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Evolution of animal and human brucellosis in the region of Souk Ahras between 2013-2022

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Declaration of Honor

I, Mr. FASSEKH Mohamed Taha, hereby declare that I am fully aware that plagiarism of documents or any part thereof published in any form, including the internet, constitutes a violation of copyright and constitutes clear fraud. Therefore, I commit to citing all the sources I have used to write this thesis.

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ACKNOWLEDGMENTS

First of all, I sincerely thank our Almighty God
who helped me to complete this modest work.

I would like to thank my promoter Mrs. Baazizi Ratiba for kindly Supporting and supervising this work.

Also, my best thanks to all the teachers from the First to the Fifth university year

<u>**DEDICATED TO**</u>:

MY MOTHER: Thank you so much for believing in me and supporting me! You have truly given me the world, and I thank you so much for all the sacrifices you have made for me.
Dear Mom, thank you for being a mom who knows how to be a friend.

MY FATHER: Let us celebrate this day of success on completing graduation…. A big thank you to my dad who has been my strength through tough times…. This success belongs to You dad.

MY BROTHER AND SISTERS: There are no words to describe how grateful I am for having such awesome family, I love you with all my heart and I dedicate this graduation to you.

MY FIANCEE: I have always found you standing by my side during happy and difficult times. I just wanted to thank you for being there for me.

MY GRANDMOTHER MAY GOD REST HER SOUL: I have never loved anyone more than I loved you, I miss you with all my heart, and I wish that Allah grant you paradise, thank you so much for believing in me and supporting me.

MY FRIENDS: Thank you so much for standing with me and helping me through everything, I really appreciate you so much.

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INTRODUCTION

Brucellosis is a highly contagious disease with a significant economic impact on the development of animal industries (Benkiran, 2001). Furthermore, being considered the most widespread zoonosis worldwide, it poses a serious threat to human health (World Health Organization, 2000). It is transmitted through direct contact with animals or by consuming raw contaminated animal products (particularly milk and dairy products).

According to the report from the Ministry of Health and Population (2000), 3,933 Algerians were affected by brucellosis in 2000, corresponding to an annual incidence of 13.0 cases per 100,000 inhabitants, compared to 8.5 cases in 1999. The disease is thus spreading, with significant epidemic outbreaks occurring in provinces such as Tébessa, Biskra, and M'sila. As with any infectious disease, surveillance and eradication efforts require synergy between animal health services and human health services.

In this regard, we conducted this first study in Souk Ahras to contribute to the characterization of this disease by examining its trends and calculating the annual and monthly prevalence of reported cases in both humans and animals. Our work consists of two parts. The first part is a synthesis of the literature on the study of animal and human brucellosis.

The second part corresponds to our study conducted at the Directorate of Agricultural Services (DSA) and the Directorate of Health (DH) of Souk Ahras.

BIBLIOGRAPHIC PART

CHAPTER1 :

General informations about Brucellosis

CHAPTER1 :GENERAL INFORMATIONS ABOUT BRUCELLOSIS

1. History

According to Dedet (2007), brucellosis was first discovered in 1850 in Malta by British military physicians, who referred to it as "Mediterranean fever." In 1887, microbiologist David Bruce isolated the bacteria responsible for the disease from the spleen of a deceased soldier, establishing the connection between a microorganism called Micrococcus melitensis and the illness. In 1897, Wright demonstrated the presence of agglutinating antibodies in the serum of affected individuals, leading to the development of the first serological diagnostic test known as the Wright agglutination reaction. In 1905, Zammit confirmed the presence of the disease in goats in Malta, as they all tested positive using the Wright test. In 1929, Huddleson developed bacteriological methods to differentiate between the species Brucella melitensis, Brucella abortus, and Brucella suis. In 1957, Elberg and Faunce developed the first attenuated live vaccine strain, B. melitensis Rev1.

In Algeria, according to Khettab & al. (2010), Cochez provided the initial descriptions of the disease in 1895. In 1899, the disease was recognized by Brault based on clinical symptoms and bacteriologically confirmed for the first time by Gillot. Consequently, it was first revealed in humans. Following these observations, Sergent and colleagues conducted research in 1907 on goat herds in Algiers and Oran, which revealed the infection in goats as well as other domestic animals. As a result of these findings, the Governor-General of Algeria issued a decree prohibiting the importation of goats and cattle from Malta, which marked the introduction of the first prophylactic measures.

2. Definition

Merial (2016) defines brucellosis as an infectious and contagious disease that affects various animal species, including humans, caused by bacteria of the genus Brucella. According to JORA (2006), in Algeria, brucellosis is a notifiable disease in bovine, ovine, goats, and camelid species. Quieroz (2010) described brucellosis as a professional zoonosis, meaning it can be transmitted naturally between vertebrate animals and humans, particularly individuals in contact with infected ruminants such as farmers, veterinarians, slaughterhouse workers, and laboratory personnel. According to Afssa (2004), brucellosis should be classified as a presumed contagious animal disease, regardless of the mammalian species involved and the specific Brucella species responsible (except for Brucella ovis).

Abadane (2014) has emphasized that human brucellosis is a multisystemic disease with a polymorphic clinical presentation, which can pose a threat to human life. This indicates that brucellosis can affect various organ systems in the body and manifest in diverse ways, making diagnosis and treatment challenging. It underscores the importance of early detection and appropriate management to ensure the well-being and safety of individuals affected by brucellosis.

3. Synonymy

According to Bounaadja (2010), human brucellosis has several names, including "Malta fever," "Cyprus fever," "Gibraltar fever," "Mediterranean fever," "sweating sickness," or "melitococcosis." In animals, it is referred to as "Bang's disease," "Bruce's septicemia," "epizootic or contagious abortion," or "contagious epididymitis in rams" (in sheep). These various names reflect the historical and geographical contexts in which the disease was first recognized and studied, as well as the specific clinical manifestations observed in different species.

4. Importance

According to Sibille (2006) and Freycon (2015), the importance of brucellosis varies between countries depending on the implemented control measures for its eradication and the local animal populations. It is significant due to its ability to cause "Malta fever" in humans, making it a major zoonotic disease. Additionally, its economic consequences in livestock production contribute to its significance. The impact of brucellosis on public health and the economy underscores the need for effective control strategies and surveillance measures to prevent its spread and minimize its impact on both human and animal populations.

a. Economic Importance

According to Sibille (2006), bovine brucellosis causes significant losses in livestock production. Its economic importance stems from the abortions, infertility, and reduced milk production it causes, sometimes in an epizootic manner. In addition, the high cost of implementing control measures for its eradication leads to severe repercussions on trade exchanges. The economic impact of bovine brucellosis highlights the need for effective prevention and control strategies to minimize its negative effects on both animal health and the livestock industry as a whole.

b. Hygienic Importance

According to Habamina (2008), brucellosis is classified as a major zoonosis due to the frequency and severity of human cases contracted from animals and their products. Zoonoses are diseases that can naturally be transmitted between animals and humans, and brucellosis is particularly concerning in this regard. It highlights the importance of implementing effective control measures to prevent the transmission of Brucella bacteria from animals to humans, thereby reducing the incidence and impact of this disease on public health.

5. Affected species

According to International Office of Epizootics (OIE) (2011), brucellosis affects cattle, sheep, goats, horses, camels, dogs, and pigs. It can also affect other ruminants, certain marine mammals, and humans. Pebret (2003) states that cattle are the primary host of Brucella abortus, which can occasionally infect other domestic ruminants such as buffaloes, zebras and bisons, as well as wild animals like deers. Brucella abortus can also infect equines, carnivores and rodents, making it a significant zoonotic disease. It is worth noting that bovine brucellosis can also occur due to infection with *Brucella melitensis* or *Brucella suis*.

CHAPTER2:

STUDY OF THE CAUSAL AGENT

1. Classic taxonomy

Khettab & al. (2010) reported that the pathogenic agent responsible for brucellosis is Brucella, which belongs to the following classification:

- Kingdom: Bacteria
- Phylum: Proteobacteria
- Class: Alpha Proteobacteria
- Order: Rhizobiales
- Family: Brucellaceae
- Genus: Brucella

According to Bourdeau (1997), the genus Brucella comprises six main species and a certain number of varieties known as "biotypes" or "biovars" (Table 1):

Table 1: *Different species of Brucella and their main hosts (Bourdeau, 1997)*

Host	***Principal Pathogen***
Cattle	*Brucella abortus*
Sheep	*Brucella melitensis, Brucella ovis*
Goats	*Brucella melitensis*
Dogs	*Brucella canis*
Horses and camels	*Brucella abortus*

Brucella abortus is the etiological agent of bovine brucellosis (Freycon, 2015) and represents the species with the greatest economic and public health impact. Mailles and Vaillant (2007) report that four species of Brucella are known to be pathogenic to humans: Brucella melitensis, Brucella abortus, Brucella suis, and Brucella canis.

Brucella melitensis is implicated in the majority of human cases.

2. Morphological characters

According to Corbel and Morgan (1982), all Brucella species share the characteristics of being small, non-motile cocci, Gram-negative coccobacilli or short rods with straight or slightly convex edges and rounded ends, measuring 0.5-0.7 µm wide by 0.6-1.5 µm long. They occur individually, occasionally in pairs, short chains, or small clusters. They do not produce capsules, spores, or flagella.

They typically do not exhibit bipolar staining. They are not acid-resistant but can withstand weak acid decolorization (Figure 1).

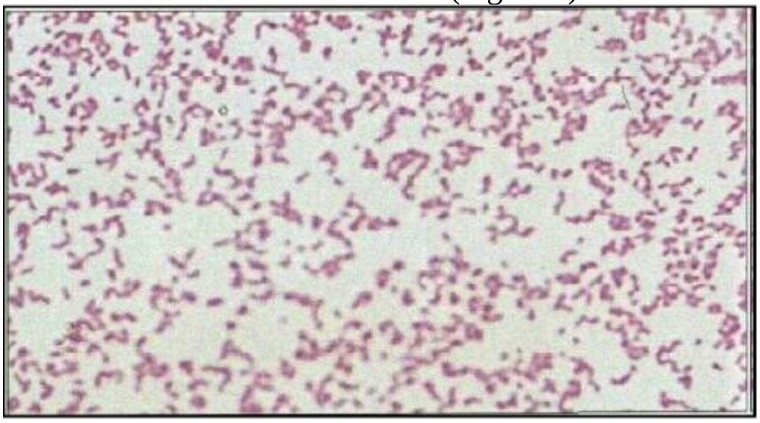

Figure 1: *Gram staining, Brucella abortus. Anonymous (2017)*

3. Cultural characteristics

The bacteria are strict aerobes, but some strains grow better in an atmosphere containing 5 to 10% CO_2, such as Brucella abortus and Brucella ovis (Bounaadja, 2010). The optimal growth temperature is 34°C, but it can range between 20 and 40°C on a suitable medium, although Brucella is typically cultivated at 37°C. The required pH for growth varies between 6.6 and 7.4, with an optimal pH of 6.8. Isolating Brucella from contaminated samples containing other bacteria or fungi requires the use of selective media.

According to Bervas & al. (2006), Brucella colonies become visible within 2 or 3 days on a suitable solid medium. Culturing them reveals two types of strains: smooth (S) and rough (R) colonies. S colonies are small, round, and convex, but dissociation frequently occurs, leading to the loss of O-chain LPS and the formation of R variants. This dissociation phase is significant in terms of vaccination.

Furthermore, H_2S production varies depending on the species and biovars (Corbel and Morgan, 1982), citrate is not the sole carbon source, and there is no indole production. Brucella is catalase positive and usually oxidase positive. The methyl red test is negative. Gelatin is not liquefied, and there is no hemolysis. Brucella abortus typically requires 5% CO_2 supplementation for growth, especially during initial isolation. It hydrolyzes urea and produces a small amount of H_2S in certain strains.

4. Biological properties of Brucella

The majority of brucellosis is a characteristic disease of placental mammals. Species such as Brucella abortus and Brucella melitensis have a placental tropism, leading to abortion in pregnant females (Crespo Léon and Ferri, 2003). Moreover, each species has one or several preferred hosts, although host specificity is broad, allowing for potential transmission between different animal species, but not always in both directions (Fournier, 2014). Brucella exhibit facultative intracellular development and can survive within any host cell. They evade phagocytosis by macrophages, where they multiply without causing their destruction.

