Sarcoptic mange infestation in pigs: an overview

R. Laha

Received: 12 August 2013 / Accepted: 13 January 2014 / Published online: 11 February 2014
© Indian Society for Parasitology 2014

Abstract Sarcoptic mange infestation in pigs is caused by *Sarcoptes scabiei* var. *suis*. It is the most common mange infestation of pigs. The parasite is distributed worldwide. Pig owners are generally concerned about the internal parasitic infections and ignored the external parasitic infestations. But the external parasitic infestation with *S. scabiei* var. *suis* has economic significance as it causes morbidity, mortality, decreased fertility and feed conversion ratio in pigs. Keeping in view of importance of *S. scabiei* var. *suis* infestation in pigs, this communication discussed about the present and past research works done on *S. scabiei* var. *suis* infestation in pigs, particularly its prevalence, life cycle, pathological lesions, clinical symptoms, haematobiochemical changes, diagnosis, treatment and control, to have an idea about this infestation at a glance. It has been concluded that the research work done on sarcoptic mange infestation in pigs in India is less in comparison to other countries. It may be due to its consideration as a neglected parasite or due to its under report. Organization of awareness programs for the farmers by extension personalities or other authorities might be able to save the farmers from economic losses due to this infestation.

Keywords Mange · Overview · Pigs · Sarcoptes

Introduction

The population of pig in India is 11.13 million as per Livestock Census (2007) with highest population in Assam followed by Uttar Pradesh, West Bengal, Jharkhand and so on. Generally

pigs are reared by the tribal population of our country for their livelihood. This population of pigs has been found to be infected with internal parasites or infested with external parasites. There is lack of awareness amongst farmers about infection or infestation of parasite on their pigs and whatever little bit awareness is there, it remains within themselves that are related to internal parasitic infections only. For this, pig owners are generally concerned about the internal parasitic infections and ignored the external parasitic infestations. But external parasitic infestations particularly mange mite infestation in pigs are very much important because of its economic significance (Damriyasa et al. 2004). Sarcoptic mange infestation in pigs are caused by the mite *Sarcoptes scabiei* var. *suis* which causes significant morbidity and mortality in wild, domestic and farm animals (Walton and Currie 2007; Dagleish et al. 2007; Eo et al. 2008; Chhabra and Pathak 2011). *S. scabiei* var. *suis* is the most common cause of mange infestation in swine. In addition to morbidity and mortality, another important aspect of this infestation is that it may cause damage to pig handlers which cause severe itching as it has been reported that 65.2 % pig handlers out of 46 studied had symptoms of *S. scabiei* and diagnosis of *S. scabiei* mite in 20 persons have been done (Chakrabarti 1990). Besides, improved there are reports of mange control programme to reduce pig mortality (Forgues et al. 1988). Keeping in view of importance of *S. scabiei* var. *suis* infestation in pigs, the present communication have been made to have an overall idea regarding present and past research works done on *S. scabiei* var. *suis* infestation at a glance (Fig. 1, 2).

About the parasite

Sarcoptes scabiei var. *suis* are small tiny parasite of the Family Sarcoptidae and the Order Acarina. In length, these

R. Laha (✉)
Division of Animal Health, ICAR Research Complex for NEH
Region, Umroi Road, Umiam 793 103, Meghalaya, India
e-mail: rglaha@gmail.com

Fig. 1 Dorsal view of *Sarcptes scabiei* var. *suis* under of microscope

Fig. 2 Loss of hair from the thickened skin of mite infested pig

mites are up to 0.5 mm long and from dorsal aspect, only two pairs of anterior legs can be seen. They can be observed only under microscope.

Life cycle

Eggs are laid by the female parasites in the skin tunnels at the rate of 1–3 eggs per day. After a period of 5 days, the eggs hatched to form larvae. Larvae moult to form nymph and further moulting of nymph form adult. It takes about 10–15 days to complete the life cycle of this parasite. The adult female parasite can live up to 30 days. These parasites have no capacity to reproduce outside the host, but the mite may survive outside the pig for up to 12 days at a temperature of 7 °C to 18 °C and a relative humidity of 65 to 75 % (Jacobson et al. 1999).

Prevalence

The parasite was first reported in 1857 and now it is distributed worldwide (http://www.uaex.edu/Other_Areas/publications/

