions of porcines, nasopharynx, lungs, spinal fluid, joints, and semen of equines and external genitals of guinea pigs. Experimentally, it has been shown to produce conjunctivitis, pneumonia and death in goats.

A single isolate of *A. oculi* was cultured from amniotic fluid at 19 weeks of gestation (Waites *et al.*, 1987). Its identification by direct immunofluorescence appeared to preclude contamination. The remainder of pregnancy in question was unremarkable and a full term infant was delivered without any complication.

##### *Comment*

Pathogenicity of *A. oculi* can not be ignored. However, in absence of any record of proven virulence, it is not wise to draw any conclusion as to its zoonotic potential.

#### 5. DETECTION OF ZOONOTIC MYCOPLASMA

Details of media, cultural conditions and other requirements for isolation and identification of mollicutes are available in the literature ( Razin and Tully, 1995; Tully and Razin, 1995 ). The current biotechnological approach to laboratory diagnosis of mollicutes infection has also been described earlier by Garg ( 1993 ).

Differential characteristics of zoonotic species of genus *Mycoplasma* and *Acholeplasma* so far recorded are given the Table. Final identification, however, depends on determination of serological relatedness, for which commonly used methods viz. growth inhibition, direct or indirect immunofluorescence and/or metabolic inhibition tests are available. Rapid detection for quick diagnosis of zoonotic mycoplasmas and prevent

severe consequences in affected humans and animals seems essential. Although culture is well adapted to most but not all species of zoonotic mycoplasmas listed in this paper. Thus, many methods for direct (DNA probes, rDNA) and amplified detection of mycoplasmas (PCR) of possible zoonotic significance are used currently. Reviews on use of diagnostic DNA probes and PCR for mycoplasma are available (Razin *et al.*, 1987; Johansson, 1993; Razin, 1994).

**Table:1. Differential characteristics of zoonotic species of *Mycoplasma* and *Acholeplasma***

Mollicutes organism	Gl	Ma	Arg	Phos	Film, Spot	Tet A/an	Gel	SD	CD	H	G+C MoI%
<i>Mycoplasma</i>											
<i>M.arginini</i>	-	-	+	-	-	-/+		-		-	27.6-28.6
<i>M.arthritis</i>	-	-	+	-		-/-	+	-	-	-	30.03-2.6
<i>M.bovis</i>	-	-	-	+	d	+/+		-	-	x	27.8-32.9
<i>M.canis</i>	+	-	-	-	-	-/+	D	-	-	+	28.4-29.1
<i>M.felis</i>	+	-	-	+	+	-/+	-	-	-	-	25.2
<i>M.edwardii</i>	+	-	-	-	+	-/+	-	-		-	29.2
<i>M.salivarium</i>	-	-	+	-	+	-/w	-	-	-	-	27.3-31.4
M.sp. (Str.M 7806)	+										
<i>Acholeplasma</i>											
<i>A.laidlawii</i>	+		-	-		w/+	D	-	-	-	31.0-36.0
<i>A.oculi</i>	+		-			+/+					26.0-27.0

Notes: += 90 % or more strains are positive, - = 90 % or more strains are negative, d = 11 to 90% strains are positive, x= not definitely settled, Gl=glucose catabolization, Ma=mannose, Arg= arginine deimination, Phos= phosphatase, Tet=tetrazolium reduction, A/An=aerobic/anerobic, Gel=gelatin hydrolysis, SD=coagulated serum digestion, CD=casein digestion, H= haemadsorption, the test performed with RBC from species from which mycoplasma originated plus guinea pig (sometimes with a variety RBC)

Rapid detection of *M. pneumoniae* antigen (total antigen, P1 adhesin or glycolipids) includes direct immunofluorescence, counter-immuno-electrophoresis, immunoblotting and antigen capture enzyme immunoassay (EIA). Detection of *M. pneumoniae* by probing for specific nucleotide sequence by primers of P1 or cytoadhesin gene with product identified by dot-blot-hybridization (DBH) following PCR amplification (P1-PCR-DBH-Assay).

Amongst other zoonotic mycoplasmas, available rapid detection systems are : a PCR diagnosis for *M arthritis* (Van Kupperveld *et al.*, 1992); an antigen capture ELISA using monoclonal antibodies (Heller *et al.*, 1993); a DNA probe ( Hotzel *et al.*, 1993) and PCR system based on amplification of 16S rRNA gene for *M. bovis* (Chavez Gonzalez *et*

al, 1995), an immunoenzyme assay using MOAb and streptavidin-biotin detection for *M. arginini*, *M. salivarium*, *A. laidlawii* (BRL, Maryland, USA), DNA probes to detect either mycoplasmal DNA or mycoplasmal rRNA and 16S rRNA based PCR for *M. arginini*, *M. salivarium*, *A. laidlawii* (Gobel and Stanbridge, 1984. Razin *et al.*, 1984, Mattson and Johansson, 1993; Teysson *et al.*, 1993). However, such fast detection methods are neither available for *M. canis* nor for *A. oculi* providing scope for research on this account.

