Zoonotic Importance of Bartonellosis

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ABSTRACT

History has witnessed several vector-borne zoonotic diseases which have taken millions of precious human lives. Bartonellosis is one of the most important vector-borne diseases that caused 7,000 causalities in 1870, and these causalities continued even after centuries. Bartonellosis is a broad term that describes the diseases caused by a gram-negative bacterium of a genus Bartonella (Oroya fever, Carrison's disease) and spp. Bartonella. Members of the Bartonella genus are short, pleomorphic, gram-negative, aerobic, and oxidase-negative organisms within the α2 subgroup of the Proteobacteria class. Hosts for Bartonellosis vary from rodents to domestic dogs and cats. B. henselae, B. clarridgeiae, and B. koehlerae mainly infect cats. B. vinsonii subsp. berkhoffii causes infection in dogs and coyotes (Canis latrans), B. alsatica, causes infection in wild rabbits. Similarly, B. bacilliformis and B. quintana B. bacilliformis and B. quintana infect humans. The bacteria enter the host's bloodstream directly or via lymphatic system and colonize within the erythrocytes. The signs of infections vary from species to species, but Bartonellosis is mostly characterized by fever, hemolytic anemia, myalgia, paler, and arthralgia. In cats, Bartonellosis is associated with lymphadenitis, endocarditis, gingivitis, and stomatitis. Endocarditis is the most important feature of Bartonellosis in dogs. Human activities are affecting the global environment and the rise in temperature, is increasing the interaction of arthropods with human or mammalian species. Thus, to control the disease effectively, reduction in animal-vector interaction, improving diagnostic techniques, and updating treatment regimens are essential.

Key words: Bartonellosis; Vector-borne disease; Oroya fever; Carrison's disease; Zoonotic diseases

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1. INTRODUCTION

Many vector-borne pathogens have emerged in the past few decades; nearly all have zoonotic potential, creating a new challenge for global health. Arthropods such as ticks and mosquitoes have been the most important cause of vector-borne diseases for centuries. These arthropods provide a space for several bacterial, viral, and parasitic agents and act as transmission sources from animal to human. Arthropods having a pathogen with zoonotic potential mainly affect pets or domestic animals, ultimately spreading infection to humans when these animals are consumed or in contact with humans (Telfer et al. 2007). Some of the most compelling bacterial zoonotic and vector-borne diseases throughout the globe include Lyme disease, Bartonellosis, Ehrlichiosis, etc. These diseases have caused severe infections in the past and still exist as an endemic in several countries. An increase in the different vector-borne diseases in the past few decades provides a chance for One Health professionals to collaborate to understand the complex pathophysiology of vector-borne zoonotic diseases (Walker et al. 1996; Mai 2022).

Genus *Bartonella* is a clade of alphaproteobacteria that contain gram-negative, pleomorphic, and fastidious aerobic bacteria. Until 1993, it was thought that the genus *Bartonella* consists of only one species. However, with the advancement in microbiology and the interest of One health professionals due to their high morbidity, several other species of *Bartonella* have been identified. *Bartonella spp.* gained the attention of veterinarians in the late 1990s when an increase in animal reservoir hosts was recorded. For example, *Bartonella henselae* was found in cats, *Bartonella vinsonii* was isolated from wild canids, and *Bartonella bovis* was isolated from domestic cattle (Boulouis et al. 2005). *Bartonella* causes bacteremia in mammalian reservoir hosts with few or no symptoms. Thus, contact with a healthy dog, cat, or other reservoir host of *Bartonella* can cause the transmission of bacteria from one animal to another or human as well. Bartonellosis is a term used to describe the infection caused by *Bartonella spp.* The most common infection caused by Bartonella spp. include peliosis hepatitis, Carrison's disease, Oroya fever, and trench fever. Arthropod vectors, such as ticks, fleas, and lice, are also considered the most important source of Bartonellosis transmission within animals and humans (Jacomo et al. 2002).

