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Spatial Aspects of Foot-Pad Dermatitis in Swedish Broilers

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Ekstrand C, Carpenter TE: Spatial aspects of foot-pad dermatitis in Swedish broilers. Acta. vet. scand. 1998, 39, 273-280. – This study aimed at analysing spatial and spatio-temporal aspects of foot-pad dermatitis in Swedish broilers. The information on disease prevalence and severity was based on a two-year foot-health surveillance programme where information on producer, breed, feed manufacturer, region, abattoir, date of slaughter and several other variables was recorded. The level of clustering in space was analysed on 2-digit zipcode level using Moran's I test which measures similarity of location. The level of clustering in space was also analysed using the I_{pop} test, which takes the population at risk into consideration. The examination of time-space interaction was carried out using the Barton method and the Knox method. We found a significant ($p<0.001$) clustering of regions with respect to foot-pad dermatitis score using Moran's I test, and a significant ($p<0.0001$) clustering in space also when related to the number of flocks delivered from each region. The flocks with very high prevalence of foot-pad dermatitis were significantly ($p<0.05$) clustered in both time and space, i.e. the flocks with high prevalence of lesions came from the same geographic area during the same time periods. This information will permit us to focus the control efforts within the foot-health surveillance programme on specific regions in specific time periods, thus making the programme more effective.

chicken; cluster; feed; feet; poultry; region; slaughterhouse; surveillance programme; zipcode.

Introduction

Foot-pad dermatitis, also known as plantar pododermatitis, is a condition which is characterised by lesions on the ventral foot pads of poultry (*Schulze Kersting* 1996). The lesions start with necrotising degeneration of the epithelial cells followed by ulceration and inflammation (*Nairn & Watson* 1972). Foot-pad dermatitis in broilers is related to moisture and chemical irritants in the litter (*Greene et al.* 1985, *Martland* 1985). Wet litter is a rather common problem in the broiler industry in many countries, and quite substantial research has been carried out to investigate different possible risk factors. An association between litter depth and material and the prevalence of foot-pad dermatitis have been identified by *Shanawany* (1992) and *Ekstrand et al.* (1997a). Stocking density and type of water equipment have also been identified as factors of importance for the development of wet litter (*Cravener et al.* 1992, *Tucker & Walker* 1992). Other factors which have previously been identified as risk factors for wet litter are feed composition and climatic conditions (*McIlroy et al.* 1987). There is a

correlation between foot-pad dermatitis and other types of contact dermatitis in broilers, such as breast blisters and hock burns (*Greene et al.* 1985, *Martland* 1985).

Several of the risk factors mentioned above are likely to vary both among countries and regions within a country. Litter condition is correlated with indoor relative humidity which is linked to the outdoor relative humidity (*Payne* 1967) and it has been shown that broiler contact dermatitis is significantly more common during the winter months when the air humidity is high (e.g. *Bruce et al.* 1990). A similar pattern of seasonality in the prevalence of foot-pad dermatitis in broilers in Sweden has been demonstrated by *Ekstrand & Carpenter* (1998).

This cross-sectional observational study is based on a Swedish surveillance programme which was developed to improve the knowledge about the prevalence of broiler foot-pad dermatitis and its distribution in the population. The programme also contained an advisory system which aimed at decreasing the incidence of the lesions. This paper covers the first 2 years of the programme, from July 1994 through June 1996. Results considering a number of variables recorded in this programme have been reported previously (*Ekstrand et al.* 1997b, *Ekstrand et al.* 1998, *Ekstrand & Carpenter* 1998). The aim of the part of the study presented here was to further describe and analyse spatial and spatio-temporal aspects of foot-pad dermatitis in Swedish broilers. An additional aim of this publication is to describe the spatial distribution of Swedish broiler farms and their size/production capacity in general terms for future reference.