## 6. ZONOTIC MYCOPLASMOSES: OBSTACLES AND PROPOSALS

Is zoonotic mycoplasmoses emerging ? should microbiological examination of foods viz. meat, milk and their product include their screening for mycoplasmas ? Answer to such question has been provided reasonably by Garg and Singh ( 2009 ) in a recent paper. Though the available reports on zoonotic mycoplasmoses are limited but it appears that it is just waiting to happen at the verge of emergence.

Obstacles in the way of recognition of zoonotic mycoplasmoses includes: i). absence of specific or distinguishable clinical sign in the affected individuals (s) or difficulty in diagnosing healthy or convalescent carriers capable of transmitting zoonotic mycoplasmas, and ii). lack of training to recognize the pathogenic mycoplasmas. Presently, zoonotic aspects are beginning to surface at the hands of those expertising in mycoplasma work. Our human or veterinary clinical or diagnostic laboratories are not yet ready to diagnose mycoplasmal infections, either in man or in animals. Thus, laboratory training in mycoplasma work increasing the competency of medical and veterinary diagnosticians will flip the reporting of zoonotic occurrence of mycoplasmas. Fastidious nature of mollicutes is reflected in slow cultivation, identification and diagnostic procedures. Recently developed molecular methods viz. nucleic acid probes/ PCR, 16S rRNA sequence analysis, molecular based ELISA have certainly obviated the need to cultivate and identify mollicutes organisms. These sophisticated and fast methods, however, are usually applied in research laboratories and remain limited there. Unless these methods are routinely used by diagnosticians, slow reporting of zoonotic mycoplasmoses will continue. Development of diagnostic kit and their commercial availability will go a long way; leading to mounted occurrence of zoonotic mycoplasmas helping to understand the epidemiological linkages viz. transmission path, geographic locations of zoonotic mycoplasmoses.

It is assumed that mycoplasma, being Gram-negative, in large numbers in foods could lead to some sporadic or outbreaks of food-borne gastroenteritis, which remains undiagnosed etiologically. As mycoplasmas do not grow on conventional SPC plating media and limulus amoebocyte lysate (LAL) as screen test for endotoxin or mycoplasmological examination is not used routinely, it will be a wise step to introduce such tests in food analysis/ public health laboratories so as to define the possible association of mycoplasma with contaminated foods.

## 7. CONCLUSIONS

Emerging zoonotic mycoplasmoses is a direct challenge to veterinary and medical profession. So far, it has occurred in the form of an out break and a few sporadic incidences only; all being occupational zoonoses and involvement of a veterinarian in the life cycle of mycoplasma is incidental or accidental as dead end host. Zoonotic mycoplasmas and acholeplasmas recorded so far include; *M. pneumoniae*, *M. salivarium*, *M. arthritidis*, *M. canis*, *M. bovis*, *M. arginini*, *A. laidlawii* and *A. oculi*. This list of zoonotic mycoplasma may possibly extend in future. The recorded reports support the apparent transmission of animal mollicutes to human and *vice-versa*. Immediate concern is where serious clinical infections in human have occurred with a fatal outcome from apparently animal derived mollicute. The slow reporting of zoonotic mycoplasmoses is possible to circumvent if only diagnostic mycoplasma antigen and antisera as well as rapid molecular tests ( nucleic acid probes/ PCR, 16S rRNA sequence analysis, MOAb-ELISA ) as kits are made available commercially. Till now, a few reports on zoonotic mycoplasmas provide only incomplete and inconclusive information. Generation of competent human resource capable to work with mycoplasma-biotechnology is a prerequisite to increase the capability of diagnostic laboratories for diagnosis of mycoplasmoses. Aim to diagnose zoonotic mycoplasmoses should always be directed to gather information on involved transmission vehicles and routes, ecological parameters as well as on spatial and temporal distribution. All this will provide better understanding of hidden aspects of zoonotic mycoplasmas / zoonotic mycoplasmoses.