PDF/FSA-3077.pdf). The reports of occurrence of *S. scabiei* var. *suis* infestation in pigs from abroad and India are available (Chellapandian et al. 2004; Rueda-Lopez 2006; Loewenstein et al. 2006a). Gill et al. (1990) studied a total of 583 pigs of Indian Punjab and typical sarcoptic lesions were observed in 80.6 % pigs and 42.76 % pigs showed the presence of *Sarcoptic scabiei*. A perusal of available literature revealed that recently in India most of research work on sarcoptic mange infestation in pigs has been undertaken in the state Jharkhand (Prasad et al. 2001; Minz 2002; Sinha et al. 2004; Kumar et al. 2005, 2007; Minz et al. 2006). Apart from Jharkhand, reports of this infestations are available from Tripura (Roy 2000), North India (Dwivedi and Sharma 1985, 1986; Chhabra and Jakhar 1994; Mukherjee 1996) and other parts of the country (Subramanian et al. 2001; Maiti et al. 2004; Rajeshwari et al. 2004). Among suspected skin lesions of pigs from Chattishgarh, Maiti et al. (2004) found 37.50 % pigs were affected with sarcoptic mange. In North-Eastern region of India, where population of pigs are more and they are maintained in the village in unorganized way as well as in organized farms, reports of *S. scabiei* var. *suis* infestation in pigs are available from that part of the country. Report of *S. scabiei* var. *suis* infestation in pigs maintained in a remote village of Ri-Bhoi District of Meghalaya are available (Anonymus 2009). In one organized farm of Meghalaya, presence of *S. scabiei* var. *suis* infestation were detected in five pigs out of 15 suspected pigs which were suffered from skin lesions (Das et al. 2010). In another study of Meghalaya, among suspected skin lesions of pigs maintained in both organized and unorganized way, overall 11.11 % pigs were found positive for *S. scabiei* var. *suis* infestation (Anonymus 2010). In a recent study, Rajkhowa et al. (2012) from Assam reported over all 23.61 % pigs is infested with *S. scabiei* var. *suis* in an organized pig farm of Assam. The infestation is restricted not only in sporadic forms but it may occur as an outbreak form also. Subramanian et al. (2001) reported about an outbreak of scabies in a piggery unit. The infestation has been found to be occur more in winter season than rainy season (Galhotra et al. 1980) with younger animals suffered more (44.53 %) than adult animals (24.37 %) (Rajkhowa et al. 2012).

In a recent study from Mbeya Region, Tanzania 2 % pigs have been found to be infected with *S. scabiei* var. *suis* (Braae et al. 2013). From Ghana 38.2 % pigs have been reported as infested with *Sarcoptes suis* (Permin et al. 1999). The prevalence of the infestation from Germany has been recorded as 45.4 % (Damriyasa et al. 2004). Alonso de Vega et al. (1998) reported 37 % of the 1,318 slaughtered pigs of southeastern Spain examined were found positive for *S. scabiei* var. *suis* infestations. The ear scrapings of 33.7 % pigs of northeastern Spain were diagnosed as positive for *S. scabiei* var. *suis* infestations out of 818 pig samples examined (Gutierrez et al. 1996).

Pathological lesions and clinical symptoms

This parasite penetrate deep into the skin, produce itching sensation, cause stress and resulted loss of body weight of the infested pigs. Some times secondary bacterial infection may develop in the damaged skin caused by rubbing and scratching due to this mite infestation. In experimentally infested pigs, *S. scabiei* var. *suis* infestations causes excoriations on the luminal surface of the ear after seven days of initial infestations, developed encrusted lesions in the ears between third and eight weeks of infections, generalized pruritis accompanied by focal erythematous skin lesions with eosinophilia and allergic reactions (Cargill and Dobson 1979a). In natural infestations in crossbred pigs (Hampshire X Khasi local) lesions were mostly observed in ears, head, neck region, shoulders, leg and back region of those pigs. The lesions were characterized by reddening of the infested area, formation of crusts, hyperkeratosis, and fall of hairs from the area with wrinkled, thickened, rough, raised and thick asbestos-like skin (Das et al. 2010). The main clinical symptoms observed in the naturally infested pigs were pruritis as a result affected pigs showed rubbing of the skin against the wall of the pen (Loewenstein et al. 2006b; Das et al. 2010). The infestation may be a hypersensitive form, characterized by pruritis and the presence of small red papules or a chronic form, characterized by crusts (Rambozzi et al. 2007). Naturally contact-infected *S. scabiei* var. *suis* pigs reported to have nine time higher pruritic behaviour in compare to non-infected pigs (Elbers et al. 2000).

Haematobiochemical changes

Pigs naturally infested with *S. scabiei* var. *suis* showed significant decreased value of haemoglobin (Hb), packed cell volume (PCV), total erythrocytic counts (TEC), serum copper, serum zinc and serum glucose with increased level of Alanine aminotransferase (Sinha et al. 2004). Reduced haematological values like Hb, PCV and TEC along with decreased level of biochemical constituents of serum such as Ca, P, Zn, Cu, total serum protein and albumin have been observed in naturally gastrointestinal nematode infected and sarcoptic mange infested desi pigs (Kumar et al. 2007).