2. BACTERIOLOGY

Genus *Bartonella* consists of more than 20 bacterial species, and most of these bacteria have been reclassified from the genus *Rochalimeae* and *Grahamella.* All *Bartonella spp.* are very closely related to each other and have 98% homology in the sequences of their 16S rRNA genes. Members of the Bartonella genus are short, pleomorphic, gram-negative, aerobic, and oxidase-negative organisms within the α2 subgroup of the *Proteobacteria* class. They have very close evolutionary relations with bacteria of the genera *Rhizobium* and *Brucella.* Bartonella spp. can be easily grown at 37°C with 5% carbon dioxide on an axenic medium. However, fetal bovine serum and tissue culture also provide a suitable environment for Bartonella for its growth (La Scola and Raoult 1999).

Some species of *Bartonella,* such as *Bartonella bacilliformis* and *B. clarridgeiae* have a unique structure called flagella, facilitating the bacterium in erythrocyte invasion. Other species of Bartonella use the actin-dependent invasion-mediated mechanism of cellular invasion (Dehio et al. 1997).

3. HISTORY OF BARTONELLOSIS

In 1870, a severe fever outbreak occurred among the Railway workers in Oroya, leading to 7,000 causalities. The disease was named "Oroya fever" and was a headache for all medical professionals and local communities at that time. In 1885, Daniel Carrison, a medical student and native of Peru, tried to solve the problem by vaccinating himself from the verruca tumor. But, twenty-three days later, Daniel Carrison experienced the signs of Oroya fever and died. In honor of Carrison's attempt, the disease was later named "Carrison's disease." In 1902 and 1903, Barton performed a bacteriological investigation and performed a necropsy of the people who died from Carrison's disease. Healthcare professionals studied the different characteristics of the causative agent of Carrison's disease, the pathogen associated with this disease, and the pathogen *Bartonia* (Medicine 1915).

Until 1990, before the discovery of the AIDS virus, most of the *Bartonella* spp. were not identified. However, during the early epidemic of AIDS, the bacteria responsible for the transmission of Carrison's disease was histopathologically visualized with silver stains within bacillary angiomatosis and peliosis hepatis lesions. With the effort of Dr. David Relman and colleagues, a new species of *Bartonella* was identified. It was concluded that the identified species cause cat scratch disease, which highlights the zoonitic spread of Bartonellosis. Later, it was confirmed that most of the *Bartonella* spp. transmit to cats through fleas (Yore et al. 2014).

In 1993, Brenner studied the characteristics of the *Rochalimaea* species and provided a proposal to remove the Family *Bartonellaceae* from the Order *Rickettsiales* and unify the different species of genus *Rochalimaea* with *Bartonellaceae.* This led to the addition of four new members in the genus *Bartonellaceae.* These members include B. *.quintana*, *B.vinsonii*, *B.henselae*, and *B. elizabethae* (Brenner et al. 1993).

Similarly, in 1995, the genus *Grahamella,* an arthropod transmitted gram-negative bacterium, was unified with the genus *Bartonellaceae* and led to the addition of five new species, including *Bartonella talpae*, *B. peromysci*, *B. grahamii*, *B. taylorii*, and *B. doshiae* (Birtles et al. 1995). Later, more species of Bartonella were isolated from dogs, domestic cats, and wild rats and *Bartonella washoensis* was isolated from a patient with cardiac disease. The investigation revealed that the patient had contact with rodents, confirming the zoonotic potential of the genus *Bartonella.*

4. LIFE CYCLE

The infection cycle of Bartonellosis starts with the inoculation of the bacteria in specific mammalian hosts. Inoculation is mainly performed by the blood-sucking arthropods or contact with the infected animals or rodents. When a bacterium containing arthropods sucks blood from a mammal, the affected area experiences irritation and scratching, leading to the inoculation of bacterium-containing insect feces into the dermis. Upon inoculation, the Bartonella resides in the primary niche (dermis) of the host for a specific time and then seeded in the bloodstream, where it colonizes in erythrocytes. But, during the invasion of the dermal niche, several immune cells, including macrophages, phagocytosed the bacteria to prevent entry into the blood. But, sometimes, *Bartonella* also gains entry to the bloodstream via lymphatic vessels. Mainly, research has proved that *Bartonella* invades the blood-containing niches by affecting the endothelial cells (Shown in the fig-1). Colonization of the bacteria within the erythrocytes is performed in several steps, including adhesion with erythrocytes, invasion, and intracellular persistence that enable the continuous vector transmission of the infection (Fig. 1). During the whole course of the infection, the weak immune response of the patient and moderate inflammatory profile is highly beneficial for *Bartonella.* The bacterium also affects the host's immune response via passive immune evasion and immunomodulation (Harms and Dehio 2012; Jin et al. 2023).