## 8. REFERENCES

- Armstrong, D. Yu, B.H., Yagoda, A. and Kagnoff, M.F. (1971). Colonization of humans by *Mycoplasma canis*. *J. Infect. Dis.* **124**: 607-609.i ). pp. 164-174.
- Baseman, J.B. and Tully, J.G. (1997). Mycoplasmas: Sophisticated, reemerging and burdened by their notoriety. *Emer. Infect.Dis.* **3**: 21-32.
- Bonilla, H.F., Chenoweth, C.E., Tully, J.G., Blythe, L.K., Robertson, J.A. and Kauffman, C.A.(1997). *Mycoplasma felis* septic arthritis in a patient with hypogammaglobulinemia. *Clin. Infect. Dis.* **24**: 222-225.
- Chavez Gonzalez, Y. R., Bascunana, C. R., Bolske, G., Mattsson, J. G., Molina, C.F. and Johansson, K-E. (1995). *In-Vitro* amplification of the 16S rRNA genes from *Mycoplasma bovis* and *Mycoplasma agalactiae* by PCR. *Vet. Microbiol.* **47** : 183-190.
- Engel, L. D. and Kenny, G. E. (1970). *Mycoplasma salivarium* in human gingival sulci. *J. Periodon. Res.* **5** : 1- 9.
- Erickson, B. Z., Ross, R. F. and Bove, J. M. (1988). Isolation of *Mycoplasma salivarium* from swine. *Vet. Micrbiol.* **16**: 385-390.
- Forest, N. (1979). Caracterisation de *Mycoplasma salivarium* dans les parodontopathies. *J. Biol. Buccale.* **7** : 321-330.
- Garg, D. N. (1993). Current biotechnological approaches to laboratory diagnosis of to laboratory diagnosis of molecules infection. In : Srivastava, Prasad, Kalra, Gupta (Eds.) *Anmal Health Biotechnology.* ( Arvin Printing Press, New Delhi) pp. 164-174.

- Garg, D. N. and Singh, Y. (2009). Zoonotic mycoplasmoses : Waiting to happen. In : Singh, Funk, Tripathi, Joshi (Eds.) Food Safety Quality Assurance and Global Trade : Concerns and Strategies ( Int. Book Dist. Coy., Lucknow, India ). pp. 167-172.
- Gobel, U. B. and Stanbridge, E. J. (1984). Cloned mycoplasma ribosomal RNA genes for detection of mycoplasma contamination in tissue cultures. *Science*. **226** : 1211-1213.
- Heller, M, Berthold, E., Pflutzner, H. Leirer, R. and Sachse, K. (1993). Antigen capture ELISA using a monoclonal antibody for detection of *Mycoplasma bovis* in milk. *Vet. Microbiol.* **37**: 127-133.
- Hotzel, H., Dermuth, B., Sachse, K, Pflitsch, A. and Pflutzner, H. (1993). Detection of *Mycoplasma bovis* using *in-vitro* deoxyribonucleic acid amplification. *Rev. Sci. Tech. Off. Int. Epizl.* **12** : 581- 591.
- Johansson, K-E., (1993). Detection and identification of mycoplasmas with diagnostic DNA probes complimentary to ribosomal RNA. In : Khane, Adoni ( Eds. ). *Rapid Diagnosis of Mycoplasmas.* (Plenum Press, NewYork ). pp. 139-154.
- Lemcke, R. M. (1965). A serological comparison of various species of *Mycoplasma* by an agar gel double-diffusion technique. *J. Gen. Microbiol.* **38**: 91-100.
- Lind, K. and Bentzon, M. W. (1988). Changes in the epidemiological pattern of *Mycoplasma pneumoniae* infections in Denmark : a 30 years survey. *Epidemiol. Infect.* **101** : 377-386.
- Madoff, S., Pixley, B. Q., Del Guidice, R. A. and Modelling, Jr. (1979). Isolation of *Mycoplasma bovis* from a patient with systemic illness. *J. Clin. Microbiol.* **9**:709-711.
- Markham, J.G. and Markham, N. P. (1969). *Mycoplasma laidlawii* in human burns. *J. Bacteriol.* **98** : 827-828.
- Mattson, J. G. and Johnsson, K-E. (1993). Oligonucleotide probes complimentary to 16S rRNA for rapid detection of mycoplasma contamination in cell cultures. *FEMS Microbiol. Lett.* **107** : 139-144.
- McCabe, S J., Murray, J. F., Ruhnke, H. L. and Rachlis, A. (1987). *Mycoplasma* infection of the hand acquired from a cat. *J. Hand. Surg.* **12A** :1085-1088.
- Mikola, I., Balogh, G. Nagg, A., Matyas, M., Rady, M., Glavits, R. and Stipkovits, L. (1997). Zoonotic outbreak of *Mycoplasma pneumoniae* infection. *Magyar allatorvosok Lapja.* **119**: 403-405.
- Pflutzner, H. (1990). Epizootiology of *Mycoplasma bovis* infection in cattle. *Zbl. Bakt. (suppl)* : **20** 394-399.
- Pflutzner, H. and Sachse, K. (1996). *Mycoplasma bovis* as an agent of mastitis, pneumonia, arthritis and genital disorders in cattle. *Rev. Sci. Tech. Off. Int. Epiz.* **15**:1477-1494.
- Poland, J. and Lemcke, R. (1978). Mycoplasmas of the respiratory tract of horses and their significance in upper respiratory tract disease. *Proc. 4<sup>th</sup> Int. Cong. On Equine Infect. Dis. Lyon. J. Equine Med. Surg. (Suppl.)* **1** : 437-446.
- Prayson, M.J., Venkatarryappa, I, Srivastava, M., Northern, I. and Burdette, S.D. (2008). Deep infection with *Mycoplasma arginini* in an open femur fracture secondary to an African lion bite : A case report. *Injury Extra.* **39**:243-246.