Economic losses

There are several aspects of economic impact of *S. scabiei* var. *suis* infestation in pigs. It may be due to decreased growth rate, decreased fertility and lower feed conversion ratio due to the infestation. *S. scabiei* var. *suis* infestation

have been found as detrimental for the production performance in pigs (Arends et al. 1990; Davies 1995; Elbers et al. 2000). In experimental *S. scabiei* var. *suis* infestations in growing pigs, a depressed mean growth rates from 9.2 to 12.5 % has been observed (Cargill and Dobson 1979b). The economic losses due to sarcoptic mange infestation are also caused by decreased fertility of sows and lower feed conversion ratio (Zimmermann and Kircher 1998). In a study, growth performance of piglets from *S. scabiei* var. *suis* infested and treated sows showed significantly higher (541.5 g per day) than piglets from *S. scabiei* var. *suis* infested and untreated sows (518.4 g per day), because naturally infested untreated sows transmit the infestation to piglets and thereby showed less growth performance (Mercier et al. 2002). The growth performance (average daily gain in gram per day) of naturally contact-infected *S. scabiei* var. *suis* pigs, in comparison to non-infected pigs has been found to be differ according to the period of infestations (Elbers et al. 2000). They recorded a decreased growth performance of 35, 50 and 41 g per day during 0–35, 35–112 and 0–112 days of infections, respectively.

Diagnosis

Diagnosis of *S. scabiei* var. *suis* infestation is not so easy because most of the infested animals showed subclinical infestation where skin lesions are usually not visible and specific lesions remained absent (Matthes et al. 1990). A direct method of examination of scrapings collected from the inside of the pina can be used for diagnosis (Gutierrez et al. 1996; Alonso de Vega et al. 1998) where collected materials are to be placed on a petridish and incubate at 30 °C for a minimum of 8 h and to be examined under low power of microscope. Examination of skin scrapings of suspected cases is the way of diagnosis of *S. scabiei* var. *suis* in field condition, although it's specificity is 100 % but sensitivity is low (Kambarage 1991; Hollanders et al. 1995; Gutierrez et al. 1996). Digestion of suspected scraping materials with 10 % potassium hydroxide, then centrifugation followed by examination of sediment under microscope is the way of examination of skin scrapings of suspected cases (Soulsby 1986). One improved technique is digestion of scraping materials in 10 % potassium hydroxide and examination under microscope after sugar flotation for eggs, immature and adult parasites (Hollanders and Castryck 1988). This sugar flotation technique found to be more sensitive than direct method, as in a study sugar flotation technique detected 92.0 % infestation where direct method detected 33.5 % infestations (Gutierrez et al. 1996). In another study, Alonso de Vega et al. (1998) diagnosed 37 % pigs as positive using sugar flotation technique against 25.56 % by direct method. Whatever

may be the method of examination of scraping materials, collection of scraping materials is very much important. Superficial scrapings are not recommended and during scraping oozing of blood are needed.

Serodiagnosis of infestation by detection of antibodies against *S. scabiei* var. *suis* infestation in pigs is another method of diagnosis. Earlier passive haemagglutination test was used for detection of serum antibodies of *S. scabiei* var. *suis* infested pigs using tanned bovine red blood cells and in experimentally infested animals titers ranged from 1:40 to 1:160 were detected (Wooten and Gaafar 1984). Now-a-days enzyme linked immunosorbent assays (ELISAs) are being used for detection of antibodies against *S. scabiei* var. *suis*. The status of *S. scabiei* in pig herds is routinely monitored by serodiagnosis (Hejduk et al. 2011). Kessler et al. (2003) used indirect ELISA for detection of antibodies against *S. scabiei* var. *suis* infested and treated pigs and opined that sensitivity of serological techniques must be taken into consideration for diagnosis particularly during its use in monitoring and eradication programs. For detection of antibodies in sera of *S. scabiei* infested pigs, Bornstein and Wallgren (1997) developed an ELISA where they observed the sensitivity and specificity of this serodiagnostic test is 87.8 and 99.5 %, respectively considering clinical diagnosis as gold standard. When skin scrapings were taken as gold standard, the test showed higher sensitivity (100 %) with lower specificity (32.8 %). Van der Heijden et al. (2000) validated an ELISA for detection of antibodies against *S. scabiei* in pigs. Antibody detection ELISA has been used successfully to monitor the eradication strategies against sarcoptic mange infestation in swine herds (Jacobson et al. 1999). Antigens prepared from extracts of *S. scabiei* var. *vulpes* have been used successfully in ELISA for detection of antibodies against *S. scabiei* infestation in pigs (Bornstein and Zakrisson 1993; Wallgren and Bornstein 1997). Now-a-days polymerase chain reactions are being used for diagnosis of various parasitic infections in different animals. Research regarding diagnosis of sarcoptic mite is going on and methods for collection to DNA extraction for such purposes has been beautifully mentioned by Alasaad et al. (2009). Sarcoptes-World Molecular Network (Sarcoptes-WMN) is working for immunodiagnosis and molecular diagnosis of sarcoptes using PCR (Alasaad et al. 2011).