Materials and methods

The foot-health surveillance programme and the data collection methods have been described in detail elsewhere (*Ekstrand et al.* 1998). In summary, the programme included classifying foot-pad lesions and recording flock prevalence at slaughter. A flock was defined as a group of birds reared in the same compartment at the same farm and slaughtered at the same time. For each flock, information on producer, breed, feed manufacturer, region, abattoir, date of slaughter, age at slaughter, planned and actual stocking density was recorded.

A total of 6988 flocks, representing approximately 110 million broilers, was examined. A total of 175 broiler producers from 15 counties is represented. The programme involved all 11 major broiler abattoirs in Sweden, representing 97% of the broiler producers. From every slaughtered flock 100 single feet were systematically taken out for gross examination at the abattoir. The foot-pad lesions were scored by the veterinary inspectors or assistants at each slaughterhouse. A flock-specific value was calculated as a weighted average of the lesion scores and their relative frequency (*Ekstrand et al.* 1998). The possible total score achievable ranged from 0 to 200, where 0 represented samples without foot-pad dermatitis, and 200 represented samples where all feet displayed severe foot-pad dermatitis lesions.

Data on location of broiler farms, origin of flocks slaughtered and the mean foot-pad score in different regions were mapped (*MapInfo Professional* 1995) using geographic data supplied by the Swedish Central Bureau of Statistics (SCB) (*Lantmäteriet KartCentrum* 1996). We mapped and analysed the level of clustering of number of broiler farms per region, of the average farm size (indicated by the number of flocks delivered during the study period) by region and of the mean foot-pad score by region. The level of clustering in space, i.e. similarity of location, was analysed on 2-digit zipcode level using Moran's I test (*Moran 1948;* 1950), which measures similarity of location or adjacency. The level of clustering in space was also analysed using the I_{pop} test (CAST 1993),

which takes into consideration not only the degree of disease in different areas but also the number of flocks at risk, i.e. the number of flocks delivered from each region.

The examination of time-space interaction was carried out using the Barton method (*Barton et al.* 1965, *David & Barton* 1966, *Cluster* 1993), which compares the spatial separation of cases located within the same time interval with the spatial separation of cases in other time intervals, and the Knox method (*Knox* 1964a; b, *Cluster* 1993), which examines the cases pairwise with respect to their separation in time and space, compared with the presumed random critical time-space separation. The critical time interval was set to 4 weeks (approx. one month), as this time period had been used in previous analyses of the temporal aspects of foot-pad dermatitis (*Ekstrand & Carpenter* 1998). The critical distance was set to 10 km. The computer programme available for analysing the time-space interaction by the Barton method and the Knox method (*Cluster* 1993) can handle datasets of <300 cases and not of the size in question in this study. In order to get a reasonable sample size, the Barton test was performed on the 41 records where the total foot-pad dermatitis score was 200 (maximum achievable score), i.e. the farms with the worst problems. One reason for choosing such a high cut-off point was that the inspectors at the slaughterhouses had noticed that most of the flocks with maximum score were in notably worse condition (extremely severe lesions) than flocks in the interval just below 200. The time-space interaction tests were also performed on a dataset where all multiple flocks delivered from the same farms within one month's time had been excluded from the dataset.

Climate data was supplied by the Swedish Meteorological and Hydrological Institute (SMHI). The regional values for air relative humidity used in this study are mean values over a 30 year period, based on records from monitoring stations in the 15 counties of interest in this study. The level of clustering in space of regions in relation to relative humidity was thus analysed on county level using Moran's I test.

Figure 1. Map showing zipcode areas (2-digit level) where broiler farms in Sweden are located (1994-1996).

Results

Clustering in space with reference to location and capacity of farms

Broiler farms were present in 27 different 2-digit level zipcode regions, all located in the southern part of the country (Fig. 1). The number of broiler farms per region varied from 1 to 40 (Fig. 2). There was no statistically significant ($p>0.05$) clustering of regions with respect to number of farms per zipcode region.