- Razin, S. (1994). DNA probes and PCR in diagnosis of mycoplasma infections. *Mol. Cell. Probes*. **8** : 497-511.
- Razin, S. and Tully, J. G. (1995). *Molecular and Diagnostic Procedures in Mycoplasmology*. Vol. I. Molecular characterization (Academic Press, New York).
- Razin, S., Gross, M., Wormser, M., Pollack, Y. and Glaser, G. (1984). Detection of mycoplasmas infecting cell cultures by DNA hybridization. *In Vitro*. **20**: 404-408.
- Razin, S., Hyman, H. C., Nur, I and Yogev, D. (1987). DNA probes for detection and identification of mycoplasmas. *Isr. J. Med. Sci.* **23** : 735-741.
- Razin, S., Michmann, J. and Shimshoni, Z. (1964). The occurrence of mycoplasma pleuropneumonia like organisms (PPLO) in the oral cavity of dentulous and edentulous subjects. *J. Dent. Res.* **43**: 402-405.
- Ross, R. F. (1993). *Mycoplasmas : Animal pathogens*. In: Khane, Adoni (Eds.). *Rapid Diagnosis of Mycoplasmas*. (Plenum Press, New York). pp. 69-109.
- So, A. K. L., Furr, P. M., Taylor-Robinson, D., Webster, A.D. B. (1983). Arthritis caused by *Mycoplasma salivarium* in hypogammaglobulinaemia. *Brit. Med. J.* **286** : 762-763.
- Teysson, R., Poutiers, F., Saillard, C., Grau, O., Laigret, F., Bove, J. M. and Bebear, C. (1993). Detection of mollicute contamination in cell cultures by 16S rRNA amplification. *Mol. Cell. Probes*. **7** : 209-216.
- Tully, J. G. and Razin, S. (1995). *Molecular and Diagnostic Procedures in Mycoplasmology*. Vol. II. Diagnostic Procedures. (Academic Press, New York).
- Van Kupperveld, F. J. M., van der Logt, J. T. M., Angulo, A. F., van Zoest, M. J., Quint, W. G. V., Neisters, H. G. M., Galama, J. M. D. and Melchers, W. J. G. (1992). Genus and species specific identification of mycoplasmas by 16S rRNA amplification. *Appl. Environ. Microbiol.* **58** : 2006-2615.
- Waites, K.B., Tully, J.G., Rose, D.L, Marriot, P.A., Davis, R.O., Casell, G.H. (1987). Isolation of *Acholeplasma oculi* from human amniotic fluid in early pregnancy. *Curr. Microbiol.* **15**: 325-327.
- Williamson, J., Marmion, B.P., Worswick, D.A., Kok, T., Tannock, G, Herd, R. and Harris, R. T. (1992). Laboratory diagnosis of *M. pneumoniae* infection. 4. Antigen capture and PCR gene amplification for detection of the mycoplasma : Problems of clinical correlation. *Epidemiol. Infect.* **109** : 519-537. New York).
- Yechouron, A., Lefebvre, J., Robson, H. G., Rose, D. L. and Tully, J. G. (1992). Fatal septicemia with *Mycoplasma arginini*: A new human zoonosis. *Clin. Infect. Dis.* **15**: 434-438

***Disclaimer: The views and opinions expressed in this review article are author's own and not of Webmaster.***

**June 2009**