Characterization of immunogenic proteins

There is a need to characterize the antigens used in antibody detection immunodiagnostic tests, to know about the immunogenic proteins of antigens involved in such immunodiagnosis. Sodium dodecyl sulfate–polyacrylamide gelelectrophoresis of antigens prepared from *S. scabiei* of

pigs and its subsequent immunoblotting revealed seven immunodominant proteins (MW 36, 52, 66, 80, 110, 218 and >220 kDa) out of which five immunodominant proteins (MW 52, 66, 80, 110 and 218 kDa) also reacted with sera from *S. scabiei* negative pigs. Thus two immunodominant proteins of MW 36 and >220 kDa were identified as specific immunodominant proteins of *S. scabiei* of pigs (Rambozzi et al. 2007). They also reported that proteins of MW 36 kDa are more frequently recognized by hypersensitive pigs and proteins of MW >220 kDa is more frequently recognized by chronically infected pigs. Crude antigens prepared from *S. scabiei* var. *canis* or *S. scabiei* var. *vulpes* are generally used for ELISA. Characterization of such antigens after western blotting using sera from infected pigs revealed potential cross reactivity among *S. scabiei* (var. *canis*, *suis* and *bovis*) and hydrophobic *S. scabiei* antigens were detectable in the range of 40–50 kDa (Hejduk et al. 2011).

Treatment and control

This is the vital issue for farmer's field as it has direct involvement with farmer's economy. Treatment can be discussed in two aspects depending on the economical condition of the farmers. One can go for a treatment which is costly but less laborious like the use of injectable or oral preparations containing avermectin compounds or farmer's can choose the medicines for local application, the use of which are laborious but comparatively less costly, like the use of some herbal preparations. Plants are being used for the treatment and control of acariasis in animals. A successful treatment was done by Dwivedi and Sharma (1985) using a mixture of onion, garlic, lemon, turmeric and powdered gunja (*Abrus precatorius*). Dwivedi and Sharma (1986) used locally a herbal preparation containing onion, lemon extract, garlic, turmeric powder and camphor in karanj oil once in a day for consecutive five days and infestation was eliminated within 5 days of application. Chhabra and Saxena (1998) described about phytotherapeutic agents for the control of acariasis in animals. The efficacy of extracts of six plant products i.e. mugwort, wormwood, garlic, tansy, hogweed and tea tree were evaluated against sarcoptic mange infestation in pigs (Magi et al. 2006). They found all plant products were toxic to swine mites and ethanol extracts of hogweed (*Heracleum sosnowskyi* Manden) showed highest efficacy which killed 57–93 % parasites in 2–4 weeks after two treatments with one week intervals. Application of a poly herbal cream containing oils of *Linum usitatissimum*, *Eucalyptus globulus*, *Cinnamomum camphora*, *Ocimum sanctum*, *Acorus calamus* and powders of Tankana, twice daily for 7 days cured the infestation after 15 days of local application and

after 20 days of treatment, skin became normal (Rajeshwari et al. 2004). Kumar et al. (2005) suggested the use of a herbal preparation consisting neem oil (50 ml), karanj oil (50 ml) and camphor (10 g) in control of *S. scabiei* infestation in pigs as they found application of this preparation cured 100 % infested pigs on 13 days post treatment. In another study, this group of researchers reported that use of these herbo-mineral preparations and ivermectin in the treatment of *S. scabiei* infestation in pigs could able to return the altered haemato-biochemical changes due to this infestation to almost its normal ranges during post treatment periods (Sinha et al. 2004). Kumar et al. (2007) successfully used cypermethrin and a mixture of herbo-mineral consisting neem oil (50 ml), karanj oil (50 ml), camphor (10 g) and sulphur (10 g) for the treatment of sarcoptic mite infestation in desi pigs. They also reported that the decreased haematological and biochemical parameters due to the infestation could be restored during post treatment periods. Three applications of 0.1 % amitraz at an interval of one week could able to control an outbreak in a piggery unit (Subramanian et al. 2001). Treatment and control of *S. scabiei* var. *suis* infestation was done successfully by treatment of pigs with 20 % phosmet @ 20 mg per kg. b.wt. and environment with 2 % trichlorphon (Kambarage 1991). Maiti et al. (2004) successfully used Cypermethrin in the treatment of sarcoptic mange in pigs. A brushing over thick scab may be needed before topical application of anti-sarcoptic agents to reach the agent up to the parasites.

Introduction of macrocyclic lactones (i.e. ivermectin, doramectin) for the treatment of *S. scabiei* var. *suis* made it easy to treat the infestation. Lee et al. (1980) reported ivermectin @ 300–500 µg/kg body weight orally was 100 % effective against *S. scabiei* in pigs. Ivermectin @ 300 µg/kg body weight single or twice injected subcutaneously has been found effective to treat the infested pigs (Soll and Smith 1987; Gill et al. 1990). Injection of ivermectin subcutaneously @ 300 µg/kg body weight has been used successfully for the treatment of *S. scabiei* var. *suis* infestation in pigs (Seamen et al. 1993; Arends et al. 1999; Chellapandian et al. 2004). Treatment of *S. scabiei* var. *suis* with ivermectin @ 300 µg/kg body weight sub cutaneously at the start of fattening could able to change scratching behavior and dermatitis of treated pigs similar to mange free herds (Hollanders et al. 1995). Kumar et al. (2005) successfully used ivermectin @ 300 µg/kg body weight subcutaneously which cured the infested pigs on 7 days post treatment. Das et al. (2010) successfully used Ivermectin subcutaneously @ 200 µg/kg body weight in treatment of *S. scabiei* var. *suis* infestation in crossbred pigs. Ivermectin @ 300 µg/kg body weight was used for treatment of *S. scabiei* var. *suis* in pigs with a repeated treatment after two weeks and the medicine was found to