5. EPIDEMIOLOGY

5.1 HOST

Many research studies have proved a species-specific association between the *Bartonella spp.* and their hosts or vectors. Most of the Bartonella species infect the mammalian hosts, where a primary infection occurs, followed by chronic bacteremia, which might be asymptomatic. Hosts for Bartonellosis vary from rodents to domestic dogs and cats. *B. henselae*, *B. clarridgeiae*, and *B. koehlerae* mainly infect cats. *B. vinsonii* subsp. *berkhoffii* causes infection in dogs and coyotes (*Canis latrans*), *B. alsatica,* causes infection in wild rabbits. Similarly, *B. bacilliformis* and *B. quintana B. bacilliformis* and *B. quintana* infect humans (Jacomo et al. 2002).

5.2 VECTORS

Bartonellosis can be transmitted by several vectors, including sand flies, human louse, cat flea, the mite, and the vole ear mite; still, the data is considered incomplete. Research conducted in Los Angeles confirmed that 61% of the fleas found on rats are infected with *B. elizabethae* and other species. Contact of these bacterium-containing rodents with a human or other animal causes endocarditis and febrile illness (Breitschwerdt and Kordick 2000).
Table 1 explains the different reservoir hosts and vectors for important *Bartonella* species.

5.3 TRANSMISSION

5.3.1 TRANSMISSION BETWEEN NATURAL HOSTS

As previously discussed, vectors play an important role in transmitting Bartonellosis from one infected animal to another. Furthermore, there is a specific association between the vector, natural host, and *Bartonella* species. Research has proved that the vector may inoculate *Bartonella* species through the bite and scratch of the reservoir hosts or direct contact with the blood of infected animals.
Bats also play an essential role in the transmission of Bartonellosis. A study conducted in the USA confirmed the presence of *Bartonella spp*. in bat flies. These significant findings suggest that bats as a reservoir host can cause spillover of the infection, leading to the transmission in animals and humans (Morse et al. 2012).

Table 1: Species of *Bartonella* spp. in various animals with their vectors

Specie	Reservoir host	Vector involved.
B. bacilliformis	Human	Phlebotomines
B. quintana	Human	Human Body Lice
B. henselae	Cats	*C. felis (fleas)*
B. clarridgeiae	Cats	*C. felis*
B. vinsonii subsp. *berkhoffii*	Dogs	Fleas and ticks
B. alsatica	Rabbits	Fleas or ticks.

In 2018, Corduneanu et al. (2018) detected the presence of *Bartonella spp.* DNA in bats' heart tissues led to the addition of four new species in the genus Bartonella. The presence of Bartonella species in bats opens a new debate and area of research for veterinarians and One health professionals. Interaction of Bartonella-infected bats or bat flies with animals can lead to the transmission of Bartonellosis within the animals and humans.
Rats are another important reservoir hosts for several Bartonella species. In an extensive analysis of rats from 13 sites in the United States and Portugal, *Bartonella spp.* were isolated from the blood of 19% *Rattus norvegicus* and 112% *Rattus* (Ellis et al. 1999).

5.3.2 ZOONOTIC TRANSMISSION

The Bartonella species present in the bloodstream of an infected animal can be transmitted to humans by biting the vector or close contact with the bacterium-containing secretion, including blood of the infected

