



## The immunopathogenesis of staphylococcal skin infections – A review



P.B. Hill (BVSc, PhD) (DVD, DipACVD, DipECVD, MANZCVS)<sup>a,\*</sup>, A. Imai (DVM)<sup>b</sup>

<sup>a</sup> Companion Animal Health Centre, School of Animal and Veterinary Sciences, University of Adelaide, Roseworthy Campus, Roseworthy SA 5371, Australia

<sup>b</sup> Dermatology resident, Synergy Animal General Hospital, 815 Kishigami Kawaguchi, Saitama, 333-0823, Japan

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### ABSTRACT

*Staphylococcus aureus* and *S. pseudintermedius* are the major causes of bacterial skin disease in humans and dogs. These organisms can exist as commensals on the skin, but they can also cause severe or even devastating infections. The immune system has evolved mechanisms to deal with pathogenic microorganisms and has strategies to combat bacteria of this type. What emerges is a delicate “peace” between the opposing sides, but this balance can be disrupted leading to a full blown “war”. In the ferocious battle that ensues, both sides attempt to get the upper hand, using strategies that are comparable to those used by modern day armies. In this review article, the complex interactions between the immune system and the organisms are described using such military analogies. The process is described in a sequential manner, starting with the invasion itself, and progressing to the eventual battlezone in which there are heavy casualties on both sides. By the end, the appearance of a simple pustule on the skin surface will take on a whole new meaning.

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### 1. Introduction

Bacterial skin infections are common in domestic animals and represent an important reason for dogs to be presented to veterinarians for treatment. A variety of lesions can be seen with the dermatosis commonly referred to as canine pyoderma, including papules, pustules, crusted papules and epidermal collarettes (Fig. 1). The inflammatory events that underlie this condition comprise two major aspects of skin immunity, namely the development of grossly visible erythema (which is a manifestation of inflammation, and more specifically vasodilatation) and the infiltration of neutrophils at a microscopic or gross level. Both of these changes reflect a complex series of immunological events that are initiated by the presence of pathogenic bacteria on the skin surface. In the case of canine pyoderma, the inciting bacteria are already present on the skin and take advantage of an opportunity that allows them to proliferate and gain entry. What follows is a titanic battle between the invaders and the host, a battle in which both sides try to outwit each other with sophisticated attack and defence mechanisms. As with any invasion, the enemy will attempt to thrust forward, build up its numbers and establish a base on the newly captured territory. To repel and defeat such an invasion requires a range of highly coordinated defences, including physical barriers, an army of highly trained and well equipped soldiers, and some

