Acta vet. scand. 1998, *39,* 229-236.

Temporal Aspects of Foot-Pad Dermatitis in Swedish Broilers

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Ekstrand C, Carpenter E: Temporal aspects of foot-pad dermatitis in Swedish broilers. Acta vet. scand. 1998, 39, 229-236. – This study aimed at analysing the temporal aspects of foot-pad dermatitis in Swedish broilers. The information on disease prevalence and severity was based on a 2-year foot-health surveillance programme where information on producer, breed, feed manufacturer, region, abattoir, date of slaughter and several other variables was recorded. The seasonal effects were evaluated using classical multiplicative decomposition time series analysis. This study shows that there has been a significantly consistent decrease in the prevalence of severe foot-pad lesions during the first 2 years of the programme. Looking at the development over time we found a trend-cycle component of 10.4% and a seasonal component of 48.7% resulting in a total adjusted R-square value of 58.5% for the total foot-pad score. This means that almost 60% of the variation in flock foot-pad score can be explained by the variable 'time', and that this variation was mainly related to seasonal effects but also to a general decreasing trend over the study period. However, substantial differences in temporal patterns among slaughterhouses, feed suppliers and regions were found. The time series analysis approach was found to be useful for this type of investigation when evaluating the effects of an intervention programme, and it can also be applied for projecting the future development of disease status in a stable population.

chicken; feed; feet; poultry; region; relative humidity; season; slaughterhouse; surveillance programme; time series.

Introduction

Foot-pad dermatitis is a type of contact dermatitis where lesions appear on the plantar regions of the bird's feet (*Greene et al.* 1985). The lesions are considered to be caused by a combination of moisture and chemical irritants in the litter (e.g. *Harms et al.* 1977, *Greene et al.* 1985, *Martland* 1985). They may be mild, showing only hyperkeratosis and discoloration. In severe cases, however, swelling and erosions or ulcers can be seen (*Martland* 1985).

A number of risk factors for wet litter, such as litter depth and material, feed composition, stocking density, enteric *campylobacter* infections, climatic conditions, and type of water equipment have been identified (e.g. *Neill et al.* 1984, *McIlroy et al.* 1987, *Shanawany* 1992, *Tucker & Walker* 1992, *Gaardbo Thomsen* 1993, *Ekstrand et al.* 1997a).

There is a correlation between foot-pad dermatitis and other types of contact dermatitis, such as breast blisters and hock burns (*Harms & Simpson* 1975, *Greene et al.* 1985). Litter condition is correlated with indoor relative humidity which is linked to the outdoor relative

humidity (*Dobrzanski & Mazurkiewics* 1984). In studies carried out in Northern Ireland *McIlroy et al.* (1987) and *Bruce et al.* (1990) showed that broiler hock lesions and breast blisters are significantly more common during the winter months when the outdoor air relative humidity (RH) is high. In an experimental study carried out in climatic chambers, *Weaver & Meijerhof* (1991) found the incidence of swollen, calloused foot-pads to be significantly higher when RH was kept at 75% compared to 45%.

This cross-sectional observational study is based on a Swedish surveillance programme which was developed to improve the knowledge about the prevalence of the lesions and their 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.* in press). The aim of the part of the study presented here was to further describe and analyse temporal aspects of foot-pad dermatitis in Swedish broilers.

Materials and methods

The foot-health surveillance programme and the data collection methods have been described in detail elsewhere (*Ekstrand et al.* in press). 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 geographical regions (counties) is represented. The programme involved all eleven 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. 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. The main factor used to encourage the farmers to keep the prevalence of foot-pad lesions low was that they otherwise were forced to decrease the bird stocking density.

Climate data was supplied by the Swedish Meteorological and Hydrological Institute (SMHI). The monthly values for air relative humidity used in this study are mean values over a thirty year period (1961-1990), based on records from 15 climate monitoring stations in the southern part of the country, where broiler farms are located.

Time series analyses were conducted to determine seasonality and secular trend of mean flock foot-pad lesion scores. The seasonal effects were evaluated using time series decomposition (*Minitab for Windows* 1996) and a classical multiplicative decomposition, exponential smoothing model (*Forecast Pro for Windows* 1994). The correlation between monthly outdoor air humidity mean values and monthly mean values for total foot-pad score was determined by calculating the Pearson product moment correlation coefficient between each pair of data (*Minitab for Windows* 1996). This procedure was also performed after applying a one-month lag of the foot-pad score

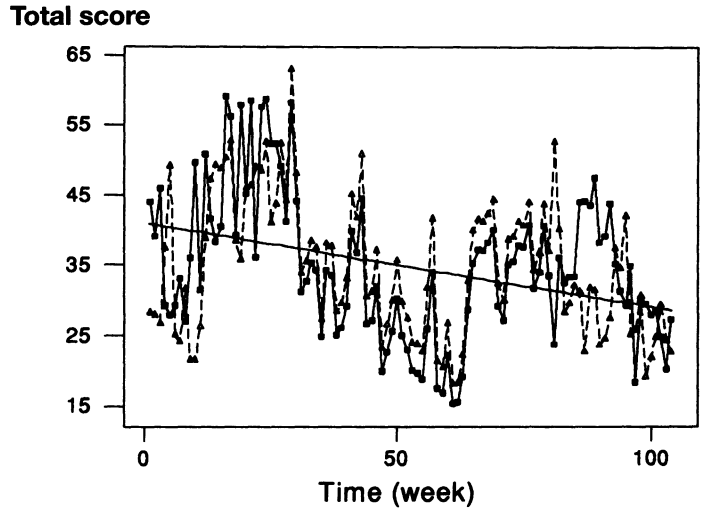

Figure 1. Total foot-pad dermatitis score over the entire study period (104 weeks, starting July 1st 1994, ending June 30th 1996). An exponential smoothing model for classical multiplicative decomposition showed a trend-cycle component of 10.4% and a seasonal component of 48.7% resulting in a total adjusted R-square value of 0.585 for the total foot pad score ($p<0.05$). Actual (■) and predicted (Δ) values are shown.

data, in order to better meet the criteria for exposure – outcome correlation.

