



Lesion distribution in cases of canine atopic dermatitis in South Australia

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Objective To determine the lesion distribution patterns in different breeds of dogs affected by atopic dermatitis in South Australia.

Methods The presence or absence of erythematous skin lesions in 267 cases of canine atopic dermatitis (CAD) was recorded across 36 anatomical sites. Breeds represented by ≥ 9 dogs were included in the analysis. The percentage of dogs showing lesions at each of the body sites was calculated and illustrated on colour-coded diagrams. Variations in affected body sites within and between breeds were compared using Kruskal-Wallis ANOVA and Dunn's multiple comparison tests.

Results The prevalence of skin lesions at different body sites differed significantly both in the population as a whole and within breeds. The sites affected in $\geq 75\%$ dogs were the dorsal and ventral aspects of the front and hind paws. The sites affected in 50–74% were the medial pinnae, axillae, ventral chest, abdomen and perineum. Sites affected in 25–49% of dogs included the face, periocular region and forelimb. Remaining body sites were affected in $< 25\%$ of dogs. Analysis at the breed level revealed some differences from this standard distribution pattern.

Conclusion The results of this study confirmed the typical lesion distributions seen in CAD and highlighted some subtle differences in breeds commonly seen in South Australia. This will be useful for clinical practitioners in prioritising differential diagnoses for pruritic skin conditions.

Keywords atopic dermatitis; dogs; South Australia

Abbreviations CAD, canine atopic dermatitis; GR, Golden Retriever; GSD, German Shepherd Dog; SBT, Staffordshire Bull Terrier; WHWT, West Highland White Terrier

Aust Vet J 2019

doi: 10.1111/avj.12828

Canine atopic dermatitis (CAD) is an inflammatory and pruritic allergic skin disease with strong breed predispositions and characteristically presents with clinical signs associated with IgE antibodies directed against environmental allergens.¹ Signs may include erythema and pruritus of the face, paws, axillae and ventral abdomen, but none of the clinical signs are pathognomonic and a definitive diagnosis cannot be made on preliminary examination, because of the diversity of the presenting signs.² This often presents a diagnostic challenge for general practitioners.³

Assessment of skin lesion distribution is a critical component of dermatological diagnosis. A clinical diagnosis of CAD is made by fulfilling a strongly associated set of clinical criteria while ruling out similar pruritic conditions.^{2,3} Two such sets of criteria by Willemse⁴ and Favrot et al.⁵ have been widely accepted by the veterinary community when diagnosing suspected allergic skin diseases.

Intradermal allergy tests or IgE serology can be used to confirm a state of IgE-mediated hypersensitivity and identify allergens that can be used for allergen-specific immunotherapy.³

Two different systems have been validated to determine the severity of lesions in dogs presented with CAD. They include the Canine Atopic Dermatitis Lesion Index (CADLI) and Canine Atopic Dermatitis Extent and Severity Index (CADESI-03 and -04), both of which can be used to grade the severity of lesions and determine the efficacy of a given treatment protocol.^{6,7} The most frequently affected areas of the body are highlighted in both indices and include the head, pinnae, front paws, hind paws, ventral thorax, axillae, ventral abdomen and inguinal region (CADLI), as well as the cubital fossa, caudal/lateral elbow, flank and flexural carpus (CADESI-04).

The clinical phenotype of atopic dermatitis varies among breeds, regions and countries. Previous studies have demonstrated that breeds such as the Labrador Retriever, Golden Retriever (GR), German Shepherd Dog (GSD), West Highland White Terrier (WHWT), Boxer, Cocker Spaniel, Bichon Frise, Shar-pei and Scottish Terrier are genetically predisposed to CAD.^{8–12} The clinical presentation in some of these breeds has been documented briefly by Picco et al.,⁹ and more extensively by Wilhem et al.,¹³ who demonstrated the clinical phenotypes in nine often affected breeds of dog to highlight the variability of this allergic skin disease. Those studies however, were completed in countries other than Australia and did not include several breeds of dog commonly owned in Australia such as the Staffordshire Bull Terrier (SBT), Australian Kelpie and Maltese Terrier.