Brucella can also be present in the environment, which can play a role in the epidemiology of the disease and in food products. Bacterial survival in the environment is influenced by factors such as humidity, temperature, and pH. Brucella can survive for several months in water and several years in frozen products. However, their survival in meat is short (Bervas & al., 2006; Fournier, 2014). Brucella exhibit significant resistance in the external environment, contributing to indirect transmission of the infection. They tolerate cold, humidity, darkness, and alkalinity better (Bezzaoucha, 2004).

On the other hand, Gourreau (2008) and Fournier (2014) have reported that Brucella are also sensitive to heat and are destroyed by pasteurization or heat treatment of milk for more than 30 minutes between 60 and 70 °C. They are also susceptible to physicochemical agents such as UV rays, disinfectants, antiseptics, and acidification, but they are resistant to quaternary ammonium compounds. Heat decontamination remains the most effective method.

5. Pathogenicity

Brucella are facultative intracellular parasites that cause characteristic diseases in a wide range of animals (Corbel and Morgan, 1982). This situation, according to Pilly (1997), is responsible for the persistence of the bacteria within reservoirs and, consequently, for chronic functional manifestations that are not influenced by antibiotic therapy. According to Afssa (2006), Brucella are classified as a Group III biological risk for humans and animals.

Adamou Harouna (2014) and the Bacteriology Department of the Pierre and Marie Curie University Hospital (2003) have reported that the pathogenicity of Brucella is defined by its toxicity through lipopolysaccharide (LPS) and its ability to multiply within cells of the reticuloendothelial system, genital and mammary apparatus, or joints.

6. Antigenic power

According to Adamou Harouna (2014), the surface membrane antigens are composed of S-type (Smooth) lipopolysaccharides (LPS). As for the R antigen (Rough), it is only present in Brucella ovis and Brucella canis. The LPS is responsible for the development of antibodies detected in the host.

The different Brucella species present the same antigenic factors but in different proportions (Habamina, 2008). Furthermore, the genus Brucella shares antigens with other bacteria such as Yersinia, Vibrio, and Campylobacter, which explains the issues of cross-reactivity in serological reactions. Brucella antigens are immunogenic. In fact, the presence of antigens leads to the production of antibodies by the organism, which can be detected through serology from 30 days to 3-6 months after infection.

7. Immunogenicity

LPS (lipopolysaccharide), the major antigen of Brucella, is responsible for inducing an immune response in animals. This immunity involves both humoral and cell-mediated responses. The humoral response is identical in all infected animal species (Araita Hebano, 2013; Khettab & al., 2010) and is primarily directed against the bacterial LPS. These anti-LPS antibodies induce bacterial lysis through the classical complement pathway. The cell-mediated response is exclusively directed against bacterial proteins. Cell-mediated immunity is essential for defending the body against infection. However, brucellosis can sometimes manifest as a prolonged disease with frequent relapses, despite appropriate antibiotic treatment, and "reactivations" can still occur from a previously quiescent focus. The intramacrophage persistence of Brucella leads to a state of delayed hypersensitivity contributing to the effects of tertiary or chronic brucellosis.

CHAPTER3:

Clinical and epidemiological study of Brucellosis

CHAPTER III: CLINICAL AND EPIDEMIOLOGICAL STUDY OF BRUCELLOSIS

1. Clinical study

a. Pathogenesis

- **With animals.**

According to Godfroid & al. (2003), Brucella enter the body through the oral mucosa, nasopharynx, conjunctiva, and genital tract, as well as through skin lesions. The crossing of this initial barrier triggers an inflammatory reaction in the host. The infection then spreads to local lymph nodes via the lymphatic route, where the bacteria persist for a long period of time in the draining lymph nodes of the inoculation site. If the bacteria are not eliminated at this stage, they disseminate through the blood and reach various tissues (lymphoid tissues, genital organs, nervous tissue, etc.). The growth of Brucella abortus is stimulated by erythritol, which is produced in the uterus of pregnant females (with high concentrations in the placenta and fetal fluids), explaining the localization of the infection in these tissues.

- **With humans.**

The incubation period of brucellosis lasts between 1 to 2 weeks (not exceeding 21 days). During this phase, Brucella reaches the regional lymph nodes after cutaneomucosal penetration (Pilly, 1997).

The primary invasion or lymphatic septicemia occurs when the bacteria enter the bloodstream and colonize tissues rich in reticulo-histiocytic cells, such as the liver, spleen, bone marrow, and genital organs (Bourdeau, 1997).

The secondary or post-septicemic period is a phase of adaptation to bacterial parasitism (Bourdeau, 1997; Pilly, 1997), and blood culture may be positive. It can manifest as the isolated progression of established foci or, rarely, as a severe polyvisceral involvement.

In chronic brucellosis, the disease typically resolves clinically but without sterilization. This phase may involve slow-progressing foci and/or septicemic relapses (Pilly, 1997 and Dentoma, 2008). It represents a delayed hypersensitivity reaction to the toxins secreted by Brucella.

b. Symptoms

- **Animal brucellosis.**

It is a septicemia followed by various secondary visceral localizations with a marked genital tropism. Therefore, it is a reproductive disease characterized by mammary and uteroplacental localizations in females and testicular lesions in males (Hamou, 2016).

According to Fournier (2014), extragenital forms can also occur, such as arthritis, bursitis, and tendinitis in horses infected with Brucella abortus, as well as arthritis, bursitis, tendinitis, and discospondylitis in dogs. Merial (2016) reported that the incubation period varies widely.

❖ **Genital symptoms:**

The disease is generally asymptomatic in non-pregnant females (Sibille, 2006).

In pregnant cows, the cardinal symptom is abortion, which can occur at any stage of gestation, but most commonly between the 5th and 7th month. The timing of abortion varies depending on the natural resistance of the animal, the infectious dose, and the timing of infection. If the infection occurs in the second half of gestation, the cow may give birth to an infected calf (Godfroid & al., 2003). Generally, the fetus is easily expelled in the absence of dystocia. The aborted fetus (Figure 3) is always dead and sometimes mummified when abortion occurs before the 6th month. Infection can also result in premature delivery a few days before term: however, the newborn may die within 24 to 48 hours due to nervous system damage secondary to hypoxia (Merial, 2016).

According to Godfroid & al. (2003), the disease becomes more insidious, clinically undetectable, due to improvements in farming techniques and the implementation of preventive measures. Metritis and retained placenta (failure to expel the placenta) can be sequels of abortion, with no apparent mastitis, and the udder feels normal on palpation.

Endometritis lesions may be responsible for temporary infertility (Merial, 2016).

In males, the disease manifests as epididymitis, orchitis, and sterility (Hamou, 2016).

Figure 2: *Aborted fetus between the 5th and 7th month ITELV (2015)*

- **Extra-genital symptoms:**

Merial (2016) reported that extra-genital symptoms are rarely observed in cattle. They may include frequent knee hygroma (Figure 4) or arthritis.

Figure 3 : *hygroma chez un veau atteint de la brucellose Hamou (2016)*

• Human brucellosis.

According to Calvet & al. (2010), the incubation period of brucellosis can vary greatly, ranging from two weeks to five months, and the clinical presentation is usually polymorphic, earning it the nickname "the disease with a hundred faces."

- **Subclinical form:**

  The disease is asymptomatic. This clinical form is diagnosed through serology and has been reported in individuals professionally exposed, such as veterinarians and farmers. (Bervas & al., 2006)

- **Acute form:**

  The septicemic form is the most classic and least common (Perelman, 1970). After an incubation period of 14 to 21 days, the classic picture of undulating suduro-algic fever appears. The fever is accompanied by profuse night sweats with an odor of wet straw, as well as generalized, fleeting, and migratory arthralgia-myalgia (Bodelet, 2002). Examination may reveal splenomegaly, sometimes hepatomegaly, or lymphadenopathy (Kernbaum, 1982).

- **Focal brucellosis:**

  According to Kernbaum (1982), it is most commonly observed within the first year. Bodelet (2002) reported that osseous foci primarily affect the vertebral bodies (spondylodiscitis). Bursitis or tenosynovitis can also occur due to the involvement of bursae, tendons, or synovial sheaths. Genital complications manifest as orchitis or orchio-epididymitis in males and mastitis in females. Nervous system involvement, according to Kernbaum (1982), can result in brucellar meningoencephalitis, presenting with meningeal syndrome, athetoid movements, external strabismus, and alterations in consciousness that can progress to coma. Other observed manifestations include mild hepatitis or, less commonly, jaundice and angiocholangitis, bronchitis (inflammation of the respiratory bronchi), pleurisy (inflammation of the pleura membrane of the lungs), and, rarely, endocarditis as a consequence of exceptional cardiovascular involvement.

- **Chronic brucellosis:**

According to Pilly (1997), chronic brucellosis has a dual expression: one is general, characterized by fatigue and thermal imbalance upon exertion or immediate hypersensitivity upon contact with Brucella. The other is focal, represented by quiescent osseous, neuro-meningeal, or visceral foci.

c. Lesions

• Animal brucellosis

In general, the organs of animals that have died from brucellosis show specific but variable and inconsistent histological alterations. Local lymphadenitis is systematic, accompanied by lymphoid hyperplasia (Sibille, 2006). The uterine cavity contains a variable amount of dirty gray, firm or viscous exudate, loaded with purulent flakes of varying volume. The cotyledons of the uterus are necrotic, grayish-yellow, and covered with a sticky, odorless, and brownish exudate. In the aborted fetus, significant subcutaneous edema develops, and the splanchnic cavities are filled with serosanguinous exudate (Godfroid & al., 2003). The fetal membranes may appear cloudy and sometimes yellowish (Merial, 2016).

• Human brucellosis

According to Bodelet (2002), the Brucella granuloma known as "brucelloma" is formed by polymorphonuclear cells that have phagocytosed the bacteria, surrounded by aggregated lymphocytes creating an epithelioid crown. These granulomas are primarily found in the liver, spleen, bones, heart, or kidney, and represent necrotic lesions with a granulomatous reaction at the periphery on a histopathological scale. They are mainly associated with three Brucella species: melitensis, abortus, and suis. According to Bourdeau (1997), deep muscular abscesses can occur as a result of bone involvement.

2. Epidemiology

a. Geographical distribution

Brucellosis has a global distribution with a predominance in the Mediterranean basin. The disease is more common in rural areas than in urban areas (Dentoma, 2008). Due to its biodiversity, environmental and climatic variability, as well as human and animal migratory movements, the Mediterranean region has become a highly sensitive area to zoonoses. In fact, brucellosis, also known as “Mediterranean fever” is one of the most widespread zoonoses in this region (Figures 5 and 6). The countries with the highest incidence of human brucellosis are Algeria, Saudi Arabia, Iran, Palestine, Syria, Egypt, and Oman (Bounaadja, 2010). North Africa is considered an endemic area for brucellosis. According to data from the

World Organisation for Animal Health (OIE), the incidence of brucellosis in Algeria ranks 10th among the countries most affected by brucellosis worldwide, with 84.3 cases per millioninhabitants annually (Abadane, 2014).

