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# A review on zoonotic sarcoptes

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**Abstract**
Scabies is a characteristic skin disease of both animals and humans caused by itch mite *Sarcoptes scabiei*, It was the first known disease with microscopic causative agent. WHO recognised scabies as neglected tropical disease and reported it needs more attention. Zoonotic transmission of scabies is of major public health concern as both human health and animal welfare can be impacted as it can spread from animals to humans. Risk factors of zoonotic transmission are contact with pets, crowded living conditions and poor hygiene. Life cycle of sarcoptes is complex and they exhibit host specificity and adaptations to different host species neglected cases can lead to complications such as crustated scabies, post scabies syndrome, zoonotic scabies requires one health approach and awareness among people.

**Keywords:** Sarcoptes, zoonosis, dog, human beings, scabies

## 1. Introduction
Scabies is a skin disease caused by *Sarcoptes scabiei* which burrows into the skin of humans and other animals leading to itchy rash and other symptoms (Bandi, 1979) [2]. Sarcoptes is a genus of mites in the family Sarcoptidae that includes the species *Sarcoptes scabiei*, also known as the scabies mite (Whitfield, 1979) [1]. Many species of Sarcoptes have been described but they are morphologically indistinguishable.
The earliest written references of skin diseases which can be due to Sarcoptes was Leviticus in the Bible dated back to 1200 BCE (Roncalli, 1987) [42]. Friedman reported that *Sarcoptes scabei* infestation was first discovered by Bonomo and Cestoni in 1687 (Friedman, 1947) [43]. This is first disease in human beings with known microscopic causative agent. Global outbreaks of human scabies have followed a pattern of recurring since 30 years, separated by intervals of 15 years (Orkin, 1975) [46] but there is no clear explanation for the fluctuations in scabies prevalence. Judge reported that the first crustated scabies case in a pregnant lady on 1994 (Judge, 1975) [45].

### 1.1 Importance of zoonotic transmission
The zoonotic transmission of *Sarcoptes scabiei* is important because it can lead to the spread of scabies between humans and animals, with potential impacts on both health and animal welfare. Zoonotic scabies has been reported in a range of animal species, including dogs, cats, pigs, and wildlife, and can result in significant economic losses and public health concerns (Reddy, 2013) [3] (Bandi, 1979)[2].

## 2. Epidemiology of Zoonotic Sarcoptes
### 2.1 Global prevalence and incidence of scabies
Scabies was recognized by the world health organization as a neglected tropical disease and has called for increased attention in the prevention and control of it (WHO, 2017) [35].
The burden of scabies is not just limited to developing countries, scabies outbreaks are common in institutional environments such as prisons and nursing homes in developed countries (Montoya, 2011) [7].A study conducted in a nursing home in the United States found a scabies prevalence of 33% ( Yonkosky *et al*., 1990) [34].
Scabies is a worldwide health problem, with the highest prevalence in developing countries. A scabies study in India reported a prevalence of 9.7% by persons, 22.5% by households, and 22.8% by families (Gulati *et al*., 1977) [10]. Another study in Africa reported a median prevalence of 7% (Montoya, 2011) [9]. A similar study conducted in Australia reported the rates of scabies were higher in indigenous communities compared to non-indigenous communities (Romani *et al*., 2015) [8].

## 3. Risk factors for zoonotic transmission

Zoonotic transmission of *Sarcoptes scabiei* is a significant public health concern, particularly in populations close contact with animals, such as pet owners, farmers, and animal handlers (Bandi, 1979) [2].

**3.1 Contact with pets** is one of the main reasons for transmission of organism from animals to human beings.

**3.2 Crowded living conditions and poor hygiene** is one of the important factors for zoonotic transmission of scabies. A study conducted on indigenous communities in Australia showed that overcrowding and poor hygiene were significant risk factors for scabies (Raza, 2009) [4] (Nair *et al*., 2016) [5]. Similar findings have been reported in other settings, including refugee camps (Richardson *et al*., 2021) [6] and nursing homes (Montoya, 2011) [7].

## 4. Biology of Sarcoptes

Sarcoptes comes under the Phylum: Arthropoda, subphylum: Chelicerata, class: Arachnida, subclass: Acari, and order: Astigmata (Sarcoptiformes).