The primary aim of this study was to determine the common lesion distribution patterns in different breeds of dog presented to the dermatology referral service at the University of Adelaide's Companion Animal Health Centre (South Australia). Secondary aims were to determine the age of onset, the prevalence of secondary infection and the significance of food versus environmental allergens.

This study intended to provide clinically useful information that can be used by general practitioners when diagnosing CAD. Breed-specific phenotypes that were identified will be invaluable in allowing differential diagnoses to be prioritised.

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Materials and methods

Study design and population

The cases for this study were identified from those presenting to the dermatology referral service at the University of Adelaide's Companion Animal Health Centre (South Australia) between 2010 and 2018. Cases were obtained from the Cornerstone practice management software by searching for the following terms and codes: 'atopic dermatitis', 'allergic dermatitis – precise cause not determined', 'intra-dermal skin test' and 'IgE serology test' or dogs that had been prescribed the anti-allergic drug oclacitinib (Apoquel®, Zoetis).

Diagnosis of CAD

CAD was diagnosed according to standard methodology and criteria.³ Briefly, parasitic skin conditions were ruled out by microscopic examination of appropriate skin samples and/or the current administration of effective ectoparasiticides. Dogs were assessed for the presence of concurrent skin infections using appropriate cytological samples. Dogs found to have evidence of secondary skin infections with either *Malassezia pachydermatitis* or staphylococci were still included in the study because these are considered to be part of the overall disease process in CAD and are known to be triggered by microbiome dysbiosis. Furthermore, the inclusion of these cases reflected a more accurate representation of real-world clinical practice. The possibility of food-induced CAD was investigated (when possible) by performing a 6–8-week elimination diet trial using either a commercial hydrolysed diet or a home-cooked diet.

Assessment of lesions

Information on the distribution of skin lesions was obtained from the dogs' medical records. All medical records contained a written description of the dog's lesions and their distribution, as well as a lesion distribution diagram. All dogs had been assessed by a single clinician who was a board-certified veterinary dermatologist (PH). All lesions that could be attributable to CAD, including erythema, scaling, lichenification, hyperpigmentation, excoriation and self-induced alopecia, were recorded for the purposes of this study. No attempt was made to grade the severity of skin lesions – they were simply reported as present or absent.

Contrary to the 8 sites of the CADLI model or the 20 sites of the CADESI-04 model (which do not cover the entire body surface), 36 anatomical sites were chosen for the purposes of this study (Supplementary Table 1). The aim was to document the presence or absence of skin lesions at any site on the dogs.

Analysis of skin lesion distribution

Data on skin lesion distribution were extracted from the medical records and transferred into an Excel spreadsheet. Breeds of dog that were represented by ≥ 9 individuals within the total population were included in the analysis of the clinical breed phenotypes. This was an arbitrary cut-off chosen by the authors, who considered that fewer representatives than this may not have generated an accurate picture. Silhouettes were drawn for each breed with the outline of the 36 anatomical sites in order to graphically present the results. The percentage of animals affected at each of the 36 anatomical sites was calculated and colour-coded as follows: white, 0–25% of dogs

affected; pink, 25–50% of dogs affected; light-red, 50–75% of dogs affected; bright red, 75–100% of dogs affected.

Using this system, a series of colour-coded diagrams depicting lesion distribution were created to highlight the specific clinical presentation of CAD in the entire population as well as in selected breeds.

Additional information collected from the medical record included the dog's age, breed and sex, together with results of microscopic examinations to determine secondary bacterial or yeast infections.

Statistical analysis

Microsoft Excel and Graphpad Prism were used to calculate descriptive and analytical statistics. The frequency of lesions in a particular anatomical site was calculated for each breed of dog. Differences in frequency between the same anatomical site in different breeds, and between different anatomical sites within the same breed, were compared using Kruskal-Wallis ANOVA and Dunn's multiple comparison tests. Significance was set at $P \leq 0.05$.