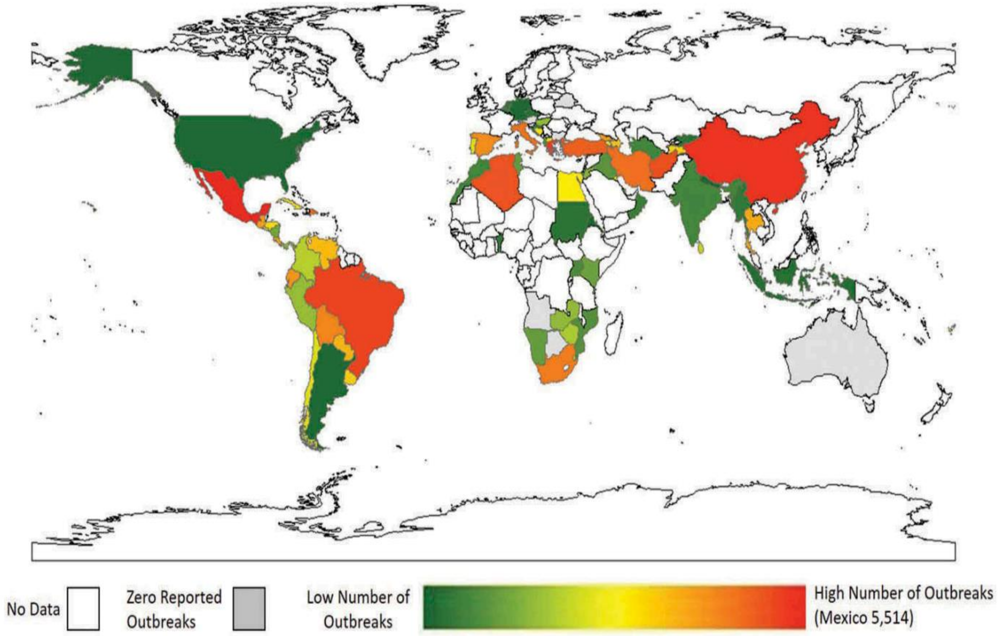

Figure 4: *Geographical distribution of animal brucellosis (Abadane, 2014)*

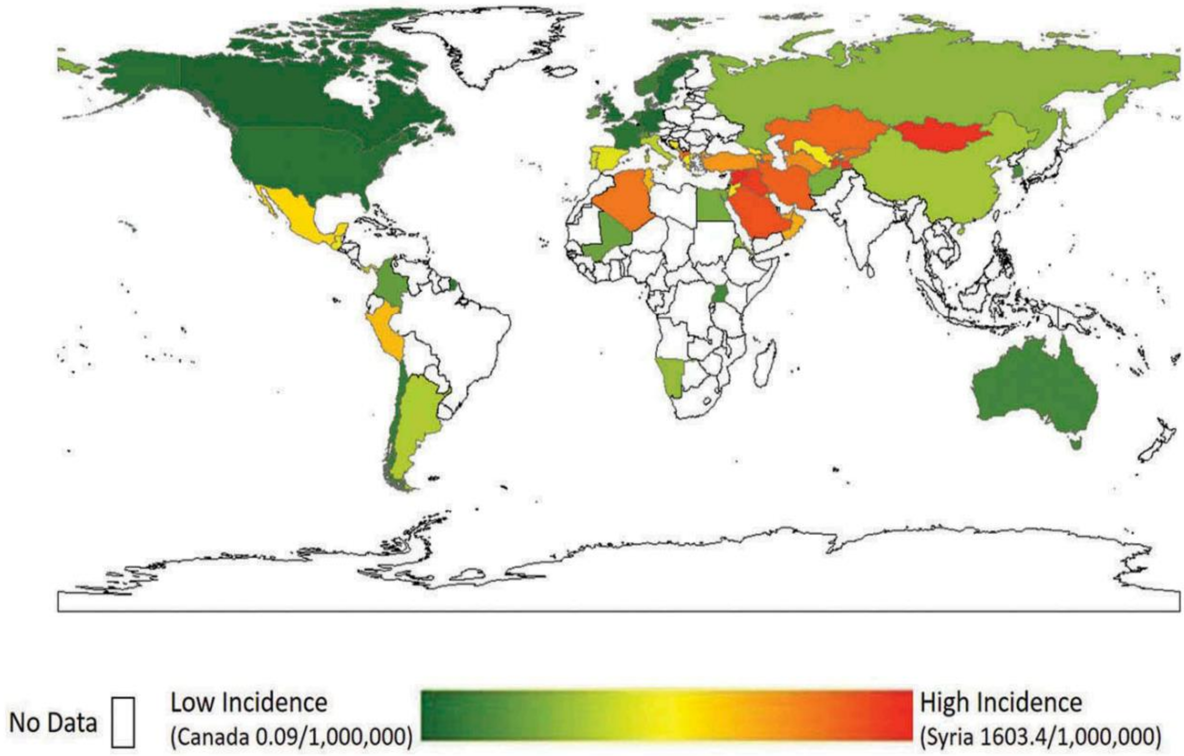

Figure 5: *Cases of human brucellosis.*

b. Contamination source

- **Animal**

The contamination of a healthy herd most often occurs through the introduction of an apparently infected animal; that is why any infected animal, whether it shows symptoms of brucellosis or not, should be considered a potential source of contamination throughout its life (Fournier, 2014). The sources of infection are specifically represented by: the placenta, vaginal secretions, the fetus, urine, and milk from an infected animal that can contaminate the stables (Bezzaoucha, 2004), as well as colostrum and semen (Adamou, 2014). Indeed, infected bulls should always be considered potentially dangerous as they can excrete Brucella abortus. Suppurative products (hygromas), feces, and infected viscera only play a potential role in human contamination (Merial, 2016)

- **Human**

According to Roux (1979) and Mailles and Vaillant (2007), human brucellosis only exists in relation to animal brucellosis. Indeed, human-to-human transmission is exceptional because humans are an epidemiological dead-end, meaning they do not facilitate the transmission of the disease. Human epidemiology in a given region generally closely parallels the animal situation and its evolution.

c. Transmission mode

- **With animals**

Vertical transmission: can occur in utero or during passage of the newborn through the pelvic canal (Godfroid & al., 2003). Young animals generally eliminate the infection if they are resistant. In infected young females, clinical signs (abortion) and serological reactions may appear during their first pregnancy or later (Merial, 2016). According to Freycon (2015), horizontal transmission can be direct through direct contact between infected and healthy individuals during cohabitation (via the airway), ingestion of contaminated food, venereal transmission, or through males acting as mechanical vectors in case of genital involvement. Indirect transmission involves the environment, where transmission occurs through objects contaminated with virulent materials. Various animals, such as dogs or birds, can participate in the dissemination of the pathogen.

- **With humans**

In most cases (Mallay, 2002 and Pilly, 1997), human contamination occurs through direct contact with animals, explaining the occupational nature of the disease. Alternatively, it can occur through the ingestion of raw milk, fresh cheeses, and, less commonly, vegetables contaminated by manure. Exceptionally, contamination may occur after the consumption of undercooked meat.

d. Condition of infection

- **Animal**

The susceptibility factors related to animals are generally influenced by extrinsic factors, particularly those related to the environment and rearing practices (Boukary, 2014). The intensification of livestock farming promotes the spread of the disease, and the distribution of brucellosis can be explained by the fact that pastures are shared among different herds with unknown health statuses (Godfroid & al., 2003). The susceptibility factors related to animals include:

-Species: Cattle are primarily infected by Brucella abortus, as stated by Godfroid & al. (2003), but they can also be infected with Brucella melitensis when in contact with infected goats or sheep.

-Breed: According to Godfroid & al. (2003) and D'almeida (1983), there doesn't appear to be any bovine breeds that are inherently more resistant to brucellosis than others. However, imported breeds may be more susceptible than local breeds. These differences in susceptibility are thought to be due to individual immunity acquired over generations under the influence of environmental factors rather than natural resistance.

-Age: The most susceptible age is after the complete development of the genital organs. Pubertal cattle typically remain infected throughout their lives, while young animals often recover from their infection (Sibille, 2006). The individual prevalence of brucellosis is higher in older animals compared to young animals, as this higher prevalence logically corresponds to a greater probability of exposure to the infection. Articular and synovial locations primarily affect adults and older females. Newborns and young animals can develop a unnoticed septicemic form, predisposing them to frequent colibacillosis and salmonellosis at that age (Boukary, 2014).

-Sex: According to Godfroid & al. (2003), both females and males can be affected by brucellosis.

-Physiological status: According to various studies, there is no clear relationship between the physiological status of the animal and its serological status. However, it appears that in dairy females, susceptibility to brucellosis is correlated with production level and overall health status of the animal. The individual prevalence of brucellosis is higher in dairy females at the beginning of lactation (Boukary, 2014). Gestation is an important factor of susceptibility (Adamou Harouna, 2014).

- **Human**

According to Perelman (1970), brucellosis can occur at any age, but in 70% of cases, it occurs between 20 and 50 years of age. The predominance in males is related to the conditions of contamination (women have less contact with virulent materials). 85% to 90% of cases are observed in rural areas because the disease affects individuals living with reservoir animals or consuming their fresh products.

3. Diagnostic

The diagnosis of suspicion is based on clinical signs such as abortions (OIE, 2011), and confirmation relies on serological tests followed by laboratory tests.

a. Epidemio-clinical diagnosis.

According to Sibille (2006), the symptoms of brucellosis are late and nonspecific, and sometimes the disease is subclinical, making diagnosis difficult. In such cases, the diagnosis is based on herd history. Suspicion of bovine brucellosis may arise from isolated or series of abortions, death of a calf from anoxia within 48 hours after parturition, retained placenta, hygromas, and orchitis/epididymitis in males. According to Perelman (1970), in humans, the medical history helps to identify a stay in an endemic country, foodborne transmission following the ingestion of raw milk or fresh cheese from an infected animal, and especially the occupation, such as shepherd or veterinarian.

b. Laboratory diagnosis

The use of laboratory methods is essential to confirm the suspicion through the isolation of the pathogen, detection of its antigens, or the detection of the host's immune response (Freycon, 2015).

- **Bacteriological diagnosis.**

The most reliable samples for bacteriological diagnosis are cotyledons of the placenta, vaginal secretions, or lung, liver, and abomasal contents of the fetus. This type of diagnosis is performed through microscopic examination with staining or culture in selective media, allowing for the identification of Brucella (Sibille, 2006).

Coloration and microscopic examination are the first steps in bacteriological examination, and the isolation of Brucella on selective media (to inhibit the growth of other organisms) is necessary to confirm the presence of the bacteria in the biological samples. After 3-4 days of incubation, Brucella colonies appear as raised, transparent, honey-colored, smooth, shiny, with a regular contour and 1-2 millimeters in diameter. Three biochemical tests, including oxidase, catalase, and urease tests, are used for the identification of Brucella colonies (Godfroid & al., 2003).

However, this method has limitations. It is not highly specific as Brucella can be confused with Chlamydia and Coxiella. Additionally, it can be laborious, dangerous due to manipulation, and has low sensitivity for milk and dairy products where Brucella is present in low quantities. Interpretation can also be difficult due to the presence of fat globules (Adamou, 2014).

In human medicine, bacteriological diagnosis involves isolating the infectious agent from blood (blood culture), and sometimes from puncture products such as lymph nodes, liver, or bone marrow (Kernbaum, 1982).

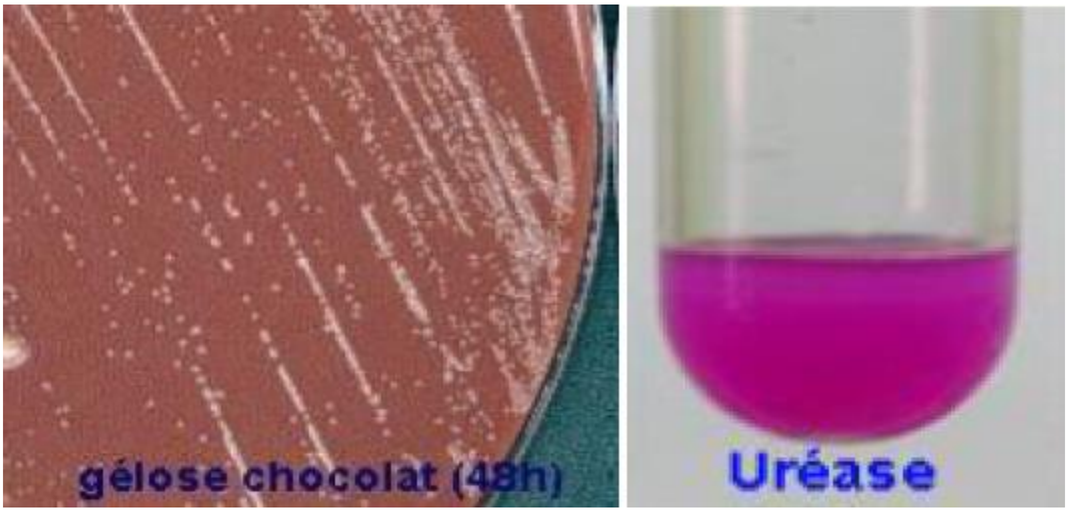

Figure 6: *Culture of Brucella*

• Diagnosis by molecular biology (PCR).

PCR (Polymerase Chain Reaction) is a technique used for the identification of nucleic acids through amplification. It can be performed on various samples such as blood, milk, nasal secretions, spleen, semen, lymph nodes, and aborted fetuses. PCR allows for the detection and identification of Brucella species and their biovars (Bounaadja, 2010).

• Serological diagnosis.

Serological diagnosis is widely used on serum or milk samples. Primary tests focus on the recognition of antigens, while classical or secondary tests depend on the ability of antibodies to perform immune functions (Godfroid & al., 2003).

In serological diagnosis, antibodies are detected against the LPS (lipopolysaccharide) of Brucella. However, the similarity between Brucella abortus and other bacteria such as Yersinia, Salmonella, and Escherichia can pose a diagnostic challenge (Freycon, 2015).