The number of flocks delivered per zipcode region varied from 2 to 1220. As could be expected, most of the regions with a high number

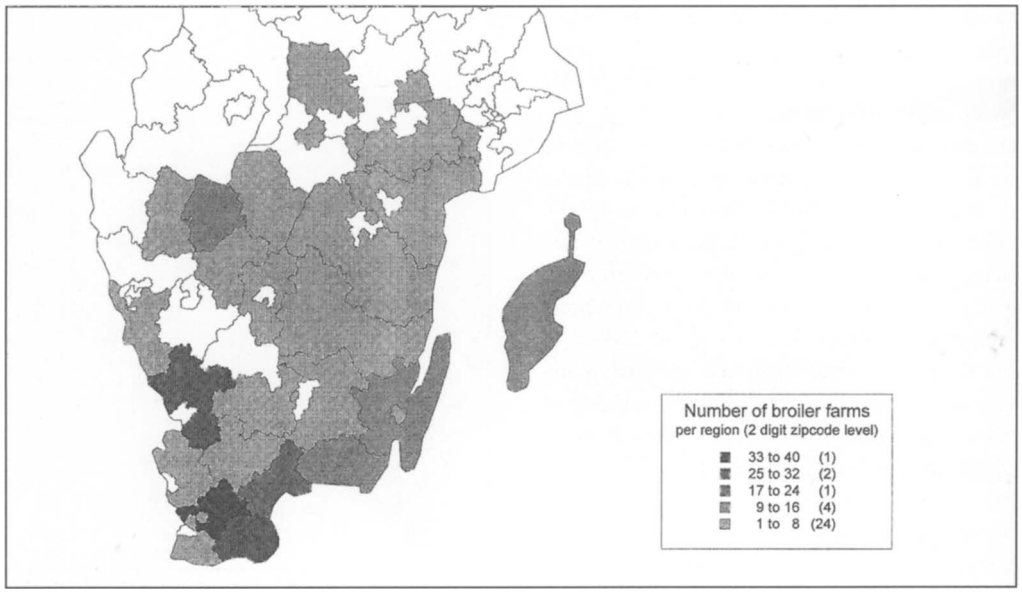

Figure 2. Map showing the number of broiler farms per region (2-digit zipcode level) in the areas of Sweden where broilers are reared.

of farms also delivered a high number of flocks during the study. There was no statistically significant ($p>0.05$) clustering of regions with regard to number of flocks delivered. However, when looking at the average number of flocks delivered per farm, which could be used as an indicator of farm size, there was a significant clustering of regions ($p<0.001$).

The Moran's I test showed marginally significant ($p=0.08$) clustering of regions with respect to outdoor relative humidity.

Clustering in space with reference to foot-pad dermatitis

The mean value for foot-pad dermatitis score per region varied from 3 to 84 (Fig. 3). The Moran's I test was based on a mean value of the foot-pad score for each zipcode region. The Moran's I test showed a significant ($p<0.001$) clustering of regions with respect to mean foot-pad dermatitis score. The zip-code regions with high mean values for foot-pad score were clustered in the south-western part of the country. The I_{pop} test, which related the mean value of the foot-pad score for the different zipcode regions to the number of flocks delivered from each region showed significant ($p<0.001$) clustering as well, mainly attributable to clustering within regions. This means that the clustering described above was not only an effect of the number of farms at risk.

Time-space interactions

The results from the examination of time-space interactions using the Barton method showed statistically significant ($p<0.05$) clustering of these cases in time and space. This clustering occurred mainly during the autumn and winter months, and was found in the south-western region of the country. When the Knox test with