Results

A total of 314 dogs were identified using the search criteria. Of these, 26 were removed from the study population because they were not examined by a specialist dermatologist; 3 dogs were removed because of an exclusive diagnosis of food-induced allergic skin disease; 4 dogs were removed because the medical record clearly stated that a diagnosis of CAD was highly unlikely; 14 other dogs were also removed because of a definitive diagnosis of a different condition. Of the remaining 267 dogs, 146 were male and 121 were female; 107 had a positive intradermal allergy test or IgE serological test and 160 had a clinical diagnosis without an allergy test being performed. In those cases, the owners of the dogs preferred to pursue symptomatic anti-allergy treatment rather than allergy testing; 39 dogs undertook a hypoallergenic food trial and 228 did not. Analysis of these subgroups did not reveal any statistical significance, so the population was examined as a whole.

Breeds represented by ≥ 9 dogs included the SBT ($n = 45$), Labrador Retriever ($n = 24$), GSD ($n = 16$), Maltese Terrier ($n = 14$), GR ($n = 11$), Boxer ($n = 10$), Australian Kelpie ($n = 9$), Beagle ($n = 9$) and WHWT ($n = 9$).

The frequency of affected body sites in the total population and in the nine individual breeds is shown in Supplementary Table 1. The frequency of affected sites in all breeds combined is illustrated in Figure 1. Figure 2 graphically depicts the frequency of affected sites in descending order. The lesion distributions in the nine individual breed are shown in Figure 3.

The sites affected in $\geq 75\%$ of all dogs were the dorsal and ventral aspects of the front and hind paws (Figure 2). The sites affected in 50–74% were the medial pinnae, axillae, ventral chest, abdomen and perineum. Sites affected in 25–49% of dogs included the face, periocular region and forelimb. Remaining body sites were affected in $< 25\%$ of dogs. Several differences from this standard distribution pattern were noted at the breed level.