-Wright's Séroagglutination Test (SAW):

This test is used to detect IgG and IgM antibodies, typically 7 to 15 days after the onset of symptoms, and it rapidly becomes negative after recovery. If a high titer persists one year after the onset, it may indicate a deep-seated infection. The SAW is the reference reaction recommended by the World Health Organization (WHO) (Hamou, 2016).

-Buffered Antigen Test (BAT) "Rose Bengal Test":

The Rose Bengal Test, also known as the Buffered Antigen Test (BAT), is a simpler and widely used method for detecting brucellosis antibodies in sera. In this test, an antigen suspension of Brucella abortus, which appears as an intense pink color, is used. This test allows serological diagnosis on a slide for brucellosis caused by Brucella melitensis and Brucella abortus. If specific antibodies are present, visible agglutination can be seen with the naked eye. If no specific antibodies are present, the mixture remains homogeneous (figure 7) (Sibille, 2006).

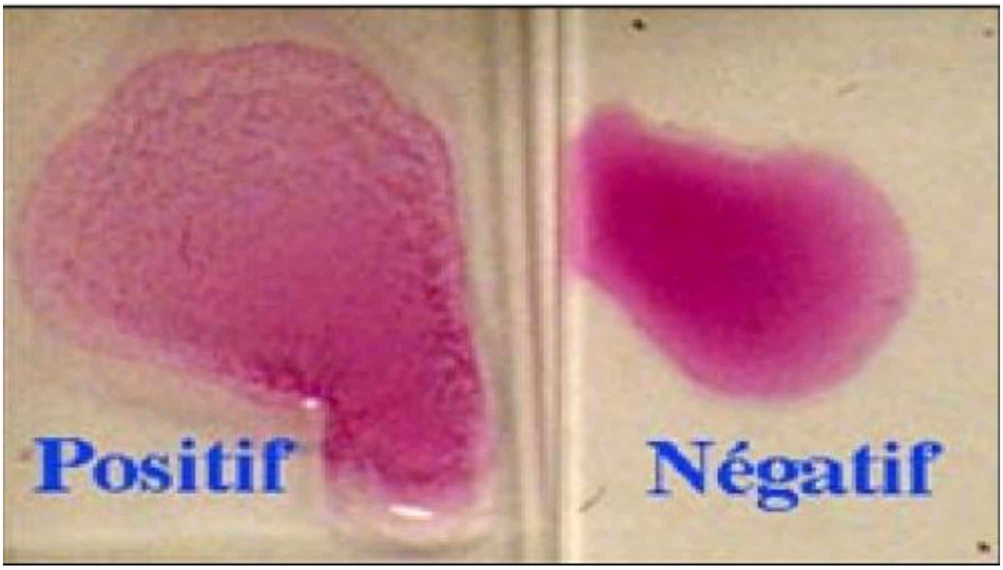

Figure 7: *Rose Bengal Test Khettab & al. (2010)*

-The Brown Ring Test, also known as the "Ring Test":

It is used to detect brucellosis antibodies in milk (Figure 9). It is a highly effective, easy-to-perform, and cost-effective test, commonly used on bulk milk samples, particularly in bovines. It can be conducted frequently to screen for infected dairy herds. The Ring Test is a qualitative agglutination reaction that occurs when the antibodies present in milk interact with the bacterial LPS antigen, which is stained with hematoxylin, resulting in the formation of a ring (Araita Hebano, 2013).

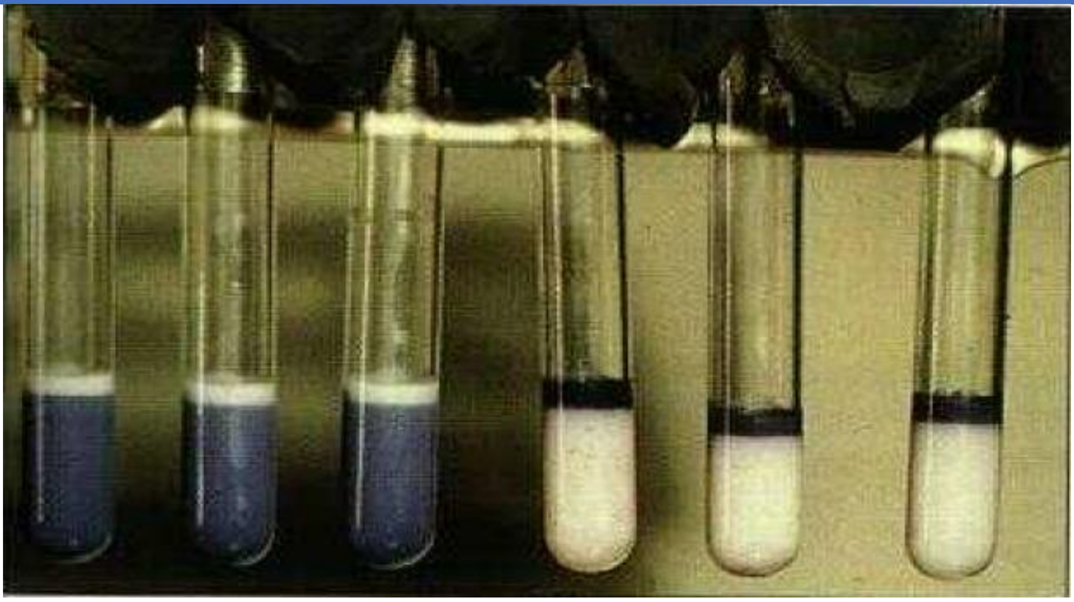

Figure 8: *Milk Ring Test*
Hart & Shears (1997)

- Other serological tests:

-Indirect Immunofluorescence Technique: It allows the identification of IgG and IgM antibodies. Its sensitivity is excellent, with a titer twice as high as that of the Wright serodiagnostic test. (Khettab & al., 2010)

- ELISA (Enzyme-Linked Immunosorbent Assay): It uses the LPS (lipopolysaccharide) as the antigen. It is an automated, rapid, and efficient diagnostic method, considered the best test used in Brucellosis monitoring and control programs. It allows for the analysis of a large number of individual milk samples or bulk milk. ELISA has a lower specificity compared to the Rose Bengal test and complement fixation test. (Adamou, 2014)

- Complement Fixation Test: According to Godfroid & al. (2003) and Mallay (2002), the complement fixation test detects the presence of IgG and IgM antibodies. Non-specific reactions are uncommon in this test. In human diagnosis, serological testing relies on the detection of anti-Brucella antibodies in serum. The Wright seroagglutination is the reference technique. Other methods include the Rose Bengal test and indirect immunofluorescence.

• Allergic diagnosis.

Allergic screening allows for the detection of cellular immunity (Sibille, 2006). It involves a delayed hypersensitivity reaction following the injection of Brucella into the dermis (intradermal brucellin test). Thickening of the skin fold 72 hours after injection indicates a positive reaction. This reaction is specific but not very sensitive (false negatives). It does not differentiate between an infected animal and a vaccinated animal. It is not commonly used in practice.

• Differential diagnosis.

-In Animals:

The symptoms of brucellosis are nonspecific and appear late. Abortion, a significant consequence of the disease, can also be caused by other pathogens such as Trichomonas fetus, Campylobacter fetus, Leptospira pomona, Listeria monocytogenes, as well as the infectious bovine rhinotracheitis virus or diseases caused by other fungi such as Aspergillus and Absidia. (Godfroid & al., 2003)

-In Humans:

Granulomas that resemble lesions observed in tuberculosis, tularemia, or yersiniosis. (Bodelet, 2002)

4. Treatment

a. In veterinary medicine

Treatment of animals is not recommended and should be avoided due to its high cost, risks of developing resistance, and the lack of guarantee for the clearance of the treated animal. Prevention is the only feasible approach, based on sanitary and medical measures. (Araita Hebano, 2013).

b. In human medicine

Pilmis et Chehaibou (2015) reported that the treatment relies on intracellular antibiotic therapy.

5. Prophylaxis

a. Animal brucellosis control measures

• Medical prophylaxis.

It is based on vaccination, which is prohibited in bovine species except under special circumstances, and practiced in sheep and goats only in highly infected areas to prevent economic losses. (Bourdeau, 1997)

• Sanitary prophylaxis.

Sanitary prophylaxis aims to prevent the occurrence and spread of the disease through hygienic measures such as disinfection, quarantine, security perimeters, and screening of sick, carrier, or healthy individuals. The measures are adapted according to the epidemiological situation and the desired goal. (Freycon, 2015)

Defensive:

Defensive measures are essential for countries that are already infected and are considering brucellosis control, as well as for brucellosis-free countries (Araita Hebano, 2013). Defensive measures include controlling the entry of animals at the borders, allowing only the introduction of certified brucellosis-free cattle, implementing quarantine and individual serological testing, enhancing reproductive hygiene, and monitoring high-risk animals, especially during artificial insemination or public mating (Bodelet, 2002). Additionally, it is necessary to protect the livestock from neighboring contaminations, isolate females during parturition, destroy placentas, disinfect facilities, and regularly monitor the herds (Sibille, 2006).

Offensive:

Offensive measures, also known as sanitation measures, are a set of actions aimed at eradicating brucellosis from infected farms. According to Araita Hebano (2013) and Sibille (2006), these measures include:

- Screening: Identification of infected animals through diagnostic tests.

- Isolation: Separation of infected animals from healthy ones to prevent further spread.
- Sanitary slaughter: The humane slaughter of infected animals to eliminate the source of infection.
- Periodic disinfection: Regular cleaning and disinfection of contaminated premises and objects.
- Elimination of offspring: Removal of young females born to infected mothers to prevent the perpetuation of the disease.
- Control of susceptible species: Monitoring and elimination of infected animals in all susceptible species.
- Use of artificial insemination: Promotion of artificial insemination as a means to limit venereal transmission.

These offensive measures are crucial in controlling and eradicating brucellosis within affected herds and preventing its spread to other animals and farms.

b. Human brucellosis control measures

According to Mahassin (2012) and Hamou (2016), the fight against human brucellosis involves individual and collective measures. The destruction of animal reservoirs is the most effective means of combating human brucellosis. Prevention is primarily based on hygiene and safety rules, including:

- Personal protective equipment: Professionals in contact with infected products should wear gloves and masks to minimize the risk of transmission.
- Hand hygiene: Regular and thorough handwashing is essential to reduce the spread of the disease.
- Hygiene in livestock settings: Proper sanitation and hygiene practices in livestock areas help prevent contamination and transmission of Brucella.
- Pasteurization of dairy products: Consuming pasteurized dairy products reduces the risk of acquiring brucellosis from contaminated milk or dairy products.

These measures aim to minimize the exposure to Brucella bacteria and prevent the transmission of the disease from animals to humans.

EXPERIMENTAL PART

INTRODUCTION

Brucellosis is a highly contagious disease with a significant economic impact on the development of animal industries (Benkiran, 2001). Furthermore, being considered the most widespread zoonosis worldwide, it poses a serious threat to human health (World Health Organization, 2000). It is transmitted through direct contact with animals or by consuming raw contaminated animal products (particularly milk and dairy products).

According to the report from the Ministry of Health and Population (2000), 3,933 Algerians were affected by brucellosis in 2000, corresponding to an annual incidence of 13.0 cases per 100,000 inhabitants, compared to 8.5 cases in 1999. The disease is thus spreading, with significant epidemic outbreaks occurring in provinces such as Tébessa, Biskra, and M'sila. As with any infectious disease, surveillance and eradication efforts require synergy between animal health services and human health services.

In this regard, we conducted this first study in Souk Ahras to contribute to the characterization of this disease by examining its trends and calculating the annual and monthly prevalence of reported cases in both humans and animals. Our work consists of two parts. The first part is a synthesis of the literature on the study of animal and human brucellosis.

The second part corresponds to our study conducted at the Directorate of Agricultural Services (DSA) and the Directorate of Health (DH) of Souk Ahras.

Brucellosis is a highly serious and contagious disease. Despite the implemented measures, the infection persists, leading to massive losses in livestock and true epidemics in humans.

Our work is a retrospective descriptive study of animal and human brucellosis based on recorded cases at the level of the Directorate of Agricultural Services (DSA) and the Directorate of Health (DH) of Souk Ahras.

Its aim is to assess the disease in this province.

1. Materials and Methods

a- Description of the study area

Souk Ahras is situated in the extreme north east of Algeria, its area is 4360 km2, its border to the north is the province of El Taref, in the east is Tunisia, westward is the province of Guelma and the province of Oum el Bouaghi, in the south the province of Tebessa.