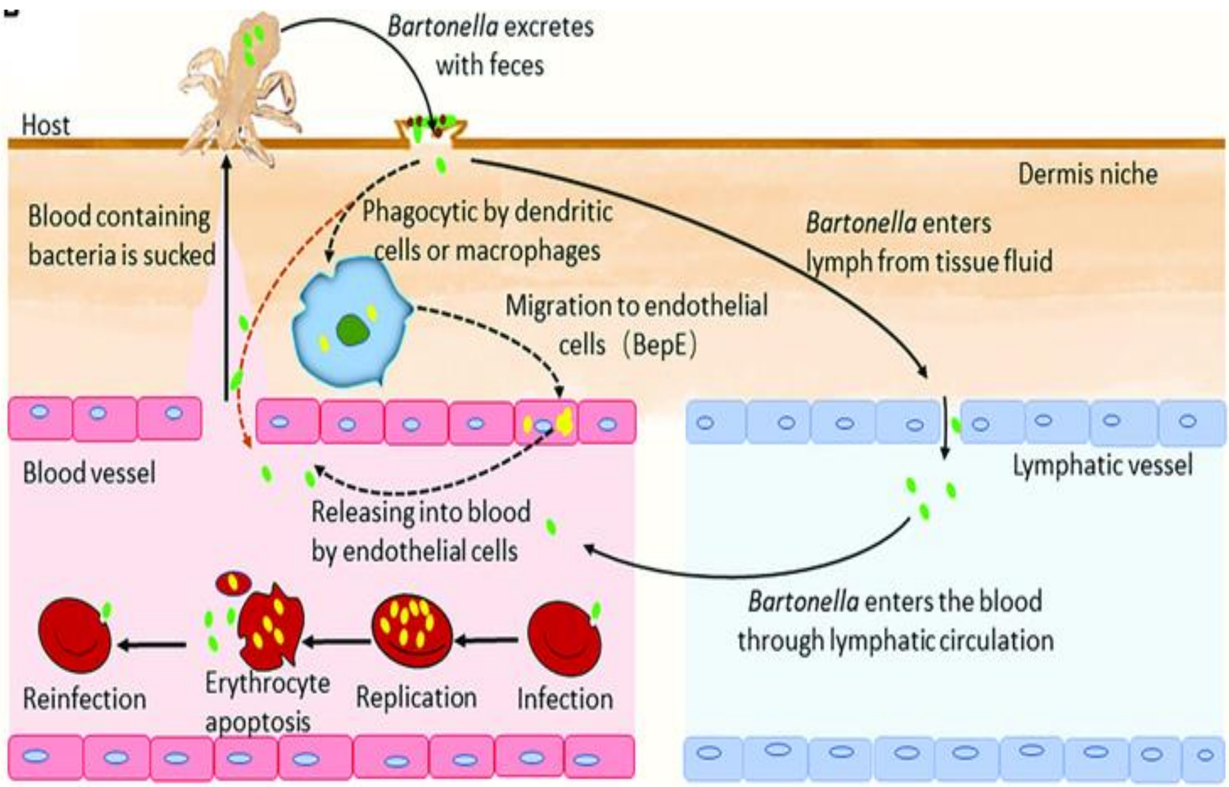

Fig. 1: Life cycle of Bartonella in the mammalian specie

dogs, cats, or other animals. Humans can be a primary or accidental host to Bartonellosis. In humans, vector transmission of *Bartonella* can be possible in two ways:

1. When contaminated, arthropod feces are inoculated through animal bites or scratches. When the host causes wound contamination by scratching irritated arthropod bites, cats, dogs, and people are essential incidental hosts and key reservoirs for these forms of transmission (Fig. 2).
2. Direct transmission of bacteria by the bite of vector. For example, sand flies, such as *Lutzomyia verrucarum,* can transmit the *B. bacilliformis* among humans. Similarly, *Ixodes ricinus* ticks can cause the transmission of *B. henselae* (Battisti et al. 2015; Cotté et al. 2008).

5.4 GEOGRAPHICAL DISTRIBUTION OF BARTONELLA SPECIES

Bartonellosis is a significant zoonotic disease that is a potential threat for the whole globe, but some specific species are endemic and limited to specific geographical regions. Bartonella infection is a recognized public health threat in the United States, where it causes CSD at a rate of 4.7 per 100,000 people aged 65 and older and 500 hospital admissions annually (Sepulveda-Garcia et al. 2023). *B. henselae* is an important species that affects domestic cats and has zoonotic potential. The population of *B. henselae* varies and is high, mainly in warm and humid environments (68% in the Philippines). There are two major genotypes of *B. henselae,* i.e., Houston-1 and Marseille. According to a study, *B. henselae* type Marseille is most commonly found in Western Europe, Western U.S.A, and Australia cats. On the other hand, Houston-1 is dominant in Asian countries, especially in Japan and the Philippines. The prevalence of Houston-1 in Australia and the U.S.A. indicates that this genotype has more zoonotic potential than Marseille (Chomel and Kasten, 2010). Cat Scratch Disease (CSD) is one of the most common