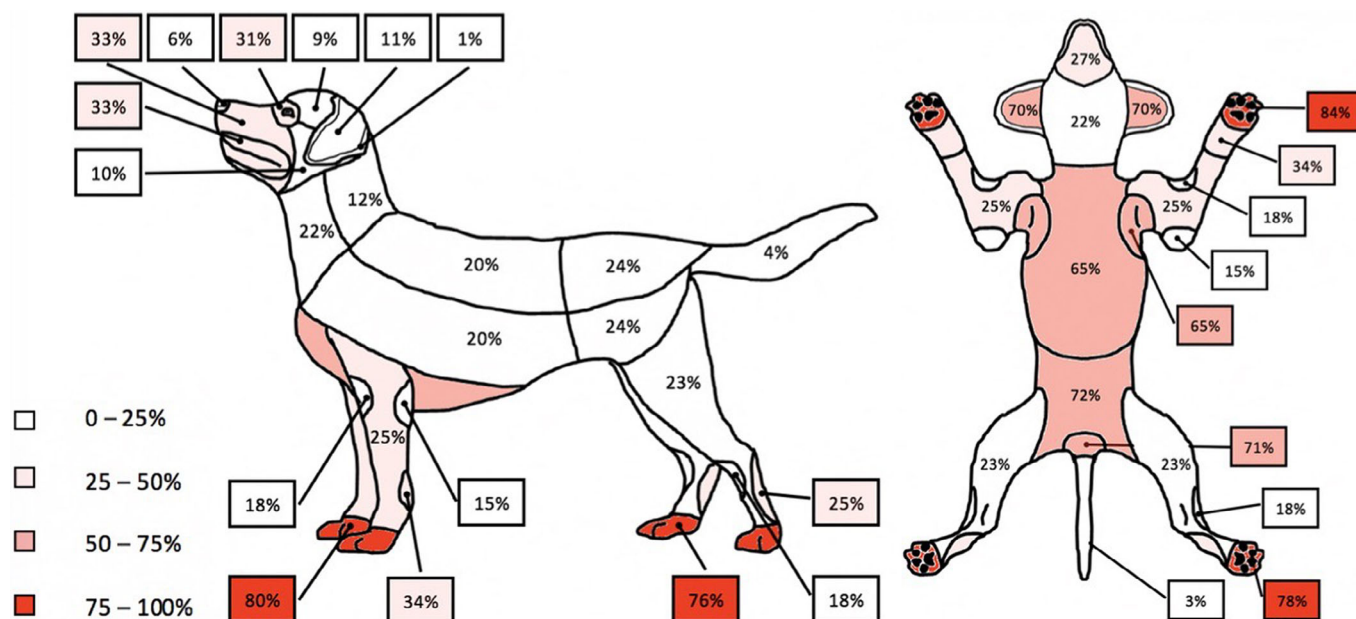


Figure 1. Skin lesion distribution diagrams for the total population. Each colour corresponds to the percentage of animals affected in that specific anatomical site.

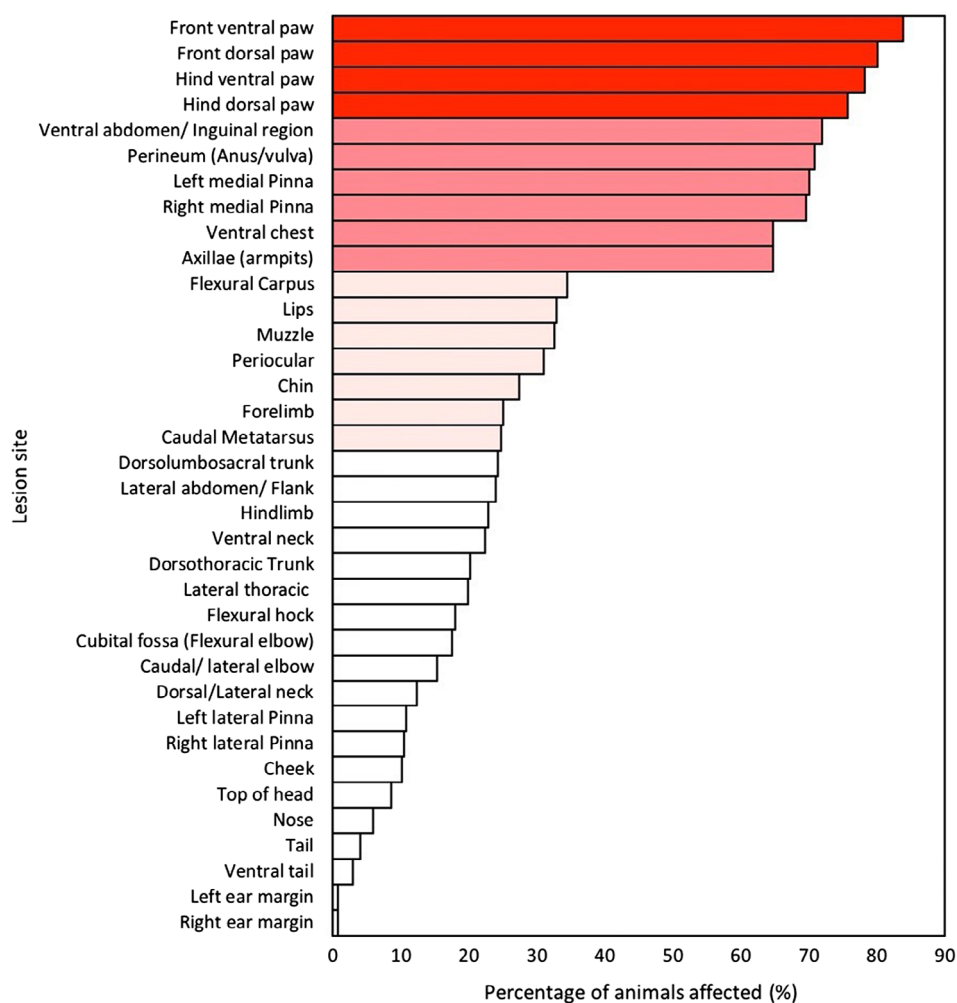


Figure 2. Bar graph representing the frequency of erythematous skin lesions across the 36 anatomical sites for the total population in descending order.