Souk Ahras has a population of 450,000 people.

The city of Souk Ahras has a semi continental and humid climate, heavy rains in the north in winter and very hot and dry in the south during summer.

The province is divided into 10 districts, which are further divided into 26 Municipalities.

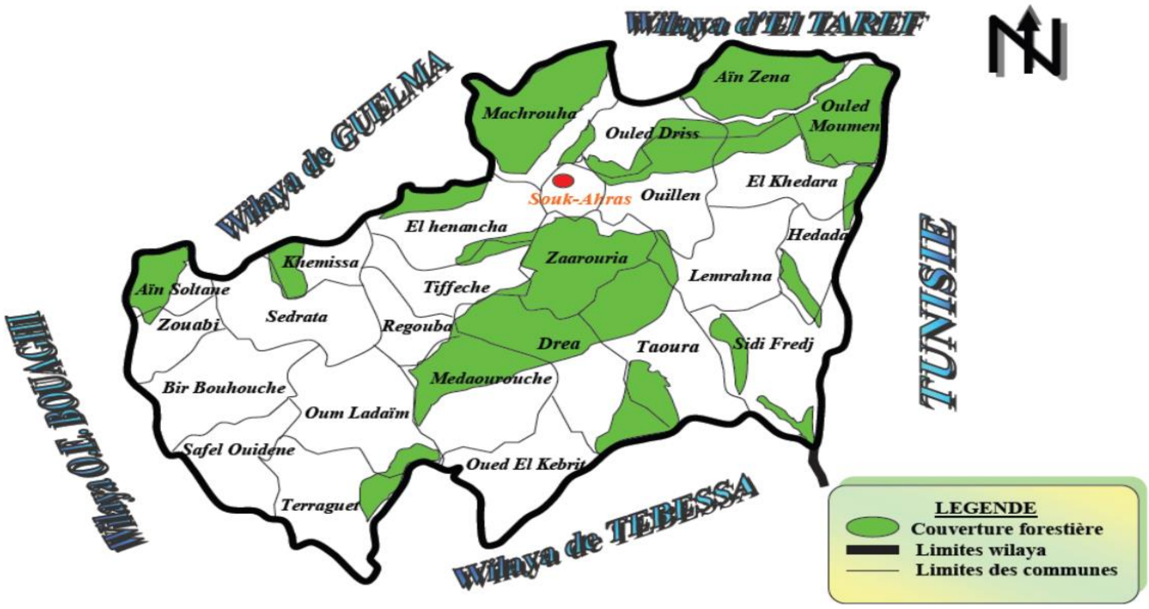

Figure 9: *Souk Ahras Province*

b- Place and period of study

Our study was conducted at the Directorate of Agricultural Services of Souk Ahras (DSA) and the Directorate of Health (DH) during the period from 2013 to 2022."

c- Methods

We collected all data related to animal and human brucellosis recorded in Souk Ahras from 2013 to 2022 using two procedures:

1. By studying the livestock registers of the Directorate of Agricultural Services in Souk Ahras.

2. By obtaining all reported cases of human brucellosis from the Directorate of Health (DH).

The obtained information includes:

- The number of cattle and goats tested and infected in Souk Ahras between 2013 and 2022.
- The number of human cases, including age, sex, and the patients' municipality.

Our database consists of almost 6000 tested cattle, 400 tested goats and 667 patients with brucellosis.

• **Statistical analysis.**

The recorded data was processed using Microsoft Excel software and presented in the form of tables and graphs.

2. Results and discussion

a- Animal brucellosis

• **Evolution of reported cases from 2013 to 2022**

The numbers of reported cases of animal brucellosis in Souk Ahras during the years 2013 to 2022 are detailed in Table 2.

Table 2: *Evolution of reported cases (2013 - 2021)*

year	2013	2014	2015	2016	2017	2018	2019	2020	2021
cattle	12	44	18	22	29	27	46	1	0
goats	/	/	21	153	85	113	44	/	/

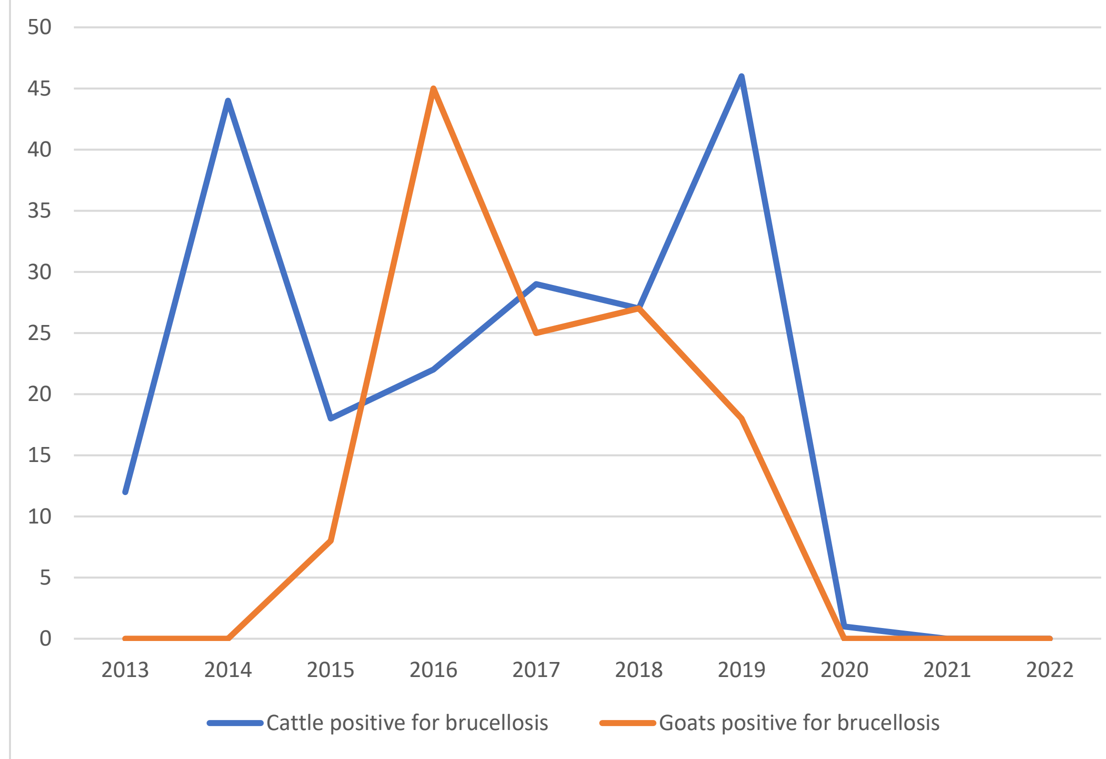

Figure 10: *Evolution of reported cases (2013 - 2021)*

According to Figure 10, it can be observed that the number of reported cases of bovine brucellosis increased from 12 cases in 2013 to 44 cases in 2014, this rise could be attributed to a lack of screening.

A significant decrease was noted after that year, likely due to the implementation of preventive measures.

In 2019, a significant increase was noted, reaching a peak of 46 cases reported, due to the relaxation of vaccination and absence of animal control at selling points, especially livestock markets.

Similarly, goats have also witnessed an increase in cases, particularly in the year 2016, likely for similar reasons.

Due to the Covid-19 pandemic, there has been a shortage of testing and data since 2020.

- **Distribution of cases of animal brucellosis by municipality**

Out of the 26 Municipalities in Souk Ahras, 16 have been affected by the disease, accounting for 62.5% of the Municipalities. This can be justified by the agricultural nature of the province.

According to Table 3, the Municipalities of Sedrata, Souk Ahras, Ouled Idriss and Medawrouch are the most affected by brucellosis infection, likely due to large cattle and goats population in these areas.

Table 3: *Distribution of brucellosis cases in the Municipalities of Souk Ahras (2013-2021)*

Municipalities	Cattle	Percentage	Goats	Percentage
Souk Ahras	25	12.5%	27	21.9%
Ain Zena	11	5.5%	0	0%
Mashroha	8	4%	0	0%
Merahna	6	3%	0	0%
Hnancha	5	2.5%	0	0%
Ouled Idriss	22	11%	16	13%
Medawrouch	20	10%	11	8.9%
Wilan	4	2%	0	0%
Taoura	6	3%	13	10.%5
Zarouriya	9	4.5%	10	8.1%
Sedrata	30	15%	45	36.5%
Sidi Fredj	10	5%	0	0%
Bir Bouhouch	17	8.5%	10	8.1%
Tifech	13	6.5%	11	8.9%
Om ladhaym	8	4%	0	0%
Ain Sultan	6	3%	0	0%

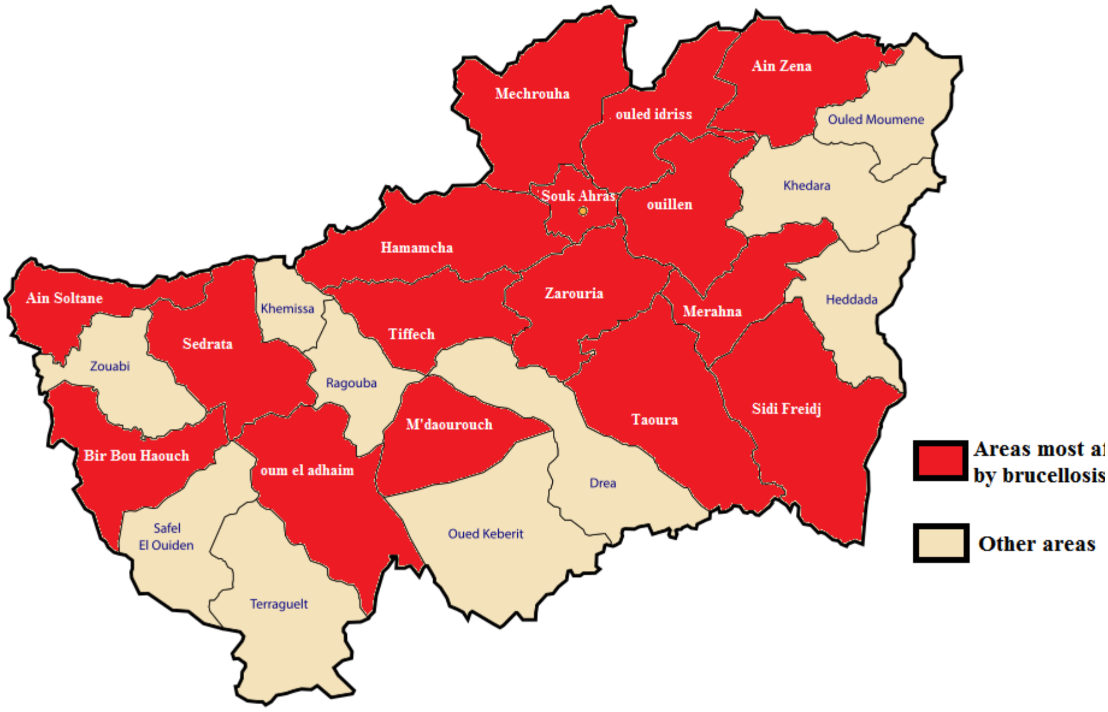

Figure 11: *Geographical distribution of bovine brucellosis cases in the province of Souk Ahras (2013-2021)*

It appears that the widespread extension of the disease is due to a lack of control over the movement of animals, especially at points of sale.

- **Prevalence of animal brucellosis.**

Prevalence refers to the number of individuals affected by a disease at a given time compared to the number of individuals at risk. It serves as a good indicator of the disease burden within a population. It is calculated as follows:

(Number of subjects affected / Number of subjects at risk) × 100

The prevalence of bovine and goat brucellosis in Souk Ahras during the years 2013 to 2021 is mentioned in Table 4.