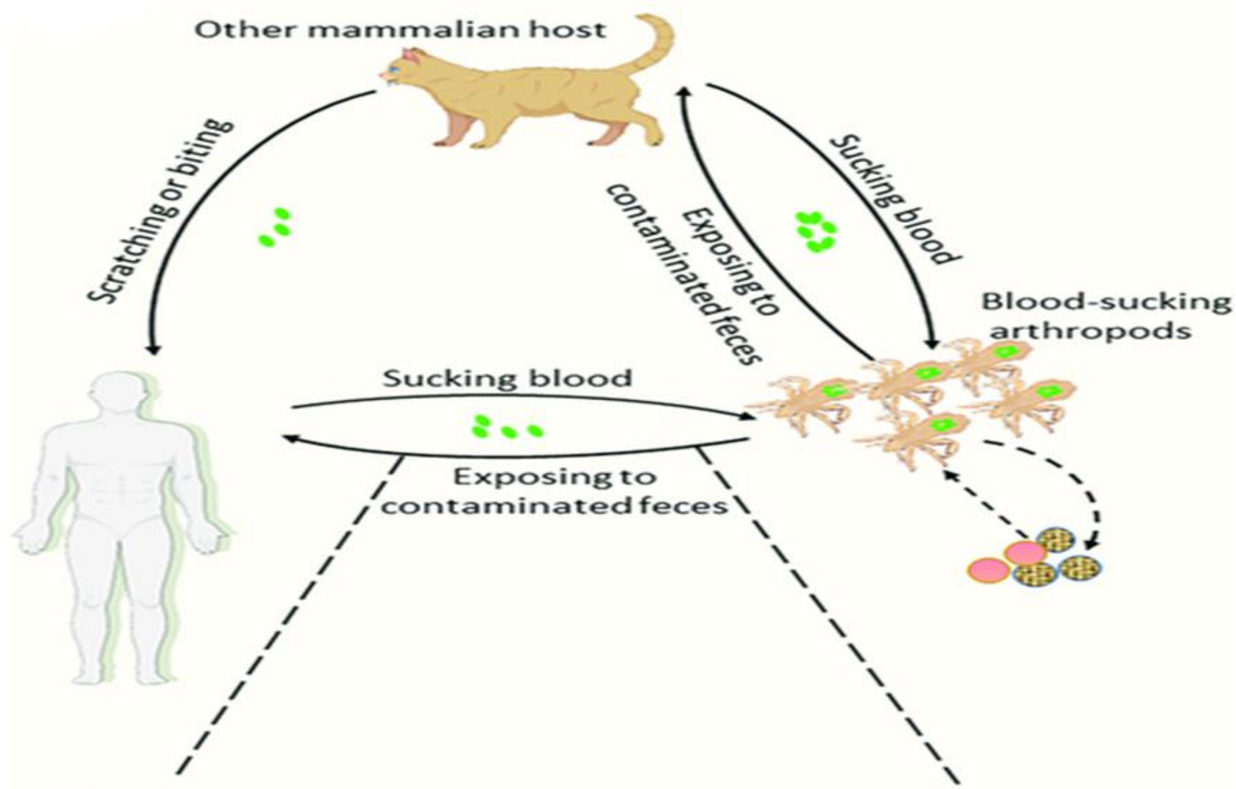

Fig. 2: Pattern of transmission of *Bartonella*

forms of Bartonellosis. The disease was first reported in France in 1950, but the causative agent was identified in 1993. A report published in 2005 showed that the total number of CSD in the U.S.A. is 22,000 and 24,000, along with 2,000 severe cases that require hospitalization (Boulouis et al. 2005).

Bartonella clarridgeiae is another important bacterium that belongs to the genus *Bartonella*. The bacterium was first isolated from the cat of an HIV patient in 1995. This species of Bartonella is more prevalent in Thailand, the Philippines, France, and the Netherlands. However, few studies have also reported its isolation from cats of other countries in the U.S.A, Australia, Japan, and Taiwan (Maruyama et al. 2001).