The frequency of skin lesions in the Beagle was higher on the front paws (90%) than the hind paws (67%), with the flexural carpus and caudal metatarsus (67%) also often affected. The frequency of skin lesions in the Boxer was notably high on the ventral neck (50%) and over the dorsum (30%), but lesions of the face were also particularly prevalent (60%). In the GSD the trunk, thorax, abdomen, lips and flexural carpus was affected in > 38% of cases and the periocular region was affected in 31% of cases. The medial pinna was the most affected area for the GR but the face, forelimb and ventral paws also recorded a high frequency of skin lesions. The Kelpie was significantly different from the Beagle ($P = 0.0105$), Boxer ($P = 0.0452$), GSD ($P = 0.0214$), GR ($P = 0.0051$) and Maltese ($P = 0.0102$), as it did not have a high frequency of lesions on the medial pinnae. However, skin lesions were most commonly recorded on the face, limbs, paws, ventrum and flank. The lateral pinnae of the Kelpie also had the same frequency of skin lesions as the medial pinnae (33%). In Labradors, a predilection for the perineum and paws (92%) was observed and the forelimb, flexural carpus (both 42%) and hindlimb (38%) were also commonly affected. Aside from the pinnae, paws and ventrum, skin lesions were frequently seen on the face, periocular region and limbs of the Maltese Terrier. The SBT presented often with skin lesions on the ventral neck and face, with the flank (29%) also frequently affected. The WHWT was the most widely affected dog analysed in the study (average 23 body sites affected). In contrast to the standard lesion distribution, erythema was prevalent on the ventral neck (56%), face (44%), periocular region (67%) and the dorsum (44%), with the flank, forelimb and hindlimb also common sites (33%).

The mean age of onset of erythematous lesions was 3.88 years in all dogs (median age, 3 years). However, the Maltese Terrier (8.2 years) and WHWT (7.7 years) did not follow this trend. The age of onset of erythematous lesions in the Maltese Terrier differed significantly from the total population ($P = 0.0085$) and suggested that this breed is affected later in life. The prevalence of secondary staphylococcal infection was 26% and 23% of the population was affected by a secondary *Malassezia* overgrowth. The GSD (68.8%) was significantly more affected by secondary bacterial infections compared with the rest of the population ($P = 0.0077$). The WHWT was affected by a secondary bacterial infection in 55.6% of cases, but this was found not to be significant ($P > 0.05$).

Discussion

The present study evaluated the distribution of skin lesions in 267 dogs with CAD (Figure 1) and nine individual breeds of dogs represented by ≥ 9 dogs (Figure 3). In the total population of dogs, the paws were the most frequently affected area (> 75%), followed by the medial pinnae, axillae and ventrum (> 50%), with the face, periocular region and forelimbs affected in > 25% of cases. The least commonly affected sites included the tail, ear margins, nose, cheek and top of the head. These findings are consistent with previous reports^{4,5,11,12,14} and are considered characteristic of CAD. In the studies previously conducted, it was shown that the distal limbs are most often affected, followed by the axillae, ventrum, medial pinnae and then the face. That finding was confirmed in the present study. Favrot et al. found that the dorsolumbar area and the ear margins

were highly associated with non-atopic conditions,⁵ which was certainly the case in our study as the ear margins were affected in only 1% of cases. However, although not commonly affected, the dorsothoracic trunk and dorsolumbosacral trunk were affected in 20% and 24% of cases, respectively.