### 4.1 Morphology of *Sarcoptes scabiei*

*Sarcoptes scabiei* is an obligate, burrowing parasite. The adult mites will be of 0.3-0.5 mm in length approximately. The body is oval in shape, with a tough integument that protects the organism from host's immune responses. They have four pairs of legs, with a characteristic sucker-like structure. (Arlian, 1989) [11].

The mouthparts are adapted for penetrating the skin and sucking of tissue fluids. The digestive system is simple and consists of a gut. The female mite is characterized by a round genital opening at the posterior end of the body.

### 4.2 Life cycle of *Sarcoptes scabiei*

*Sarcoptes scabiei* has a very complex life cycle which includes several developmental stages. The life cycle begins when a fertilized female mite penetrates into the host's skin and starts to lay eggs. The eggs hatch within 3-4 days and emerge the larvae that will migrate to the skin surface. The larvae will moult into nymphs, which undergo a second moulting and become adult males or females (Orkin, 1985) [12].

The entire life cycle takes approximately 2-3 weeks, during which the mites will feed on lymph and tissue fluids and penetrate deeper into the skin. The female mite will lay up to 40 eggs during her lifetime, which hatch and develop new mites**.**

## 5. Host specificity and adaptation of Sarcoptes

### 5.1 Host specificity of Sarcoptes

Although Sarcoptes can infest a wide range of hosts, it shows a high degree of host specificity. The mite will show a strong preference for its primary host, which is determined by wide range of factors such as odour, temperature, and immune responses. Generally Sarcoptes infesting humans will have a lower degree of host specificity compared to those infesting animals (Arlian, 1988) [16].

Studies have shown that host specificity will vary in different Sarcoptes populations. A study in Australia found that Sarcoptes infesting dogs are more specific to dogs compared to other animals.

### 5.2 Gene Expression and Host Specificity

Sarcoptes ability to adapt to specific hosts is influenced which changes in gene expression Recent studies have identified a number of genes in *S. scabiei* are differently expressed in different host species. Morgan reported that the change in gene expression was observed in CCL3 (MIP-1a), CCL5 (RANTES), CCL20 (MIP-3a), CXCL2 (MIP-2a), CXCL5 (ENA-78), CXCL6 (GCP-2), CXCL12 (SDF1), and CXCL14 (BRAK) (Morgan, 2013) [44], which affects the host specificity.

### 5.3 Adaptation of Sarcoptes to its hosts

Sarcoptes have evolved a wide range of adaptations to infest and reproduce in host species. These adaptations include changes in morphology, behaviour, and immune evasion strategies.

Morphological adaptations: The mite exhibits morphological changes in its body shape and size in response to its host species. For example, the size of the Sarcoptes infesting dogs will be small compared to size of the Sarcoptes infesting humans and other animals, which is thought to have helped mites in navigating through densely packed hair follicles (Sokolova, 1992) [17].

#### 5.3.1 Behavioural adaptations

Sarcoptes show behavioural adaptations which help them to locate and infest hosts. For example, odour, thermal stimulus seen by mites which is used to locate and burrow into the skin (Arlian, 1984) [18]. Once burrowed inside the body the mites will change its behaviour to avoid detection by immune responses.

#### 5.3.2 Immune evasion strategies

To evade hosts immune responses Sarcoptes evolved immune evasion strategies (Gazi, 2022) [13]. It will secrete immunomodulatory molecules that suppress the host's immune response, for successful infestation and reproduction (Wilson, 2003) [19].

## 6. Cross-Species Transmission of Sarcoptes

### 6.1 Mechanisms of cross-species transmission

The Sarcoptes is transmitted to hosts by several mechanisms. It can be by direct transmission between infected and susceptible hosts when coming in close contact or it can be due to indirect transmission where the mite species are carried to the susceptible host by inanimate objects (Pybus *et al*., 2001) [36].

In addition to these mechanisms, recent studies also suggested that Sarcoptes can also be transmitted by the bites of arthropods like *Ornithonyssus bacoti* (Neva *et al*., 1994) [37].

Another important factor for transmission is host specificity. Generally, each species of Sarcoptes is adapted to its host but some species can infest a wide range of hosts for example *Sarcoptes scabiei var. canis* is found in dogs but can also infest other animals including humans but *Sarcoptes scabiei var. hominis* is adopted specifically to humans.