Table 4: *Prevalence of animal brucellosis (2013-2021)*

Year	Cattle tested for brucellosis	Cattle positive for brucellosis	Prevalence	Goats tested for brucellosis	Goats positive for brucellosis	Prevalence
2013	1655	12	0.72%	/	/	/
2014	1347	44	3.2%	/	/	/
2015	660	18	2.72%	21	8	38%
2016	432	22	5.09%	153	45	29.4%
2017	419	29	6.92%	85	25	29.4%
2018	630	27	4.2%	113	27	23.8%
2019	363	46	12.6%	44	18	40.9%
2020	140	1	0.7%	/	/	/
2021	223	0	0%	/	/	/

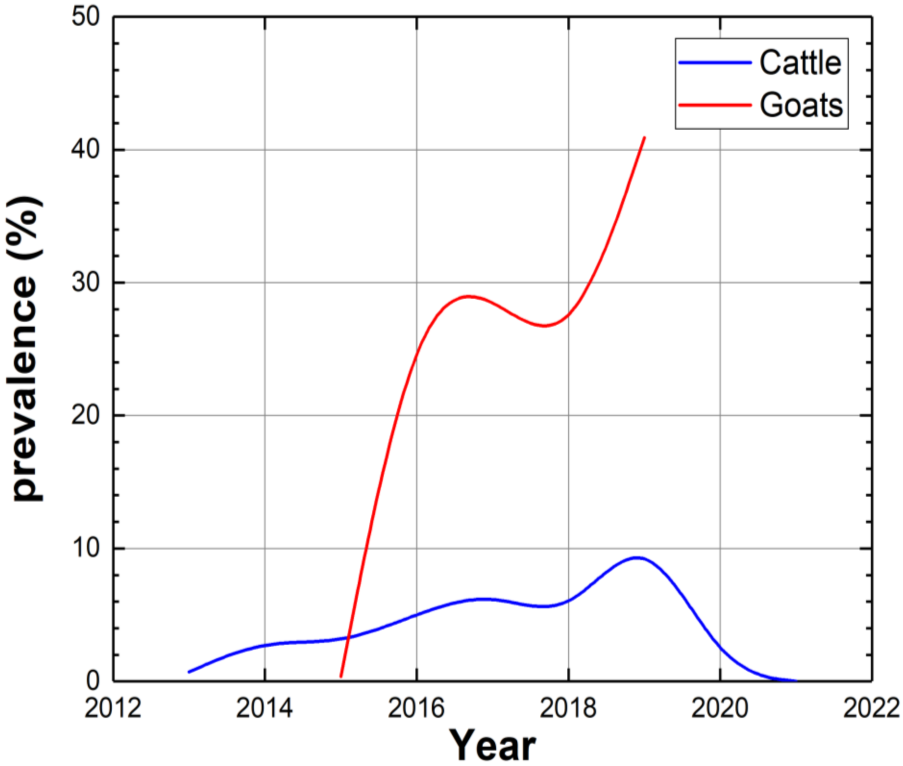

Figure 12: *Prevalence of animal Brucellosis (2013-2022)*

The Figure 12 shows that the prevalence of brucellosis in Souk Ahras varied during the period from 2013 to 2021, with the highest rate recorded in 2019 at 12.6% for cattle and 40.9% for goats. This corresponds to an average individual prevalence of 14%. This result may indicate poor vaccination practices. According to Lounes (2014), vaccination significantly reduces the prevalence of the disease. The disease cannot spread within a population when 70% to 80% of individuals are vaccinated (Charles Nicolle's law).

b- Human brucellosis

- **Evolution of human cases declared in Souk Ahras (2017-2022).**

The cases of human brucellosis recorded in Souk Ahras between 2017 and 2022 showed a peak of 192 cases in 2019, followed by a rapid decline to 39 cases in 2020 (Figure 13). The decline in reported cases of brucellosis may be attributed to the impact of the COVID-19 pandemic. Due to the similarities in symptoms between COVID-19 and brucellosis, hospitals and healthcare facilities may have prioritized COVID-19 testing and management, potentially leading to a reduced focus on diagnosing and treating brucellosis cases.

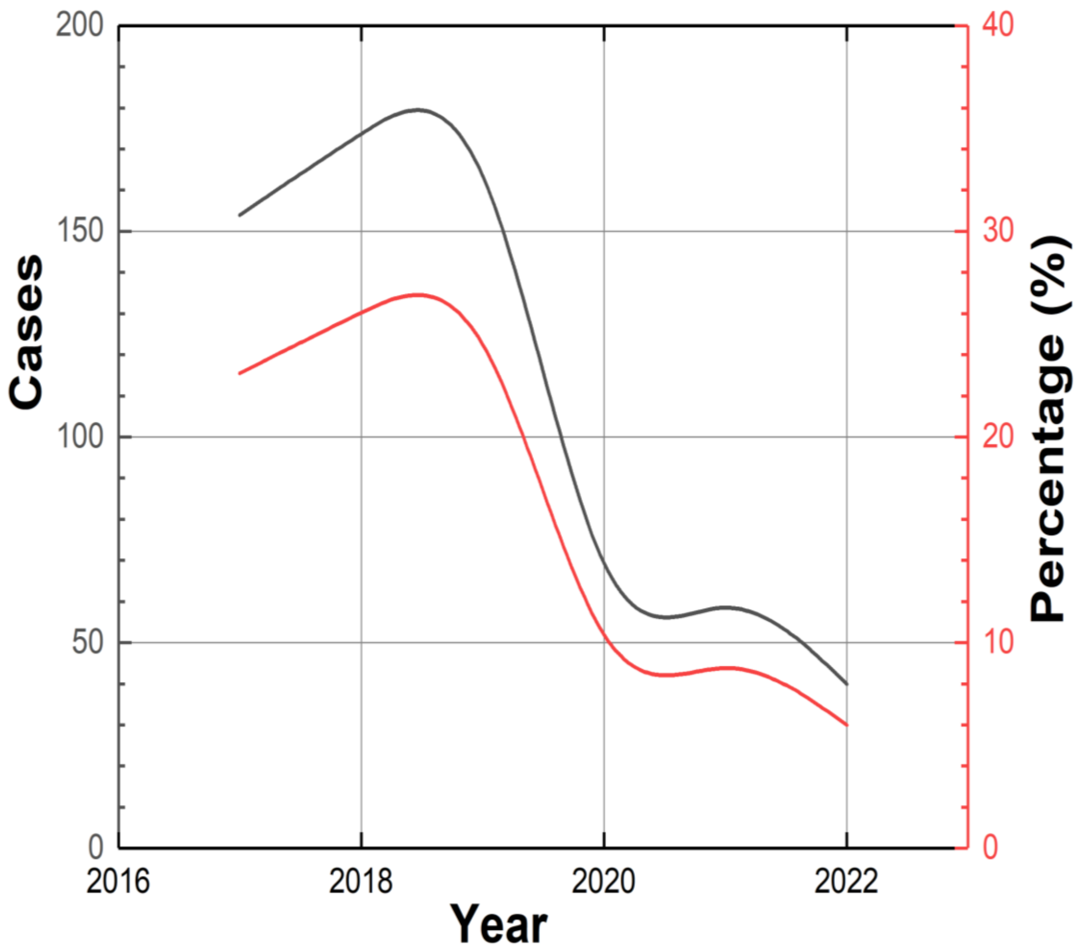

Figure 13: *Number of reported human cases in the province of Souk Ahras (2017-2022)*

The estimated number of human brucellosis cases during the six-year period (2017-2022) is 667 cases. The actual numbers of affected individuals are difficult to assess due to a lack of information regarding individuals with the disease on one hand, and the clinical polymorphism of the disease and underreporting on the other hand. In fact, according to Akayeza (1984), human brucellosis can be confused with certain diseases such as malaria, typhoid fever, and all flu-like conditions that are very common on our continent.

- **Distribution of cases of human brucellosis by region.**

According to the tables below (5, 6, 7 and 8), it is observed that the Municipalities of Souk Ahras, Sedrata and Ain Zena are the most affected by human brucellosis.

Table 5: *Distribution of human brucellosis cases in the Municipalities of Souk Ahras in 2019*

Municipality	Number of cases	Percentage%
Souk Ahras	23	11.9%
Ain Zena	41	21.3%
Mashroha	30	15.6%
Merahna	16	8.3%
Hnancha	13	6.7%
Ouled Idriss	13	6.7%
Medawrouch	9	4.6%
Other Towns	47	24.4%

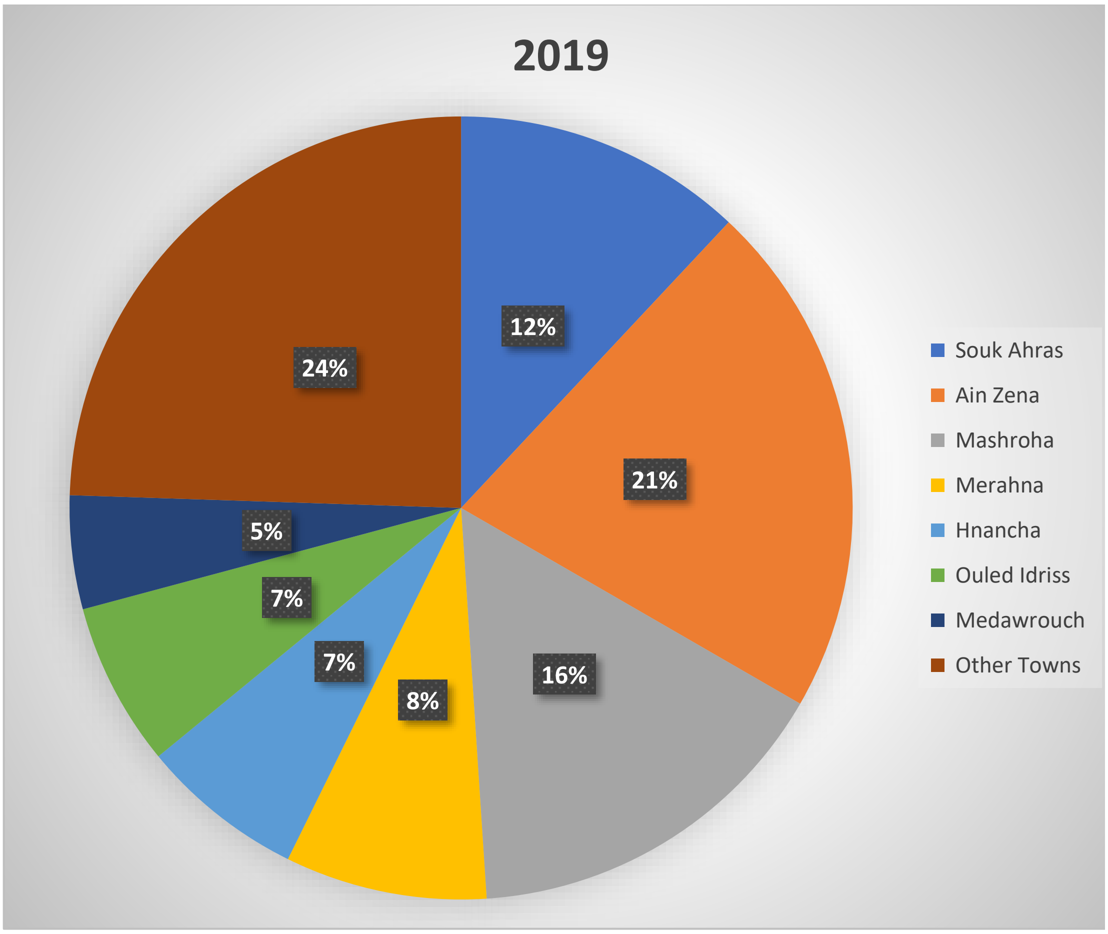

Figure 14: *Distribution of human brucellosis cases in the Municipalities of Souk Ahras in 2019*

Table 6: *Distribution of human brucellosis cases in the Municipalities of Souk Ahras in 2020*

Municipality	Number of cases	Percentage%
Souk Ahras	3	7.6%
Ain Zena	2	5.12%
Mashroha	1	2.5%
Merahna	2	5.12%
Hnancha	1	2.5%
Ouled Idriss	3	7.6%
Medawrouch	4	10.2%
Wilan	1	2.5%
Taoura	1	2.5%
Zarouriya	1	2.5%
Sedrata	5	12.8%
Sidi Fredj	1	2.5%
Bir Bouhouch	1	2.5%
Tifech	2	5.12%
Oum Ladhayem	4	10.2%
Ain Sultan	1	2.5%
Other Towns	6	15.3%