Appraising the individual breed lesion distribution diagrams (Figure 3), some appear similar to each other such as the Labrador Retriever, GR and Beagle, or the GSD and the WHWT. Some breeds, however, appear distinctly different from each other such as the Kelpie and the Boxer. A similar study conducted in 2011 documented lesion distribution in nine breeds of dogs with CAD presenting to 34 veterinary dermatologists working in 15 different countries.¹³ The Boxer, GSD, GR, Labrador Retriever and WHWT were also included in that study. The findings of the present study were similar in nature, apart from a few key exceptions, highlighted in Table 1. The reason for these differences cannot be ascertained from the present study. They could reflect geographical or genetic differences or could be related to the different methodologies used in the two studies. It is interesting to note that the GSD, Boxer and WHWT were all affected on the dorsum in over 30% of cases. Skin lesions over this site are typically regarded as more characteristic of flea allergy dermatitis rather than atopic dermatitis.³

The Australian Kelpie, Beagle, Maltese Terrier and SBT have not often been mentioned in the previous literature concerning CAD.⁸ Of these dogs, only the SBT was previously considered to have a breed predisposition to CAD.^{15,16} However, an Australian study based in New South Wales conducted in 2016 reported that the Australian Kelpie and Maltese Terrier had a significantly decreased odds ratio of developing CAD, whereas the Beagle and SBT had a significantly increased odds ratio.⁸ The reason for these differences is not known, but they too could reflect geographical or methodological differences. In the present study, the SBT presented with a typical distribution of erythematous skin lesions. The paws were most frequently affected, followed by the ventrum, medial pinnae and face, whereas the only aspects of the limbs affected in > 25% of cases were the flexural carpus and caudal metatarsus. Interestingly, the flank and ventral neck were also affected in 30–40% of cases. The Maltese Terrier also presented with some uncharacteristic skin lesions, as in 29% of cases erythema was observed on the dorsum and flank. The periocular region was affected in 43% of cases, 12% more frequent when compared with the rest of the population. The ventrum and medial pinnae were affected in > 75% of cases of CAD in the Beagle; 67% of cases presented with lesions on the hind paws and in 90–100% of cases the front paws were affected. The Beagle was the breed most affected by erythematous lesions on the flexural carpus and caudal metatarsus (both 67%), a frequency 30–40% greater than the total population.

The Australian Kelpie was found to differ significantly from the generic model of CAD. Predilection sites observed included the ventral chest (78%), followed by the ventral abdomen and paws (all 67%), with the axillae, perineum, forelimb and caudal metatarsus affected in 56% of cases. All other aspects of the limbs were affected in 33–44% of cases. The frequency of lesions on the lateral pinnae (33%) was the same as for the medial pinnae, a comparison that was found to be significantly different in the total study population