Bartonella koehlerae is one of the fastidious bacteria to grow and rarely infects cats. Major cases of this bacterium are mostly reported in warmer regions; for example, the prevalence of this bacterium in cats is 80% in California and 0% in the Netherlands. Similarly, the seroprevalence of *Bartonella koehlerae* in the Middle East is 15% (Chomel et al. 2003; Switzer et al. 2013; Alanazi et al. 2020).

B. quintana, B. bovis, and *B. vinsonii berkhoffii* also cause Bartonellosis in pets and some domestic animals, including cattle. *B. quintana* was first isolated during World War I and II, when their association was found with trench fever. *B. quintana* is most commonly found in regions with more head lice (Sangaré et al. 2014). *B. bovis* was first isolated in cattle that were suffering from endocarditis. *B. bovis* is most prevalent in French Guyanna (70%), U.S.A (50 to 89%), France (36%), Italy (24%), and West Africa (20%) (Bai et al. 2013). *Bartonella* spp. has also been identified in the cattle of Pakistan (Ghafar et al. 2020).

6. CLINICAL MANIFESTATION

The clinical manifestation of Bartonellosis varies from species to species. The below points highlight the important clinical features of Bartonellosis in different animals and humans.

6.1 CLINICAL FEATURES OF BARTONELLOSIS IN HUMANS

As discussed, humans can be accidental and primary hosts for several *Bartonella* species. The clinical feature of Bartonellosis depends on the *Bartonella* species involved in infection. *Bartonella bacilliformis,* an agent responsible for Oroya fever, only infects humans and is characterized mainly by fever, hemolytic anemia, myalgia, paler, and arthralgia (Kosek et al. 2000). The disease can be lethal if left untreated. In most cases, chronic bacteremia develops after a few weeks or even years of the acute infection, primarily associated with the eruption of nodular skin lesions. Many researchers have proved that *Bartonella bacilliformis* is endemic in several regions, including Peru, where infection is present in asymptomatic forms (Chomel and Kasten 2010).

B. quintana is responsible for trench fever, transmitted by body lice, and only infects humans. After the incubation period, the infection is characterized by fever, headache, leg pain, and sometimes thrombocytopenia. *B. quintana* also causes endocarditis, chronic lymphadenopathy, and angiomatosis. Several asymptomatic carriers of the infection had also been identified in 1940 (Swift 1920).

Some species of the *Bartonella*, such as *B. henselae,* are zoonotic and transmitted from infected cats to humans. Infection with *B. henselae* is characterized by benign regional lymphadenopathy. After scratches from infected cats, papules that turn into pustules develop within 7 to 8 days at the inoculation site. In some patients, encephalitis, endocarditis, hemolytic anemia, hepatosplenomegaly, osteomyelitis, and pneumonia also develop. Most patients with CSD recover within one year without any sequelae. In children, infection with *B. henselae* also causes arthritis and skin nodules (Margileth et al. 1987; Chomel and Kasten 2010).

In immunocompromised patients, bacillary angiomatosis is one of the most common clinical manifestations of Bartonellosis. Bacillary angiomatosis is characterized by chronic vascular lesions histopathologically and clinically similar to verruga peruana caused by *B. bacilliformis*. These lesions are most common in HIV patients with CD 4+ cell counts below 50/mm3 (Koehler 2000).

6.2 CLINICAL FEATURES OF BARTONELLOSIS IN ANIMALS

6.2.1 CATS

Domestic and wild cats are reserve hosts for several species of *Bartonella*, especially *B. henselae.* Mostly, Bartonellosis is asymptomatic, but healthy-looking cats can transmit infections to other animals and humans. However, in case of severe infection, lymphadenitis, gingivitis, and stomatitis are the most important clinical features in felines. Bartonella-associated endocarditis has also been reported. However, lymphadenitis and endocarditis in asymptomatic cats are difficult to diagnose until the causative agent is identified in lesions (Ueno et al. 1996; Chomel et al. 2003).