have 90 % efficacy within two weeks. The symptoms of pruritis and scratching were disappeared from the day 21 post treatment (Rajkhowa et al. 2012). Naturally infested herd was successfully treated with a single intramuscular injection with doramectin (Jensen et al. 2002). In a comparative study of three medicines i.e., Doramectin (1 %) @ 300 µg/kg body weight single intramuscular injection, Diazonin liquid (20 %) 3 ml in one litre water dipping for 3 occasions at weekly intervals and deltamethrin 4 ml in one litre water dipping for 3 occasions at weekly intervals found 100 % efficacy of doramectin, 86.67 % efficacy of diazinon and 76.67 % efficacy of deltamethrin in treatment of natural *S. scabiei* infestation in pigs (Baishya et al. 2003). They recommended doramectin as drug of choice for the treatment of *S. scabiei* infestation in pigs as compared to other two medicines they used. Pathak and Chaurasia (2002) reported 100 % efficacy of doramectin for the treatment of *S. scabiei* infestation in pigs. The persistent efficacy of doramectin and ivermectin when evaluated by administration of these two medicines @ 300 µg/kg body weight in experimentally infected pigs it was observed that persistent efficacy of doramectin was double (18 days) in comparison to ivermectin (9 days) (Arends et al. 1999). Ohba et al. (1989) used different doses of ivermectin like 75, 150 and 300 µg/kg body weight with single subcutaneous injection against live mites and eggs of *Sarcoptic scabiei* in pigs and found 300 µg/kg body weight was best for eradication of mites and eggs. One of the advantages of use of injectable avermectin compounds is that farmers can use the medicines as endectocidal agent's means these medicines could be used for treatment of both internal parasitic infections and external parasitic infestations (Saeki et al. 1996; Yazwinski et al. 1997). Thus farmers can save their money in such type of simultaneous treatment. Treatments with systemic medicines may have the problems of drug residue in treated animals especially for food animals. To overcome this problem, experiments on development of antibodies to prevent infestations is going on. In this aspect, Sinha (2011) reported that immunization of piglets with whole mite extracts antigen (WMEAg) prepared from *S. scabiei* of pigs with FCA increased the value of lymphocytes, basophiles and eosinophils significantly on 30th and 60th. days of observations and developed immunity against *S. scabiei* in pigs.

Treatment of affected pigs along with monitoring of infestation is very much needed for the control of *S. scabiei* var. *suis* infestation in pigs. Repeated treatment is essential, as most of the acaricide are not able to destroy the eggs. So, it is necessary to repeat the treatment after 14 days of first treatment, as per life cycle of the parasite. For eradication of infestation from the herd, (Spencer 2008) used ivermectin premix. He used ivermectin in feed and given a dose rate of 100 µg/kg body weight/day to pigs for a period

of 7 days twice within 21 days, in a 7–7–7 program that means first 7 days medication followed by 7 days non-medication then 7 days medication. Along with this treatment, a strict bio-security could be able to keep out the parasite from the herd. As the infection is contagious in nature, so segregation of infested pigs and treatment of the same is one of the ways of control strategy. Besides, overcrowding should be avoided to get rid of fresh infestation and cross infection. Pig should be purchased from a disease free herd and before entering it to the newly herd, they should be treated against sarcoptic mange. The parasite can survive out side the host. So, premises, cracks etc. of herd should be properly cleaned with acaricidal solution, to prevent reinfection of treated pigs. One of the main problem of control of *S. scabiei* var. *suis* is that, it can be transmitted from infected sows to suckling piglets. Treatment with Ivermectin (@ 300 µg/kg body weight single sub cutaneous injection) of pregnant sows just before they moved to farrowing unit could be able to control the infestation both in pregnant sows without any health hazards and piglets (Mercier et al. 2002).

Conclusion

The research work related to sarcoptic mange infestation of pigs in India is less in comparison to some other countries. It may be due to the reason that sarcoptic mite is generally considered as a neglected parasite or the work is going on in a sporadic form which are not reflected due to under report. Besides, overall control of sarcoptic mange in pigs remains in awareness of farmers about this infestation and its economic importance. Organization of awareness programs for the farmers by extension personalities or other authorities could be able to save the farmers from such economic losses.

Acknowledgments The author is thankful to the Director, ICAR Research Complex for NEH Region, Umiam, Meghalaya for providing the facilities to write this review article.