### 6.2 Role of animal hosts in the transmission

Different Animal hosts act as major reservoirs of Sarcoptes, and many species can be infected with it. Dogs and cats are common hosts for Sarcoptes, Infection can also occur in wild animals such as foxes (Little *et al*., 1998) [38] and coyotes (Pence, 1994) [39]. Some hosts may not show any clinical signs but transmit parasites to other animals.

Transmission of Sarcoptes also depends on the genetic diversity of animal hosts may also play a role in the transmission of Sarcoptes. Recent research has shown that there is significant genetic diversity among different populations of Sarcoptes, and that certain genetic variants may be more adapted to infecting certain host species.

## 7. Pathogenesis

### 7.1 Pathogenesis of Scabies in animals

In animals the pathogenesis of scabies starts with sarcoptes penetrating skin and lay their eggs which leads to intense pruritus. The mites will feed on lymph and tissue fluids, causing damage to the host skin and induces an immune response. This response involves the production of cytokines, which activate macrophages to kill the mites. The immune response involves both innate and adaptive immunity, with the activation of neutrophils, macrophages, and T cells.

In some animals such as dogs and cattle, infestations can become chronic and lead to hyperkeratotic form of scabies (Walton, 2008) [15]. This form of scabies will lead to immune dysfunction and can be difficult to treat.

### 7.2 Pathogenesis of scabies in humans

The pathogenesis in humans is similar to animals. The intense pruritus associated with scabies is thought to be due to both the mechanical damage and the host's immune response. The pruritus can lead to secondary bacterial infections, and in severe cases can lead to the development of crusted scabies (Karthikeyan, 2009) [14], a hyperinfestation of *S. scabiei* associated with immune dysfunction.

## 8. Clinical Manifestations of Zoonotic Scabies

### 8.1 Clinical Presentation of Scabies

In animals, the clinical signs vary from species to species. In dogs and pigs, severe itching will be seen and rashes will be seen on ears, elbows and hocks. In cattle and horses, the rashes will be found on the head and neck. In sheep, the rashes will be seen on the ears and legs.

In human beings scabies is characterized by severe itching mostly during night time. The itching is due to allergic reaction of mites and there faeces. The area where the mites have buried will develop typical small, red, and raised bumps. Mostly it is seen in the wrists, elbows, armpits, buttocks, and the genitalia. In young children rashes might appear on head, neck, and palms (Elsheikha, 2015) [20].

### 8.2 Diagnosis of Scabies

In animals, diagnosis is based on clinical signs and identification of mites from deep skin scrapings under microscope. In some cases, a diagnosis can also be made based on the response to treatment with a scabicidal agent.

In humans, diagnosis is based on clinical signs and identification of mites in skin scrapings. The skin scrapings can be taken from rashes and can be examined under microscope. Diagnosis can also be made based on molecular diagnosis (Angelone *et al*., 2015) [21]. Different subspecies of Sarcoptes can be diagnosed based on molecular diagnostic techniques such as PCR.

### 8.3 Differential Diagnosis

In humans, scabies should be differentially diagnosed from other causes of pruritus, such as insect bites, atopic dermatitis, and contact dermatitis. In animals, the differential diagnosis includes other causes of pruritus and dermatitis, such as flea allergy dermatitis, atopic dermatitis, and food allergy (Bandi, 1979) [2].

## 9. Management and Prevention of Zoonotic Scabies

### 9.1 Treatment options for scabies in animals and humans

**Topical Medications**

Most common treatment for scabies is topical medications such as benzyl benzoate, crotamiton, and sulfur ointment, which acts by paralyzing and killing the organism.

#### 9.1.1 Oral Medications

The most commonly used oral medication is broad-spectrum antiparasitic agent ivermectin (Meinking, 1995) [30] (Hay, 2009) [25], other medications include albendazole (Ayoub, 2009) [29] and thiabendazole.

#### 9.1.2 Alternative Therapies

Most commonly used alternative therapies are tea tree oil (Currie, 2010) [28], neem oil (Deng *et al*., 2012) [27], and clove oil (Pasay *et al*., 2010) [26] but there is no proper evidence of safety and efficacy in treating scabies.