Local inflammation, anorexia, lethargy, and lymphadenopathy are the most common clinical signs of Bartonellosis in cats. Neurological abnormalities, including behavioral and vestibular dysfunction, have also been reported in experimentally infected cats. Histopathological changes in Bartonellosis include focal monocytic myocardial inflammation and lymphocytic interstitial nephritis (Guptill et al. 1997).

In *B. koehlerae,* no clinical signs appear in infected cats.

6.2.2 DOGS

B. vinsonii subsp. *berkhoffii* is the most common cause of Bartonellosis in dogs worldwide, including in California and Arizona (Honadel et al. 2001). In dogs, *B. vinsonii* occurs as a co-infection with other tick-borne diseases, such as *Ehrlichia* and *Babesia.* Endocarditis is one of the most common clinical manifestations of *B. vinsonii* in dogs and is highly zoonotic. Other clinical signs associated with this

Bartonellosis include neurological disorders, lameness, lethargy, myocarditis, and cardiac arrhythmias. Endocarditis includes lesions associated with the aortic valve and the presence of vegetative lesions. Sometimes, *B. vinsonii-associated* Bartonellosis is asymptomatic in dogs and bacteremia results in the transmission of the bacterium to humans. However, in most cases, Bartonellosis causes immunosuppression in dogs, leading to monocytic phagocytosis, CD8 lymphocytopenia, impaired CD8+ T lymphocyte function, and impaired B cell antigen presentation within lymph nodes (Breitschwerdt et al. 1999).

6.2.3 WILD ANIMALS

Many Bartonella species have been isolated from several free-ranging and captive wild animals, including wild felids, domestic mammals, and wild rodents. For example, *B. vinsonii* subsp. *berkhoffii* has been isolated from coyotes. Similarly, *B. bovis* has also been isolated from domestic cattle, where it is responsible for endocarditis. But, in most mammalian species, Bartonellosis causes silent bacteremia and promotes bacterium transmission from one species to another (Kosoy and Goodrich, 2019).

7. ENVIRONMENTAL CHANGE: A POTENTIAL THREAT FOR BARTONELLOSIS TRANSMISSION

Due to the increase in industrialization, environmental pollution, and the trend of environmental toxic products in daily life, our earth's climate is changing rapidly. The earth's temperature is increasing daily, and glaciers are melting, leading to floods, and spreading diseases worldwide. Climate change affects the re-emergence of several vector-borne diseases, such as Bartonellosis, in several ways (Rocklöv and Dubrow 2020). Vectors are ectothermic, i.e., they change their body temperature according to the environment and perform better in warm environments. Vectors' interaction with the host for feeding and survival increases with an increase in temperature. For example, *Ixodes ricinus* is a potential vector for transmitting *B. henselae.* The lifecycle of *Ixodes ricinus* depends upon several factors, including humidity and temperature. However, climate change, such as rise in temperature, has increased the interaction of this tick with the mammalian host, leading to the transmission of *B. henselae* among wild and domestic cats (Caminade et al. 2019).

8. DIAGNOSIS OF BARTONELLOSIS

Serology, PCR, ELISA, culture, and IFA tests can diagnose Bartonellosis in humans and other animals.

8.1. CULTURE

Most species of *Bartonella* are gram-negative bacilli that are oxidase and catalase negative. Bacterium requires CO_2 -rich media for growth and can be easily obtained in 12 to 14 days when grown on blood media. Many pieces of research have proved that cell coculture media allow the more rapid growth of *Bartonella* compared to agar-rich media. Freezing the EDTA collected specimen for 24 hours results in a colony count compared to an isolator tube (Agan and Dolan 2002).

8.2. POLYMERASE CHAIN REACTION

Polymerase Chain Reaction (PCR) has revolutionized the diagnosis of several important infectious agents, including viruses and bacteria. PCR detects the pathological agent's DNA or RNA by using various clinical samples. DNA can be collected in significant quantities by using nucleic acid amplification. The collected

DNA is then analyzed by a variety of techniques. Microbiologists have successfully identified different species of Bartonella by using the PCR technique, which requires little starting time. However, PCR sample preparation to avoid contamination as an unknown inhibitor can affect the results. The most common PCR techniques for detecting *Bartonella* in a sample include ERIC-PCR, AP-PCR, PCR-EIA, and REP-PCR (Johnson et al. 2003).