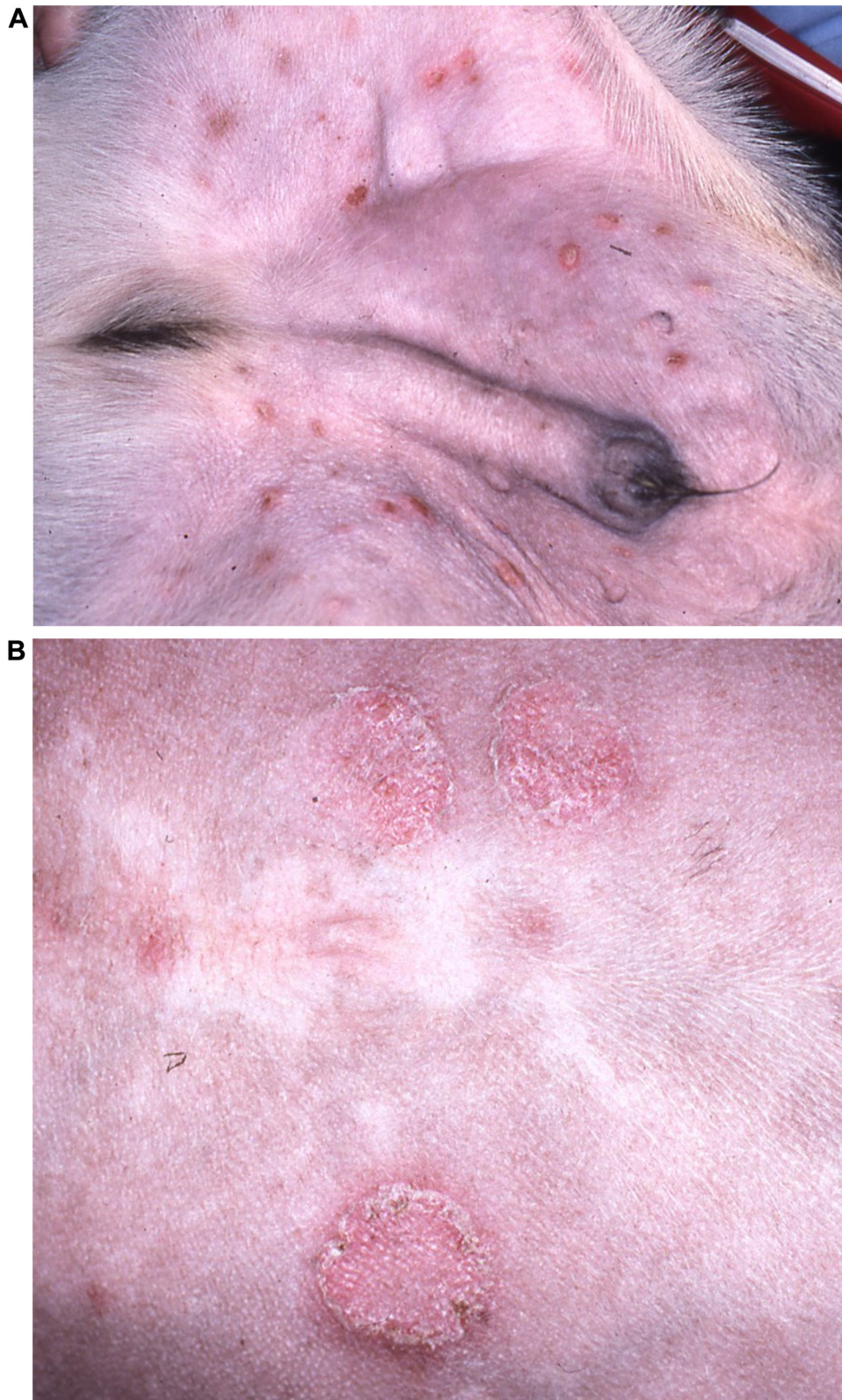
lethal weaponry. As in any battle, the outcome is never certain, and either side can get the upper hand. In this review article, we will attempt to explain the complicated interactions between staphylococci and the host immune system using such an analogy. Our aim is to simplify and demystify an area of veterinary dermatology that can appear overwhelmingly complex. In order to achieve this, we will compare each element of the immune system to a commonly understood concept of a traditional battle, with all the technology that entails. The various components of this bacterial “enemy” and the immune system “army”, are summarized in Tables 1 and 2, and will be expanded upon throughout this article. Table 3 provides a list of abbreviations used throughout this paper.

### 2. The invaders

For the purpose of this article, the bacterial invaders will be restricted to a single genus of organisms – *Staphylococcus*. This genus represents the major cause of bacterial skin infections in both dogs and humans. *Staphylococcus pseudintermedius* is a Gram-positive bacterium that lives as a commensal organism on the skin of dogs [1]. It is an opportunistic pathogen and is the major cause of canine pyoderma [1]. In dogs, it can be cultured at high frequency from the nares, oropharynx and anal ring of normal and infected dogs [2–6], but molecular analysis of the cutaneous microbiome has shown it to be present in all dogs at most sites in low numbers [7]. From these sites, it can be spread to other regions of the body such as the hair shafts, sites of infection, other dogs in the household or in-contact humans [3,5,8]. It does not cause disease unless

\* Corresponding author.

E-mail address: [p.hill@adelaide.edu.au](mailto:p.hill@adelaide.edu.au) (P.B. Hill).



**Fig. 1.** A: Papulo-pustular eruption on a dog's ventral abdomen caused by infection with *Staphylococcus pseudintermedius*. B: Staphylococcal rings on the abdominal skin of a dog. These lesions comprise erythematous annular macules surrounded by epidermal collarettes. They can be considered as expanded pustules in which the overlying epidermis has disappeared. In both images, the lesions have induced cutaneous inflammation and gross or microscopic infiltration of neutrophils.

the resistance of the host is lowered and the skin barrier altered by predisposing factors such as atopic dermatitis, medical and surgical procedures and/or immunosuppressive disorders [1]. Much of our understanding of the immunology of staphylococcal skin infec-

tions is based on work done in humans with *Staphylococcus aureus*, although it is likely that similar mechanisms occur in dogs infected with *Staphylococcus pseudintermedius*.

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