### 9.2 Control and prevention measures for zoonotic scabies

**Veterinary Measures**

Proper treatment of animals by veterinarians can decrease the infestation in pet animals which can prevent cross species transmission to human beings.

#### 9.2.1 Personal Hygiene Measures

Personal hygiene plays a crucial role in preventing the transmission of zoonotic scabies, regular washing with soap can remove the present on the skin, clothes used for the infested animal should be washed properly with hot water and detergent (Meinking, 1995) [31].

#### 9.2.2 Environmental Measures

Sarcoptes can survive in the external environment for three days. So it is essential to clean the environment for preventing transmission (Mishra, 2021) [32].

#### 9.2.3 Public Awareness Measures

Awareness campaigns for pet owners particularly when pets are under treatment will help in educating people about the risk of disease (Hasanov, 2018) [33].

#### 9.2.4 Early Detection and Treatment

The spread of zoonotic scabies can be prevented by early detection and proper treatment, veterinarians and health care workers should be trained on the symptoms and diagnosis of disease to provide appropriate treatment.

## 10. Complications of zoonotic scabies

### 10.1 Complications in Animals

**10.1.1 Self-Inflicted Trauma:** Severe itching can lead trauma of skin.

**10.1.2 Weight Loss:** Stress of infestation can lead to reduced feed intake which can eventually lead to weight loss.

**10.1.3 Reduced Productivity:** In production animals it can lead to reduced production.

**10.1.4 Crusting and Thickening of Skin:** Severe type of scabies which can lead to crustating and thickening of skin.

**10.1.5 Rejection by owners:** Due to less response to treatment some pet owners might abandon their pets.

**10.2 Complications in Humans**

**10.2.1 Secondary Infections**: Scabies can lead to secondary bacterial infections infestation can lead to bacterial skin infections which are seen in people with low immune response. Bacteria can enter the body through open wounds or scratches caused by intense itching, resulting in impetigo, cellulitis, or folliculitis (McClain, 2009) [22].

**10.2.2 Post-Scabies Syndrome:** characterized by clinical signs of long-term itching and hyperpigmentation even after successful treatment (Trasia, 2021) [23]. Terada reported that in a case study two dogs have been found to have resistance to ivermectin for *Sarcoptes scabei var canis* (Terada, 2010) [46]

**10.2.3 Crusted Scabies:** This is a severe type of scabies seen in people with low immune systems such as people who have undergone organ transplantation, suffering from HIV (Orkin, 1993) [41] characterized by crustated skin lesions (Roberts *et al*., 2005) [24].

**10.2.4 Scabies-Associated Nephropathy**: A study reported that up to 16 years persistent proteinuria can be detected in 13% of those with recognized post-streptococcal glomerulonephritis versus 4% of controls in scabies associated infection areas indicates the possibility of nephropathy as complication (Morgan, 2013) [44].

## 11. Public health and One Health perspectives on zoonotic scabies

**11.1 One Health Perspective**

Zoonotic scabies is a classic one health issue as it involves parasitic infestation from animals to humans and is also prevalent in areas associated with poverty, overcrowding and inequality. Hence a one health approach is essential in addressing the disease.

**11.2 Public Health Perspective**

Zoonotic scabies is of public health concern in rural and developing areas due to challenging diagnosis, treatment and prolonged suffering of affected individuals.

## 12. Conclusion

*Sarcoptes scabiei* is a highly contagious parasite that affect wide range of hosts including human beings, dogs, cats and wide range of wild animals which causes infection by burrowing into the skin and causes severe irritation, initially, it was thought that this disease is considered to animals alone but it can also get transmitted to humans by direct contact with infected animals.

Many studies have reported several risk factors for zoonotic transmission of Sarcoptes such as close contact with infected animals, overcrowding and poor sanitation. Additionally, immunocompromised individuals have a high risk of developing severe infections.

Prolonged exposure can lead to complications such as Post-Scabies Syndrome, crustated scabies and scabies associated nephropathy.

Resistance against ivermectin is another challenging factor for treatment of sarcoptes.

The zoonotic transmission of sarcoptes can be prevented mainly by personal hygiene which includes regular washing of hands, avoiding contact with infected animals, etc. veterinarians and medical officers will also play a major in prevention by treatment and avoiding the recurrence of infestation.

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## 14. Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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