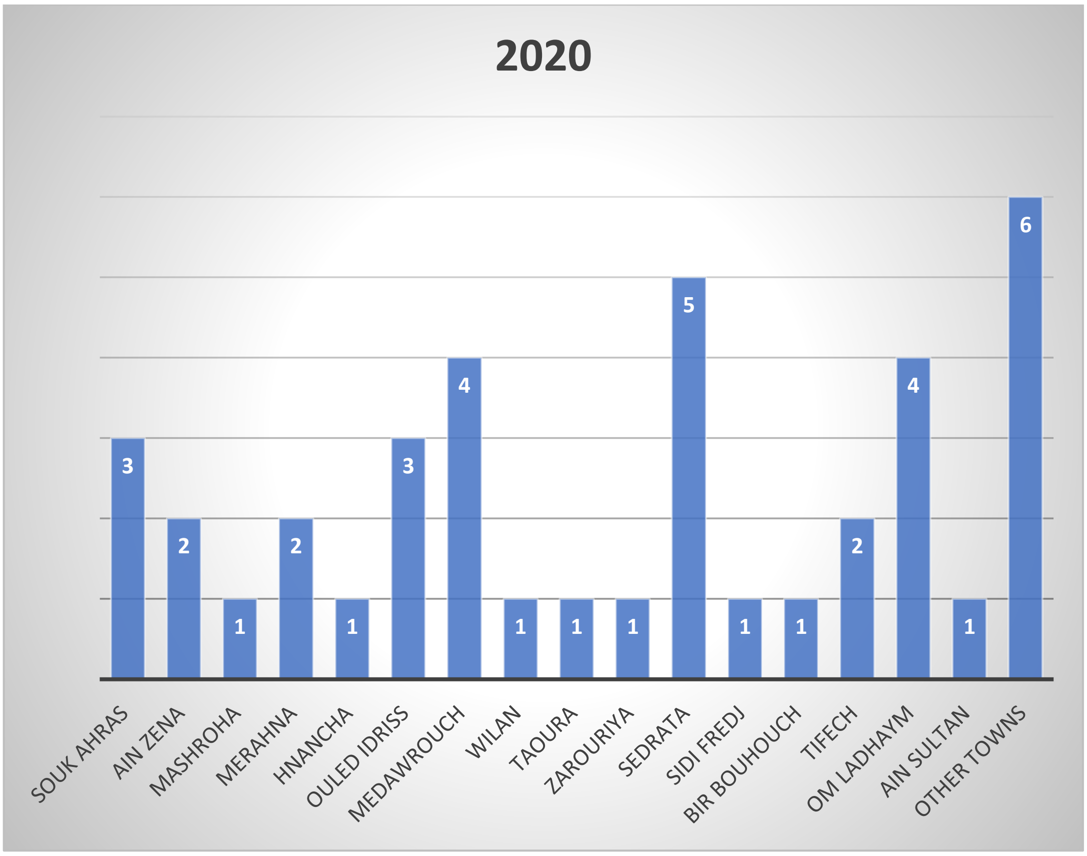

Figure 15: *Distribution of human brucellosis cases in the Municipalities of Souk Ahras in 2020*

Table 7: *Distribution of human brucellosis cases in the Municipalities of Souk Ahras*

in 2021		
municipality	Number of cases	Percentage%
Souk Ahras	12	17.6%
Ain Zena	3	4.4%
Mashroha	8	11.7%
Merahna	1	1.4%
Hnancha	6	8.8%
Ouled Idriss	3	4.4%
Medawrouch	2	2.9%
Wilan	2	2.9%
Taoura	3	4.4%
Zarouriya	16	23.5%
Sedrata	3	4.4%
Sidi Fredj	1	1.4%
Bir Bouhouch	1	1.4%
Tifech	2	2.9%
Oum Ladhayem	2	2.9%
Ain Sultan	2	2.9%
Other Towns	1	1.4%

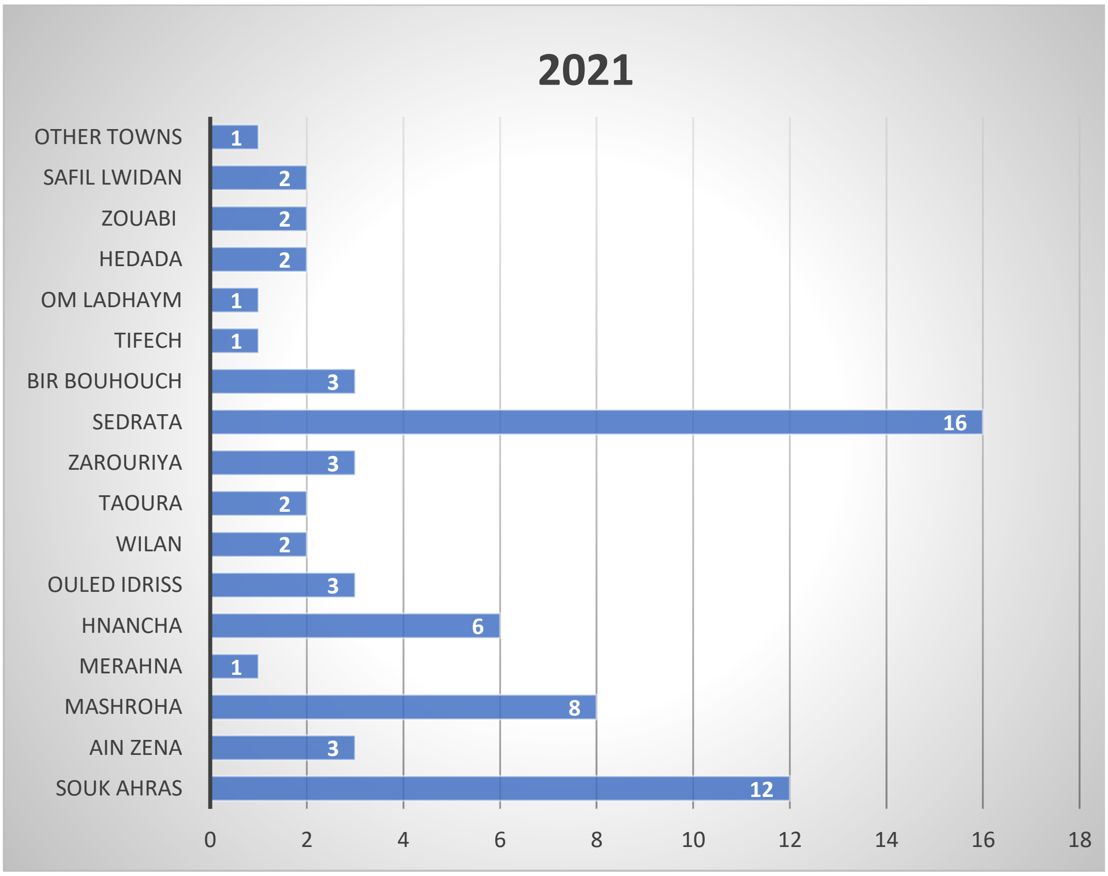

Figure 16: *Distribution of human brucellosis cases in the Municipalities of Souk Ahras in 2021*

Table 8: *Distribution of human brucellosis cases in the Municipalities of Souk Ahras in 2022*

Municipality	Number of cases	Percentage%
Souk Ahras	4	10%

Ain Zena	2	5%
Mashroha	5	12.5%
Merahna	1	2.5%
Hnancha	3	7.5%
Ouled Idriss	1	2.5%
Medawrouch	2	5%
Wilan	4	10%
Taoura	3	7.5%
Zarouriya	2	5%
Sedrata	1	2.5%
Sidi Fredj	1	2.5%
Bir Bouhouch	3	7.5%
Tifech	4	10%
Oum Ladhayem	2	5%
Ain Sultan	2	5%

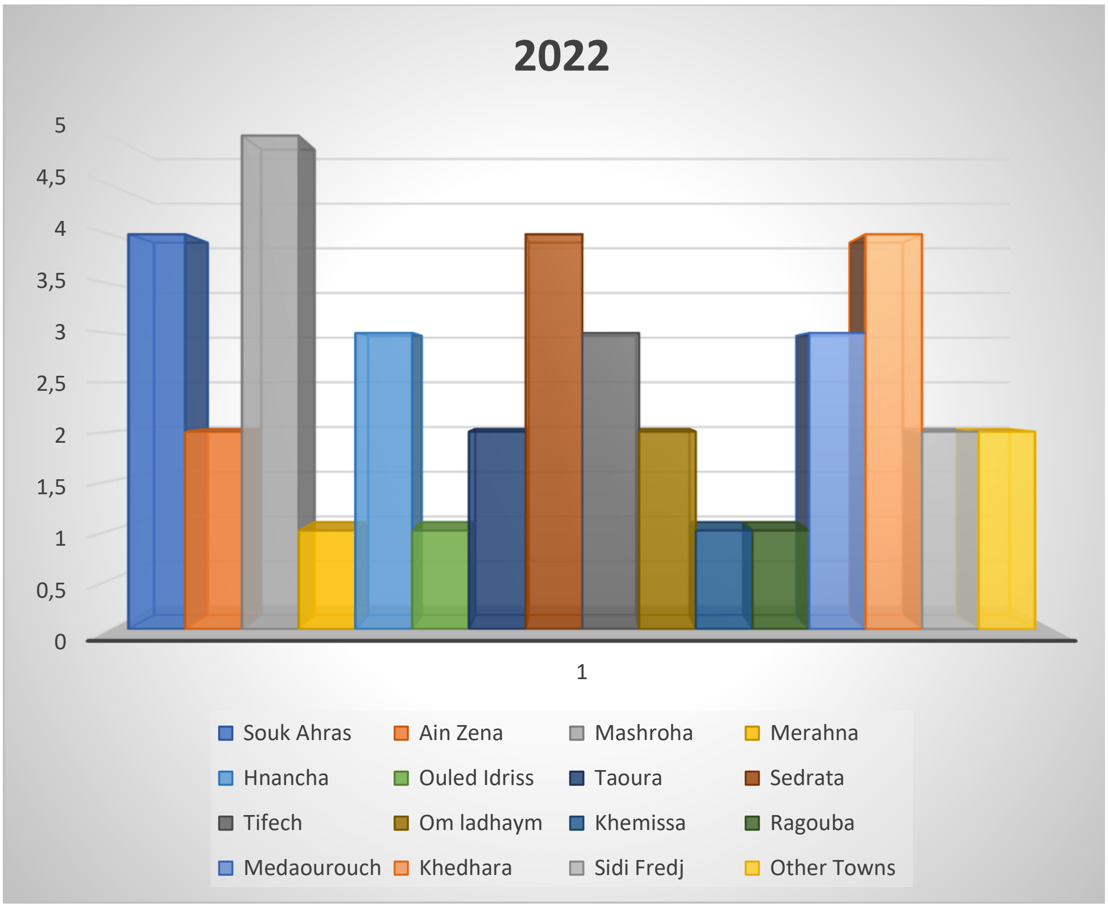

Figure 17: *Distribution of human brucellosis cases in the Municipalities of Souk Ahras in 2022*

The majority of human cases of this disease have been detected in Ain Zena, a rural and agricultural municipality, where brucellosis has affected a large number of cattle, which are responsible for the disease in humans. Additionally, cases have been reported in the commune of Souk Ahras, possibly due to the movement of people who may be infected from other communes. As Souk Ahras is the capital of the province, this has led to the contamination of its residents.

Figure 18: *Geographical distribution of human brucellosis cases in Souk Ahras (2017-2022)*

- **Distribution of brucellosis according to sex**

The distribution of brucellosis cases according to the sex of the patients is presented in table 9.

Table 9: *Distribution of brucellosis infection based on the gender of patients*

	Number	Percentage
Male	73	57.9%
Female	53	42.1%

Figure 19: *Distribution of brucellosis infection based on the gender of patients*

From this pie, we observe that the number of men affected by brucellosis is significantly higher than the number of women. This is due to the close contact of men, especially farmers and veterinarians, with animals and virulent materials. This is supported by studies conducted by Durr & al. (2000), Khettab & al. (2010), and Allouani (2013).

- **Distribution of brucellosis according to age**

The distribution of brucellosis cases by age in humans shows that the disease primarily affects individuals between the ages of 20 and 64 (table 10 and figure 20). This can be explained by the fact that this age group (20-64 years) is more active in professions such as veterinarians or livestock breeders, which increases their risk of exposure and contamination during the course of their work. Additionally, individuals in this age range may consume more milk and dairy products, further increasing their risk. This pattern has been previously described by Durr & al. (2000) and Khettab & al. (2010). According to Perelman (1970), brucellosis is rare in children.