References

- Alasaad S, Rossi L, Soriguer RC, Rambozzi L, Soglia D, Perez JM, Zhu XQ (2009) *Sarcoptes* mite from collection to DNA extraction: the lost realm of the neglected parasite. *Parasitol Res* 104:723–732
- Alasaad S, Walton S, Rossi L, Bornstein S, Abu-Madi M, Soriguer RC, Fitzgerald S, Zhu XQ, Zimmermann W, Ugbomoiko US, Pei KJC, Heukelbach J (2011) *Sarcoptes*-World Molecular Network (*Sarcoptes*-WMN): integrating research on scabies. *Int J Infect Dis*. doi:10.1016/j.ijid.2011.01.012
- Alonso de Vega F, Mendez de Vega J, Sanchez JO, Pleite CM, Serrano AA, Carnero MRR (1998) Evaluation of the prevalence of sarcoptic mange in slaughtered fattening pigs in southeastern Spain. *Vet Parasitol* 76:203–209
- Anonymus (2009) Annual report (2009–10), ICAR research complex for NEH region, Umroi Road, Umiam, p 105
- Anonymus (2010) Annual report (2010–11), ICAR research complex for NEH region, Umroi Road, Umiam, p 94
- Arends JJ, Stanislaw MC, Gerdon D (1990) Effects of sarcoptic mange on lactating swine and growing pigs. *J Anim Sci* 68:1495–1499
- Arends JJ, Skogerboe TL, Ritzhaupt LK (1999) Persistent efficacy of doramectin and ivermectin against experimental infestations of *Sarcoptes scabiei* var. *suis* in swine. *Vet Parasitol* 82:71–79
- Baishya SK, Khargharia G, Das A, Bardoloi RK (2003) Therapeutic efficacy of doramectin, diazinon and deltamethrin against mange mite infestation in pig. *Indian J Hill Farming* 16:82–85
- Bornstein S, Wallgren P (1997) Serodiagnosis of sarcoptic mange in pigs. *Vet Rec* 141:8–12
- Bornstein S, Zakrisson G (1993) Clinical picture and antibody response in pigs infected by *Sarcoptes scabiei* var. *suis*. *Vet Dermatol* 4:123–131
- Braae UC, Ngowi HA, Johansen MV (2013) Smallholder pig production: prevalence and risk factors of ectoparasites. *Vet Parasitol*. <http://dx.doi.org/10.1016/j.vetpar.2012.12.058>
- Cargill CF, Dobson KJ (1979a) Experimental *Sarcoptes scabiei* infestation in pigs: (1) pathogenesis. *Vet Rec* 104:11–14
- Cargill CF, Dobson KJ (1979b) Experimental sarcoptes scabiei infestation in pigs: (2) Effects on production. *Vet Rec* 104:33–36
- Chakrabarti A (1990) Pig handler's itch. *Int J Dermatol* 29:205–206
- Chellapandian M, Ramprabhu R, Balachandran S (2004) Treatment of sarcoptic mange with ivermectin. *Indian Vet J* 81:1051–1052
- Chhabra MB, Jakhar GS (1994) Treatment of sarcoptic mange in pigs. *Indian J Vet Med* 14:92–94
- Chhabra MB, Pathak KML (2011) Sarcoptic mange in domestic animals and human scabies in India. *J Vet Parasitol* 25:1–10
- Chhabra MB, Saxena MJ (1998) The use of phytotherapeutic agents for the control of acariasis in animals: a review. *J Vet Parasitol* 12:3–8
- Dagleish MP, Ali Q, Powell RK, Butz D, Woodford MH (2007) Fatal *Scarcoptes scabiei* infection of blue sheep (*Pseudois nayaur*) in Pakistan. *J Wildlife Dis* 43:512–517
- Damriyasa IM, Failing K, Volmer R, Zahner H, Bauer C (2004) Prevalence, risk factors and economic importance of infestations with *Sarcoptes scabiei* and *Haematopinus suis* in sows of pig breeding farms in Hesse, Germany. *Med Vet Ent* 18:361–367
- Das M, Laha R, Devi P, Bordoloi RK, Naskar S (2010) Sarcoptic mange infestation in pigs in a hilly region of Meghalaya. *Trop Anim Health Prod* 42:1009–1011
- Davies RR (1995) Sarcoptic mange and production performance of swine: a review of the literature and studies of association between mites infestation, growth rate and measures of growth severity in growing pigs. *Vet Parasitol* 60:249–264
- Dwivedi SK, Sharma MC (1985) Therapeutic evaluation of an indigenous drug formulation against scabies in pigs. *Indian J Vet Med* 5:97–100
- Dwivedi SK, Sharma MC (1986) Studies on a herbal preparation against scabies in indigenous pigs. *Indian J Vet Med* 6:51–53
- Elbers ARW, Rambags PGM, Van der Heijden HMJF, Hunneman A (2000) Production performance and pruritic behaviour of pigs naturally infected with *Sarcoptes scabiei* var *suis* in a contact transmission experiment. *Vet Quart* 22:145–149
- Eo KY, Kwon OD, Shin NS, Shin T, Kwak D (2008) Sarcoptic mange in wild raccoon dogs (*Nyctereutes procyonoides*) in Korea. *J Zoo Wildlife Med* 39:671–673
- Forgues M, Genest JJ, Glatt LD, Gloaguen Y, Gremillet JP, Guilmo B, Coz LE, Saunier A, Soyer C (1988) Test under field conditions of the profitability of ivermectin administer to sows. *Proc Int Pig Vet Soc* 10:265
- Galhotra AP, Singh RP, Gomer PS (1980) Prevalence and chemotherapy of sarcoptic mange in swine. *Haryana Vet* 19:42–46