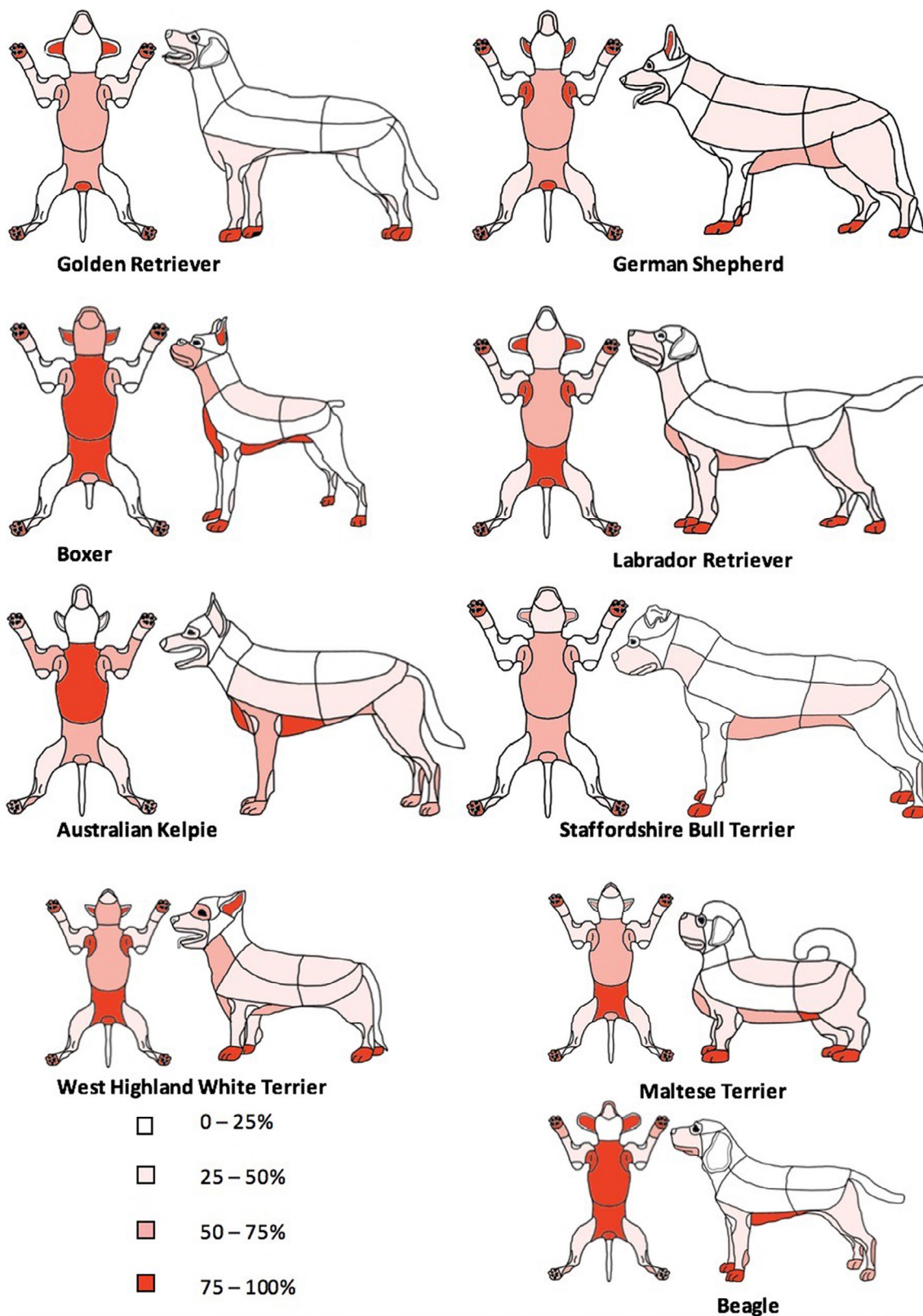


Figure 3. Lesion distribution diagrams for the Golden Retriever, German Shepherd Dog, Boxer, Labrador Retriever, Australian Kelpie, Staffordshire Bull Terrier, West Highland White Terrier, Maltese Terrier and Beagle. Each colour corresponds to the percentage of affected animals within each breed.

Table 1. Similarities and differences noted in skin lesion distribution between the present study and that of Wilhem et al¹³

Breed	Similarities	Differences in the present study
Boxer	Limbs, axillae, ventral abdomen, perineum and paws	Face, ventral chest and dorsum were more frequently affected
GSD	Face, paws and ventrum	Ventral neck, limbs, ventral abdomen less affected Dorsum more affected
GR	Face, limbs, paws, axillae, ventral abdomen	Ventral chest, perineum more commonly affected
Labrador Retriever	Limbs, paws, ventral abdomen and trunk	Ventral chest, perineum more commonly affected
WHWT	Pinnae, limbs, axillae, ventral abdomen, perineum, dorsum and trunk	Ventral neck and periocular region more frequently affected

GR, Golden Retriever; GSD, German Shepherd Dog; WHWT, West Highland White Terrier.

($P < 0.0001$). Because of the high number of comparisons made between body sites in the statistical analysis (Dunn's multiple comparisons test), there are too many associations to present in this study. For example, in the SBT, out of 630 body site comparisons, significant differences were identified between 231 sites. However, in the Kelpie, no significant comparisons were observed, despite a significantly different ANOVA result ($P = 0.0003$). This may reflect the low statistical power caused by the small sample size.

Conclusion

Assessment of skin lesion distribution is a critical component of dermatological diagnosis. The results of this study confirmed the typical lesion distributions seen in CAD and highlighted some subtle differences in breeds commonly found in South Australia. This data should be helpful to clinicians when dogs are presented with pruritic skin disease that is suspected to be CAD. First, the typical lesion distribution can be compared with that seen in other skin disorders. Second, knowledge of the variations to this generic pattern that occur in different breeds will allow clinicians to modify their index of suspicion and prioritise the differential diagnosis list more accurately.