8.3. ELECTROPHORESIS, SOUTHERN BLOT, AND RFLP

For an efficient detection of different Bartonella species, different molecular analysis procedures, such as Electrophoresis, southern blot, and RFLP, are very significant. These procedures are most commonly available and used throughout the world. However, these procedures require a large time for the sample preparation, more labor, and a large quantity of nucleic acid to perform these tests. These tests are often used in conjunction with PCR (Pérez et al. 2011).

9. TREATMENT

The ability of the Bartonella species to invade the erythrocytes provides them with protection against the host's immune system and from antibiotics used to treat infection. Any remaining bacteria after treatment can replicate the infection again, even after a year. Many studies have proved that Rifampicin, Gentamicin, and Ciprofloxacin are the best choices for treating Bartonellosis in humans (Angelakis and Raoult 2014). However, there is no standard protocol for treating dogs and cats. But Doxycycline, Amoxicillin, Enrofloxacin, and Rifampin can be effective. These antibiotics should be used carefully, as irrational use can lead to antibiotic resistance (Álvarez-Fernández et al. 2018). Table 2 shows list of effective antibiotics used against Bartonella species in different animals.

10. FUTURE INTERVENTIONS

Due to rapid environmental changes throughout the globe, illegal transport of animals, and increase in contact with wildlife, pets, and humans with each other, the number of Bartonellosis is increasing day by day. Animal bites, scrapes, arthropods, and even needle sticks can spread this zoonotic infection.

Table 2: Effective antibiotics of Bartonella species in different animals.

Host	*Bartonella* specie and clinical manifestation	Antibiotic
Cats	Bacteremia due to any specie of *Bartonella*	Doxycycline, Azithromycin
Cats	Endocarditis due to *B. henselae*	Marbofloxacin + Azithromycin
Cats	*B. vinsonii berkhoffii induced* Osteomyelitis and polyarthritis	Amoxicillin-clavulanate+ Azithromycin
Dog	Splenic vasculitis, thrombosis, and infarction/*B. henselae*	Doxycycline + Trimethoprim-sulfamethoxazole
Dog	Endocarditis/*B. koehlerae*	Ampicillin + Enrofloxacin
Human	*B. bacilliformis* induced Oroya fever	Chloramphenicol

Furthermore, diagnosing and treating *Bartonella* transmission has become more difficult due to the discovery of novel species and subspecies, as well as the wide variety of animal reservoir hosts and arthropod vectors that can transmit these bacteria. Bartonella bacilliformis infections in the Peruvian Andes were historically referred to as "Bartonallosis" and were spread by sandflies. However, it currently covers infections brought on by any Bartonella species wherever in the world. Numerous cell types are susceptible to *Bartonella* infection, which can result in a variety of clinical and pathological symptoms in both animals and people (Brook et al. 2017). Thus, there is more need to take strict control measures to prevent the rapid spread of infection among animals and humans.

Due to the unavailability of the vaccine against Bartonellosis, controlling the vectors and reservoir host from direct contact with the human is the best solution. Strict control measures should be taken to avoid the trans-boundary transmission of the infection. Transport of animals from one city to another and export from one country should be done with strict measures to control ticks and flies. In dogs and cats, acaricides should be used as collars to avoid their contact with ticks and transmission of infection. Furthermore, dogs, cats, and humans should avoid contact with rodents, bats, and other stray animals. Veterinarians and pet owners must continue to use caution while treating pets for fleas to lower the risk of disease transmission. When recommending pets or pet care to immunocompromised patients, veterinarians should consider the cat's place of origin because *B. henselae* bacteremia appears more common among cats from shelters. Veterinarians are susceptible to collecting Bartonella from bites, scratches, and needlestick wounds. Veterinarians should make efforts to prevent such injuries, such as using anesthesia when necessary, cleansing wounds properly, and seeking medical attention right after, given the high prevalence of Bartonella bacteremia in young and stray cats. When expecting to come into touch with animal blood or saliva, gloves should be worn. While cats and dogs are significant Bartonella carriers, people can also contract the illness from other sources, such as arthropods or even blood transfusions. Particularly among homeless populations, human body lice can spread B. quintana, which causes relapsing fever and endocarditis (Sykes and Chomel 2014).

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