- Gill BS, Singh J, Gill BS, Khera SS (1990) Efficacy of ivermectin against mange and gastrointestinal nematodes of pigs and goats. *Indian J Parasitol* 14:93–98
- Gutierrez JF, deVigo JM, Castella J, Munoz E, Ferrer D (1996) Prevalence of sarcoptic mange in fattening pigs sacrificed in a slaughterhouse of northeastern Spain. *Vet Parasitol* 61:145–149
- Hejduk G, Hofstatter K, Lowenstein M, Peschke R, Miller I, Joachim A (2011) Characterisation of *Sarcoptes scabiei* antigens. *Parasitol Res* 108:309–315
- Hollanders W, Castryck F (1988) Survey of prevalence of *Sarcoptes scabiei* in fatteners in Belgium. *Proceedings of the International Pig Veterinary Society 10th Congress, Rio de Janeiro*, p 255
- Hollanders W, Harbers AHM, Huige JCM, Monster P, Rambags PGM, Hendriks WML (1995) Control of with ivermectin: influence on scratching behavior of fattening pigs and occurrence of dermatitis at slaughter. *Vet Parasitol* 58:117–127
- Jacobson M, Bornstein S, Wallgren P (1999) The efficacy of simplified eradication strategies against sarcoptic mange mite infections in swine herds monitored by an ELISA. *Vet Parasitol* 81:249–258
- Jensen JC, Nielsen LH, Arnason T, Cracknell V (2002) Elimination of mange mites *Sarcoptes scabiei* var *suis* from two naturally infested Danish sow herds using a single injection regime with doramectin. *Acta Vet Scand* 43:75–84
- Kambarage DM (1991) Treatment and control of sarcoptic mange: evaluation of treatment of both the pigs and environment. *Trop Anim Health Prod* 23:59–62
- Kessler E, Matthes HF, Schein E, Wendt M (2003) Detection of antibodies in sera of weaned pigs after contact infection with *Sarcoptes scabiei* var *suis* and after treatment with an antiparasitic agent by three different indirect ELISAs. *Vet Parasitol* 114:63–73
- Kumar A, Sinha S, Prasad KD (2005) Control of sarcoptic scabies infestation in pigs by chemical and herbal acaricides. *Indian Vet J* 82:989–990
- Kumar P, Prasad KD, Singh R (2007) Haemato-biochemical alterations during common gastrointestinal helminthes and mite infestations and their treatment in Desi pigs. *J Parasitic Dis* 31:147–149
- Lee RP, Dooge DJD, Preston JM (1980) Efficacy of ivermectin against *Sarcoptes scabiei* in pigs. *Vet Rec* 107:503–505
- Loewenstein M, Ludin A, Peschke R, Kahlbacher H, Schuh M (2006a) *Sarcoptes scabiei* var *suis* in a closed pig breeding and fattening herd and control possibilities after treatment. *Berl Munch Tierarztl Woch* 119:348–354
- Loewenstein M, Ludin A, Schuh M (2006b) Comparison of scratching behaviour of growing pigs with sarcoptic mange before and after treatment, employing two distinct approaches. *Vet Parasitol* 140:334–343
- Magi E, Jarvis T, Miller I (2006) Effects of different plant products against pig mange mites. *Acta Vet Brno* 75:283–287
- Maiti SK, Chourasia SK, Gadpayle RK, Sharma N (2004) Treatment of Sarcoptic mange in pigs with Cypermethrin. *Indian Vet Med J* 28:380
- Matthes HF, Nockler K, Hiepe Th (1990) Klinische V und experimenteler *Sarcoptes suis* -Infektionen beim schwein. *Mh Vet-Med* 45:888–891
- Mercier P, Cargill CF, White CR (2002) Preventing transmission of sarcoptic mange from sows to their offspring by injection of ivermectin. Effects on swine production. *Vet Parasitol* 110:25–33
- Minz P (2002) Clinicopathological and biochemical studies of mange in pigs. M.V.Sc. Thesis, Birsra Agricultural University, Ranchi
- Minz P, Haque S, Singh SK, Mishra SN (2006) Therapeutic efficacy of different drugs against mange infection in pigs. *Vet World* 5:81–84
- Mukherjee R (1996) Efficacy of Deltamethrin in porcine mange. *Indian Vet Med J* 20:154–156
- Ohba S, Toriumi H, Takeishi M, Noda R (1989) Efficacy of ivermectin against live mites and eggs of *Sarcoptes scabiei* in pigs. *Nippon Juigaku Zasshi* 51:981–985
- Pathak AK, Chaurasia SK (2002) Scabies (Brain itch) infestation in pigs and its treatments. *Indian Vet Med J* 26:175