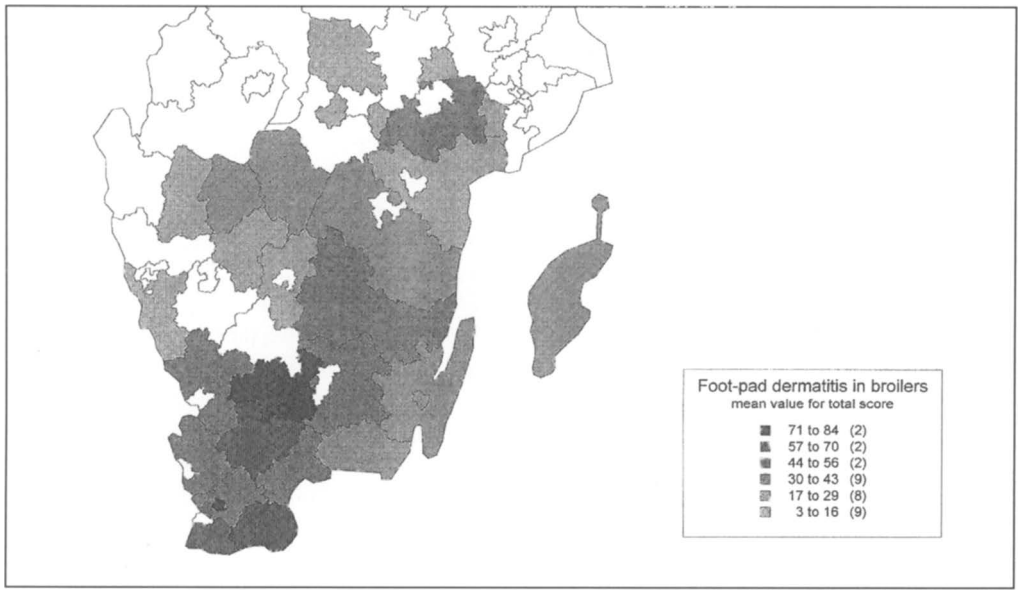

Figure 3. Map showing the mean value for total foot-pad dermatitis score in broilers in each region (2-digit zipcode level) during this two-year study.

the critical distance set to 10 km and case-time separation set to 4 weeks was performed on the same dataset, the results showed statistically significant ($p<0.05$) clustering of cases with respect to their spatial and temporal distribution. The tests performed on the dataset where multiple flocks delivered from the same farms within one month's time had been excluded did not show significant clustering.

Discussion

In this study, the regions were shown to be clustered in space with respect to the prevalence of foot-pad dermatitis. The flocks with very high prevalence were mainly found during the autumn and winter months in the south-western part of the country, where a time-space interaction was identified.

Foot-pad dermatitis in broilers is known to be related to wet litter (*Greene et al.* 1985, *Schulze Kersting* 1996). The clustering of flocks with high foot-pad dermatitis score in time and space identified in this study could partly be a result of seasonal and regional variations in the relative air humidity, affecting litter moisture content. Seasonal variation in the prevalence of breast blisters and hock burns in broilers due to variations in the relative air humidity have previously been reported by *McIlroy et al.* (1987) and *Bruce et al.* (1990). The seasonal variations in outdoor air humidity and strong correlation with foot-pad lesions in Sweden have been described in a previous paper by *Ekstrand & Carpenter* (1998).

The results from the analysis on regional differences in outdoor relative humidity indicates that the spatial clustering with respect to foot-pad dermatitis score found in this study can not be explained only by humidity. However, the relatively small number of regions on the

county level (n=15) made the power of this analysis somewhat low. It should be noticed that whereas the mean values for foot-pad score are based on a two-year period, the humidity values are based on records from 30 years. A more thorough investigation should be carried out to give better understanding of the relationship between regional climate and broiler foot-health. It should be stressed that indoor climate can be regulated successfully with the help of modern heating and ventilation equipment. Keeping the litter dry is often only constrained by management skills and finances.

The spatial clustering of high mean values of foot-pad dermatitis score in the south-western region could be a result of differences in feed composition between feed suppliers delivering feed to different parts of the country, as the feed composition can affect the bird's droppings (*Schulze Kersting* 1996) and thereby the litter condition. Further, other analyses performed on the data used for the spatial analyses presented in this paper have shown a significant association between foot-pad dermatitis and feed supplier and slaughterhouse respectively (*Ekstrand et al.* 1998). Spatial clustering could also be linked to other local factors such as management advice given by local advisors at the slaughterhouses, which are consistently receiving birds from specific areas.