Acknowledgment

Wei Yee Chan was supported by the Ministry of Higher Education of Malaysia and Universiti Putra Malaysia

Conflicts of interest and sources of funding

The authors declare no known conflicts of interest. This study was funded by The University of Adelaide clinical research project fund

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site: <http://onlinelibrary.wiley.com/doi/10.1111/avj.12828/supinfo>.

Supplementary Table 1 Frequency of erythematous skin lesions in 36 anatomical sites for individual breeds and the total population

(Accepted for publication 20 February 2019)

Supplementary Table 1. Frequency of erythematous skin lesions in 36 anatomical sites for individual breeds and the total population

Body site	All Dogs	SBT	Beagle	Boxer	GSD	GR	Kelpie	Lab	Maltese	WHWT
Nose	6	7	11	10	0	0	0	4	0	11
Lips	33	29	56	60	38	45	22	25	29	44
Chin	27	38	33	50	25	36	44	17	29	44
Muzzle	33	33	44	60	25	27	33	29	36	44
Periocular	31	24	22	20	31	27	33	21	43	67
Cheek	10	13	22	10	13	0	0	0	21	11
Top of head	9	16	0	0	6	0	22	0	7	11
RL Pinna	11	9	11	30	6	9	33	21	14	11
RM Pinna	70	67	100	90	88	100	22	75	93	78
Rear margin	1	0	0	0	0	0	0	0	0	0
LL Pinna	11	9	11	30	13	0	33	21	21	11
LM Pinna	70	67	89	90	88	91	33	83	86	78
Ear margin	1	0	0	0	0	0	0	0	0	0
Dorsal/Lateral neck	12	18	0	10	25	0	11	8	21	22
Ventral neck	22	40	11	50	13	18	11	25	14	56
Dorsothoracic Trunk	20	22	22	30	38	0	11	8	29	44
Dorsolumbosacral trunk	24	20	22	30	44	9	22	21	29	44
Lateral thoracic	20	24	22	10	44	0	33	8	14	44
lateral abdomen/ Flank	24	29	22	10	44	9	44	13	29	33
Axillae (armpits)	65	73	89	60	75	55	56	75	57	89
Ventral chest	65	67	100	100	63	55	78	63	57	67
Ventral abdomen/ Inguinal region	72	69	78	80	56	64	67	83	79	78
Perineium (Anus/vulva)	71	73	89	70	75	82	56	92	57	89
Cubital fossa (Flexural elbow)	18	22	11	10	13	18	44	17	29	33
Caudal/ lateral elbow	15	20	0	10	6	9	33	21	14	22
Forelimb	25	20	33	0	19	36	56	42	29	33
Flexural Carpus	34	38	67	40	38	27	44	42	29	33
Dorsal paw	80	89	89	90	75	82	67	92	93	89
Ventral paw	84	89	100	90	88	82	67	92	93	100
Hindlimb	23	22	33	0	25	18	44	38	36	33
Flexural hock	18	16	33	0	25	36	44	17	21	22
Caudal Metatarsus	25	31	67	30	19	36	56	17	21	11
Dorsal paw	76	91	67	90	75	73	67	83	86	89
Ventral paw	78	93	67	80	94	73	67	83	93	100
Ventral tail	3	0	11	10	0	9	11	0	0	0
Tail	4	4	11	0	13	9	0	0	0	0

White shading represents dogs affected by lesions in 0–24% of cases, light pink represents dogs affected by lesions in 25–49% of cases, dark pink represents dogs affected by lesions in 50–74% of cases and bright red represents dogs affected by lesions in 75–100% of cases.

GR, Golden Retriever; GSD, German Shepherd Dog; Lab, Labrador Retriever; SBT, Staffordshire Bull Terrier; WHWT, West Highland White Terrier.