- Permin A, Yelifari L, Bloch P, Steenhard N, Hansen NP, Nansen P (1999) Parasites in cross-bred pigs in the upper east region of Ghana. *Vet Parasitol* 87:63–71
- Prasad KD, Kumar S, Singh SK (2001) Haematological studies of pigs during *Ascaris suum* and *Sarcoptes scabiei* infection and treatment with doramectin. *J Vet Parasitol* 15:63–75
- Rajeshwari YB, Suhas YS, Bhagat VG (2004) Scavon vet cream-A herbal formulation for the treatment of mange in pigs. *The Veterinarian* 16:16 & 21
- Rajkhowsa S, Das A, Baruah RK, Kalita C, Das JP (2012) Prevalence of mange mite infestation in an organized pig farm and its management. In compendium of XXIII national congress of veterinary parasitology and national symposium on “parasitology today: from environmental and social impact to the application of geoinformatics and modern biotechnology” held in the Department of Parasitology, College of Veterinary Science, Assam Agricultural University, Khanapara, from 12th Dec to 14th Dec, 2012, p 55
- Rambozzi L, Menzano A, Molinar Min AR, Rossi L (2007) Immunoblot analysis of IgG antibody response to *Sarcoptes scabiei* in swine. *Vet Immunol Immunopathol* 115:179–183
- Roy J (2000) Efficacy of deltamethrin (Butox) against sarcoptic mange in flight. *Indian J Anim Health* 39:32
- Rueda-Lopez M (2006) Elimination of sarcoptic mange due to *Sarcoptes scabiei* var. *suis* from a 1800-sow farrow-to-finish farm. *Vet Rec* 159:595–597
- Saeki H, Fujii T, Fukumoto S-I, Kagota K, Taneichi A, Takeda S, Tsukaguchi M (1996) Efficacy of doramectin against intestinal nematodes and sarcoptic mange mites in naturally infected swine. *J Vet Med Sci* 59:129–132
- Seamen JT, Thompson DR, Barrick RA (1993) Treatment with ivermectin of sarcoptic mange in pigs. *Aust Vet J* 70:307–308
- Sinha S (2011) Control of pig mange with whole mite extract antigen. In souvenir of golden jubilee and world veterinary year 2011 of Ranchi veterinary college and symposium on ‘sustainable livestock and poultry development in Jharkhand, held at Ranchi veterinary college, Birsra Agricultural University, Kanke, from 29–30 November, 2011, p 237
- Sinha S, Kumar A, Prasad KD (2004) Haematobiochemical variations during mange mite infestation in pigs and its therapeutic management. *J Parasitic Dis* 28:127–129
- Soll MD, Smith CJ (1987) Efficacy of ivermectin against the pig mange mite *Sarcoptes scabiei* var *suis*. *J S Afr Vet Assoc* 58:29–30
- Soulsby EJJ (1986) Helminths, arthropods and protozoa of domesticated animals, 7th edn. Bailliere Tindall, London
- Spencer BT (2008) Eradication of *Sarcoptes scabiei* var *suis* by use of Ivomec premix alone. In *Proceedings of the 19th, Vol 2. International Pig Veterinary Society Congress, Copenhagen*, p 401
- Subramanian M, Thirunavukkarasu PS, Vijayakumar G, Anna T, Kavita S (2001) An outbreak of scabies in a piggery unit-a clinical report. *Indian J Vet Med* 21:107
- Van der Heijden HM, Rambags PG, Elbers AR, Van Maanen C, Hunneman WA (2000) Validation of ELISAs for the detection of antibodies to *Sarcoptes scabiei* in pigs. *Vet Parasitol* 89:95–107
- Wallgren P, Bornstein S (1997) The spread of porcine sarcoptic mange during the fattening period revealed by development of antibodies to *Sarcoptes scabiei*. *Vet Parasitol* 73:315–324

- Walton SF, Currie BJ (2007) Problems in diagnosing scabies, a global disease in human and animal populations. *Clin Microbiol Rev* 20:268–279
- Wooten EL, Gaafar SM (1984) Detection of serum antibodies to sarcoptic mange mite antigens by the passive haemagglutination assay in pigs infested with *Sarcoptes scabiei* var *suis*. *Vet Parasitol* 15:309–316
- Yazwinski TA, Tucker C, Featherston H, Johnson Z, Wood-Huels N (1997) Endectocidal efficacies of doramectin in naturally parasitized pigs. *Vet Parasitol* 70:123–128
- Zimmermann W, Kircher P (1998) Serologische Bestandesuntersuchung und Sanierungsüberwachung der *Sarcoptes scabiei* var. *suis* Infektion: erste vorläufige Resultate. *Schweiz Arch Tierheilkd* 140:513–517