The results from the Barton and Knox tests performed on the records where the prevalence of severe foot-pad dermatitis was very high indicated time-space correlation. The clustered case pairs were mainly found during the autumn and winter months, and several originated from the same farm. One possible hypothesis regarding the mechanisms behind this time-space correlation is that flocks from different houses or compartments on the same farm, originating from the same batch of day-old chickens (although not necessarily from the same parent flock) and slaughtered within a short time span are likely to have the same foot-health status. To investigate this, multiple flocks delivered from the same farms within one month's time were excluded from the dataset. The tests performed on the new dataset did not show significant clustering, which supports this hypothesis. This finding could be interpreted as an effect of the management and staff at each farm, as different farms were showing different results even when located close to each other and rearing the birds of the same hybrid under similar climatic conditions. Our conclusion is that further advice on rearing methods and animal environment directed to the broiler farmers, if taken into consideration, should continue to improve broiler foot-health. In Sweden broilers are grown strictly indoors in climate controlled houses. If the use of ventilation and heating equipment is monitored correctly by a skilled farmer it should be possible to keep the litter dry as the capacity of the technical equipment is often more than satisfactory. However, the cost of heating the house enough to achieve optimal humidity levels during the cold months is substantial.

The results from this study support our initial hypothesis about clustering in space of foot-pad dermatitis in broilers. This information will permit us to focus the control efforts within the foot-health surveillance programme on specific regions in specific time periods, thus making the programme more effective. The broiler producers will be informed about these findings, to enable them to optimise heating and ventilation measures. However, further analysis of the interactions between the factors investigated will be necessary.

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Sammanfattning

Spatiella aspekter på trampdynedermatit hos svenska slaktkycklingar.

Denna studie syftade till att analysera de spatiella aspekterna på förekomsten av trampdynedermatit ("fotskador") hos svenska slaktkycklingar. Informationen om lidandets prevalens och grad inhämtades under två år genom ett fothälsoprogram som omfattade drygt 97% av de svenska slaktkycklingbesättningarna. För varje enskild flock beräknades ett värde, så kallad "fotskade-poäng", baserat på skadornas omfattning och frekvens. Inom ramen för programmet inhämtades även upplysningar om bl.a. uppfödare, hybrid, foderleverantör, län, slakteri och slaktdatum. Förekomsten av geografiska anhopningar, s.k. kluster, av områden med hög prevalens trampdynedermatit analyserades på regional nivå. Regionernas utbredning bestämdes av de två första siffrorna i postnumret (s.k. tvåsiffrig postnummernivå), en metod som är vanlig vid denna typ av analys. Analyserna utfördes med hjälp av Moran's I-test, vilket mäter likheter i geografisk lokalisation. Nivån av geografisk anhopning analyserades även med hjälp av I_{pop} -testet, som tar hänsyn till storleken på den population som riskerar att bli sjuk, i detta fall antalet levererade flockar från respektive område.

Analyserna av interaktioner mellan tid och rum begränsades till att omfatta de flockar som hade mycket hög förekomst av fotskador, och utfördes med hjälp av Barton- och Knox-metoderna.
Vi fann en signifikant ($p<0.001$) anhopning av regioner med avseende på medelvärdet för den flockbaserade fotskade-poängen när vi använde Moran's I -test, och signifikant ($p<0.0001$) geografisk anhopning även när medelvärdet relaterats till det antal flockar som levererats från de olika regionerna. Det fanns signifikanta ($p<0.05$) kluster i både tid och rum av de flockar som hade mycket hög prevalens grav trampdynedermatit, dessa var lokaliserade i landets sydvästra delar under höst- och vintermånaderna. Denna information kommer att göra det möjligt att fokusera kontrollåtgärderna inom fothälsoprogrammet på specifika regioner under specifika tidsperioder, och på så sätt göra programmet mer effektivt. Det är angeläget att slaktkycklinguppfödarna informeras om vikten av att styra ventilation och uppvärmning så att en torr ströbädd kan erhållas även när luftfuktigheten utomhus är hög.

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