Table 10: *Distribution of brucellosis infection based on the age of patients (2020-2022)*

Age	**Cases**
[0-10[	1
[10-14[	4
[15-19[	1
[20-44[	65
[45-64[	53
More than 65	23

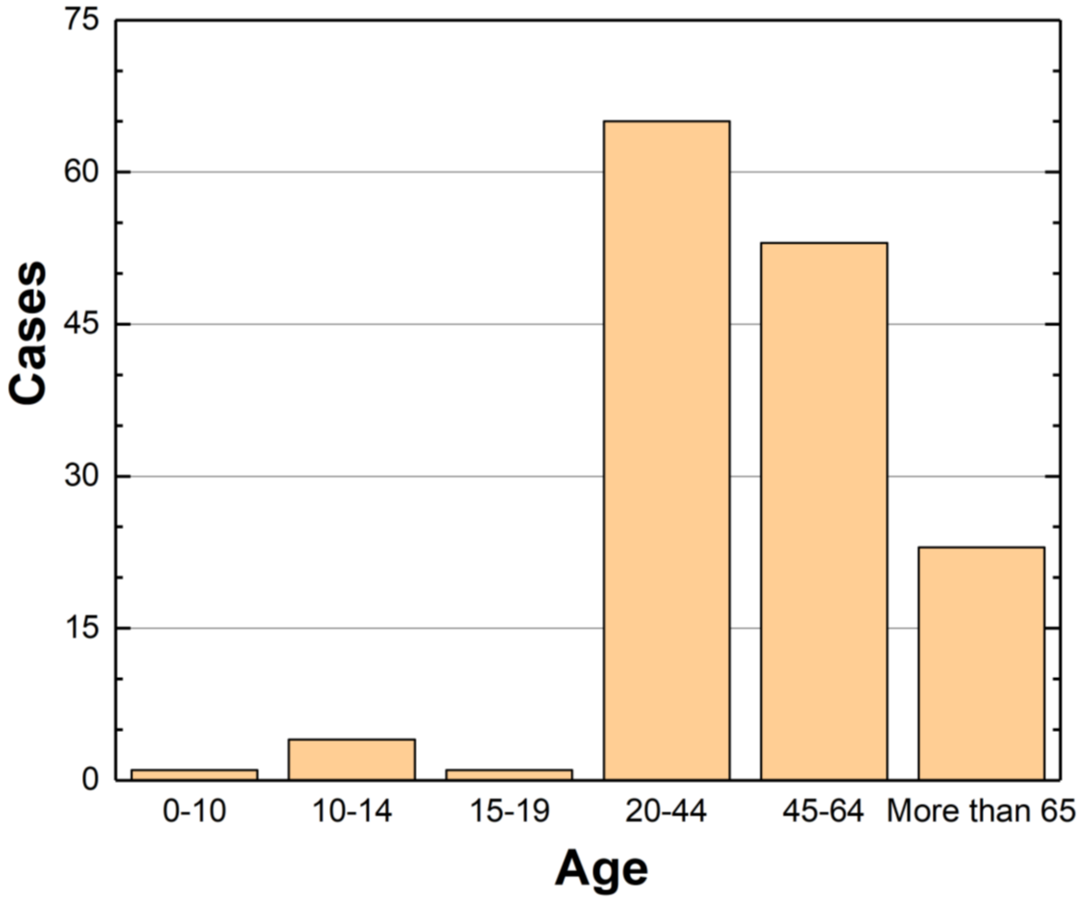

Figure 20: *Distribution of brucellosis infection based on the age of patients (2020-2022)*

- **Comparison between Animal and Human brucellosis**

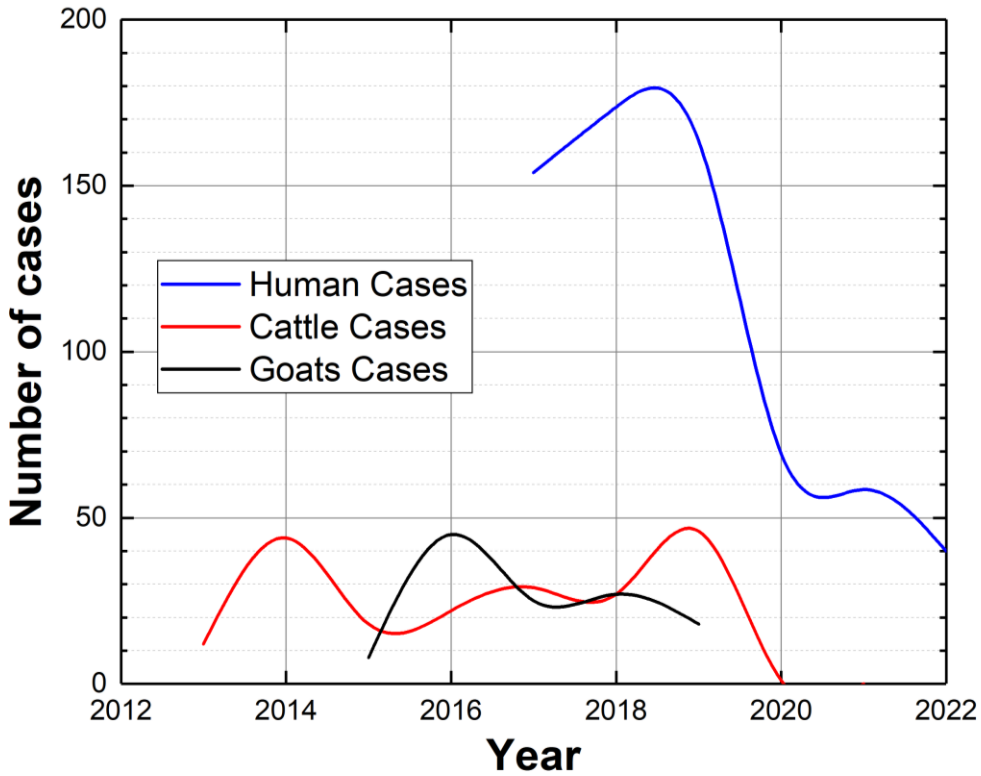

Figure 21: *Comparison between Animal and Human Cases*

In this particular scenario, the incidence of brucellosis cases in humans is higher than in animals due to several key factors. These factors contribute to a greater likelihood of humans contracting the disease compared to animals. Here are some possible explanations:

- Zoonotic Transmission: Brucellosis is a zoonotic disease, meaning it can be transmitted from animals to humans. However, certain factors may increase the risk of transmission to humans. For example, close contact with infected animals, such as handling their tissues or fluids, can facilitate the transmission of the bacteria responsible for brucellosis.

- Occupational Exposure: Humans working in occupations that involve direct contact with animals, such as farmers, veterinarians, or slaughterhouse workers, may be at higher risk of contracting brucellosis. These individuals are more likely to come into close contact with infected animals, increasing their chances of exposure to the bacteria.

- Consumption of Contaminated Animal Products: Another possible factor is the consumption of unpasteurized dairy products or undercooked meat from infected animals. If these animal products contain the bacteria causing brucellosis, humans can become infected by consuming them.

- Limited Animal Surveillance: The lower incidence of brucellosis in animals may also be due to limited surveillance and reporting systems for animal cases. In some regions, animal health monitoring and reporting might be less comprehensive or less developed compared to human health systems. As a result, cases of brucellosis in animals might be underreported or undetected.

- Differences in Disease Presentation: It's worth noting that while animals can also contract brucellosis, they may exhibit different clinical signs or remain asymptomatic carriers. This can make it more challenging to identify infected animals, leading to a lower reported incidence in the animal population.

These factors, among others, can contribute to a higher incidence of brucellosis cases in humans compared to animals in this particular scenario. It underscores the importance of implementing measures to prevent and control the transmission of brucellosis, both in human and animal populations, to reduce the overall burden of the disease.

CONCLUSION AND RECOMMANDATIONS

Conclusion

Our retrospective study on bovine and human brucellosis in Souk Ahras (2013-2022) has shown that the frequency of this disease in both species was significant during the year 2019. The animal disease affected 61.5% of the province's municipalities. Brucellosis occurs throughout the year. The infection is common in adult subjects, especially male farmers and veterinarians.

Brucellosis remains a relevant infection due to its global spread, and its impact on public health is evident through reported human cases. Despite the applied brucellosis control program in Algeria, there has been no significant improvement in the evolution of bovine and human brucellosis due to multiple failures in the implementation of this program. These failures primarily include the lack of hygiene in livestock farming, the absence of health education among farmers, non-compliance with safety measures among professionals and a lack of resources for screening and the fact that anti-brucellosis vaccination is not mandatory (farmers refuse to vaccinate their animals).

The persistence of these factors prevents the eradication of the disease. Fighting this disease requires collaboration between health services and veterinary services. It is time to implement a more tailored control program based on the situation on the ground and to raise awareness among all relevant parties about the existing danger in order to work together to control this disease.

Recommendations

Brucellosis poses a public health risk and causes economic losses in livestock farming. In order to establish an effective program to fight animal brucellosis, particularly bovine brucellosis, and reduce its impact on human health, we propose a set of sanitary measures aimed at controlling, managing, and ultimately eradicating the disease:

- Organize awareness campaigns to educate people about the importance of the disease.

- Raise awareness among farmers about the importance of vaccination and encourage them to report cases of the disease.

- Control animal movements, especially at the borders.

- Implement regular systematic screening of animals susceptible to brucellosis every six months.

- Isolate pregnant females from the herd before calving and report any abortions.

- Take necessary precautions before handling animals and their secretions, such as wearing gloves, goggles, and masks, and practicing hand hygiene.

- Strengthen the disease reporting system in healthcare facilities, emphasizing the need to specify the patient's age, gender, and profession.

- Raise awareness among clinicians about diagnosing occupational brucellosis following small ruminant vaccination.

- Equip laboratories to confirm atypical forms of brucellosis.

- Encourage the consumption of pasteurized milk and its by-products.

- Monitor milk and dairy product sales points.

- Conduct studies specifically on occupational brucellosis.

- Develop a prevention strategy targeting risk factors associated with brucellosis among professionals who have contact with animals in high-incidence rural areas.

- Improve intersectoral collaboration.

Our study serves as a preliminary investigation that allowed us to characterize the disease in Souk Ahras. Further studies are necessary to complement our findings and gain a better understanding of the underlying causes for the persistence of this disease despite the measures implemented by the authorities.

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ABSTRACT:

In this retrospective study we were interested in the evolution of animal and human brucellosis in the Souk Ahras during a period from 2013 to 2022.

We analyzed the evolution of the disease in humans, cattle and goats, it appears that the number of bovine cases reached during the last ten years is 199 bovine heads infected, 123 goats and 667 cases of human brucellosis.

The commune of AinZena alone records 7.2% human cases. The disease has affected adults, in most cases are in direct contact with livestock (breeder and veterinarians).

The prevalence of the disease is high in 2019 with 12.6% in cattle and 40.9% in goats.

Urgent measures must be taken to protect the animal and human population from this zoonosis.

ABSTRACT

RÉSUMÉ :

Dans cette étude rétrospective, nous nous sommes intéressés à l'évolution de la brucellose animale et humaine à Souk Ahras sur une période allant de 2013 à 2022.

Nous avons analysé l'évolution de la maladie chez les humains, les bovins et les chèvres. Il apparaît que le nombre de cas bovins enregistrés au cours des dix dernières années est de 199 têtes de bovins infectées, 123 chèvres et 667 cas de brucellose humaine.

La commune d'AinZena à elle seule enregistre 7,2 % des cas humains. La maladie a touché principalement les adultes, qui étaient en contact direct avec les animaux (éleveurs et vétérinaires).

La prévalence de la maladie était élevée en 2019, avec 12,6 % chez les bovins et 40,9 % chez les chèvres.

Des mesures urgentes doivent être prises pour protéger la population animale et humaine de cette zoonose.

ABSTRACT

ملخص :

في هذه الدراسة الاسترجاعية، كنا مهتمين بتطور البروسيلوز في الحيوانات والبشر في سوق أهراس خلال فترة من 2013 إلى 2022.

لقد قمنا بتحليل تطور المرض في البشر البقر والماعز، ويبدو أن عدد حالات الأبقار التي تم تسجيلها خلال العشر سنوات الماضية هو 199 رأس ماشية مصابة، 123 ماعزًا و 667 حالة من بروسيلوز الإنسان.

بلدية عين الزانة وحدها تسجل 7.2% من حالات الإنسان. وقد أثر المرض على البالغين، حيث كانوا في معظم الحالات على اتصال مباشر مع الماشية (المربين والأطباء البيطريين).

كان انتشار المرض مرتفعًا في عام 2019 بنسبة 12.6% في الأبقار و 40.9% في الماعز.

يجب اتخاذ تدابير عاجلة لحماية السكان الحيوانية والبشرية من هذا المرض المشترك بين الحيوانات والبشر.