Results

A simple linear regression analysis showed that the mean total score on a weekly basis decreased significantly ($p<0.001$, R^2 adj. = 0.108) over time during the study period (β = –0.12/week), and so did the severe lesions ($p<0.001$, R^2 adj.=0.197) (β = –0.05/week). However, the mild lesions did not show any significant decreasing trend ($p = 0.51$, R^2 adj.<0.001) over time (β = –0.01/week).

When using an exponential smoothing model for classical multiplicative decomposition (*Forecast Pro for Windows,* 1994) to analyse the time series we found a trend-cycle component of 10.4% and a seasonal component of 48.7% resulting in a total adjusted R-square value of 0.585 for the total foot pad score ($p<0.05$) (Fig. 1). The trend-cycle component for mild lesions was 3.1% and the seasonal component 60.8% resulting in a total adjusted R-square value of 0.477 ($p<0.05$). For severe lesions, the trend-cycle component was 12.6% and the seasonal component 49.1% resulting in a total adjusted R-square value of 0.571 ($p<0.05$). Foot-pad scores were generally higher in the autumn through early spring months (October-April) than in the late spring and summer months (May-September) (Fig. 2). The seasonal variation in mean foot-pad score and in outdoor relative humidity in the southern parts of Sweden, where the broiler farms are located, is shown in Fig. 2. The correlation between relative humidity and mean foot-pad score was 0.82 for un-lagged data, and 0.89 when the analysis was performed with a one month lag of the foot-pad score data.

The Duncan multiple range test (*BMDP* 1992) showed that there were statistically significant ($p<0.05$) associations between region and the mean value for total foot-pad score of the flocks slaughtered, between feed supplier and the total

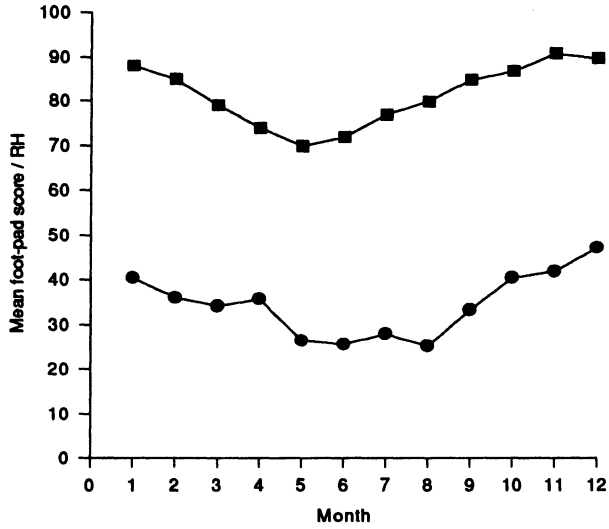

Figure 2. Mean value of total foot-pad dermatitis score (●) and mean relative air humidity (Southern Sweden) (■) by month.

foot-pad score, and between slaughterhouse and the total foot-pad score. When analysed separately, the ten regions (county level) with sufficient data also showed different trends. Five of the counties displayed significantly decreasing trends in total foot-pad score over time, while 2 showed significantly increasing trends over time and 3 showed no significant trends (Table 1). The same type of variation in the development of the average foot-pad dermatitis score was seen among the eight different feed suppliers. Four of the feed companies showed significantly decreasing trends in total foot-pad score over time, while 4 showed no significant trends (Table 2). When looking at the development of the total foot-pad score over time for the 11 slaughterhouses, 5 of them showed significantly decreasing trends in total foot-pad score over time, one showed a significantly increasing trend while 4 showed no significant trends (Table 3). In general, the seasonal pattern for the total foot-pad score was the same regardless of region, feed supplier or slaughterhouse; higher in the autumn and winter months (October-April) than in the late spring and summer months (May-September).

Discussion

This study shows that there has been a significantly consistent decrease in the prevalence of severe foot pad lesions during the first 2 years of the programme. Decreasing the prevalence of foot-pad lesions, especially the severe lesions, was one of the main aims of the foot-health programme on which this study is based. The lack of significant decrease in the prevalence of mild lesions is interpreted mainly as a result of step-wise improvement, i.e. those that previously had severe lesions later showed mild lesions instead, concealing the effect of those previously showing mild lesions and later having no lesions.

When using an exponential smoothing model for classical multiplicative decomposition to analyse the time series we found a trend-cycle component of 10.4% showing linear decrease and a seasonal component of 48.7%, which should be considered as substantial. In some

Table 1. Distribution of total foot-pad score (mean ± stdev) for the broiler flocks in this study, by geographical region. Trend line equations* for weekly means and adjusted R-square values are given, and significant time trends/seasonality indicated.

Region (County)	Mean	Trend line equation*	Adj. R^2	Trend ($p<0.05$)	Seasonality ($p<0.05$)
Stockholm	6.5 ± 5.0[a]	–	–	–	–
Södermanland	32.8 ± 36.7[a]	57.45 – 0.47	0.31	linear	additive
Östergötland	11.0 ± 16.2[a]	13.70 – 0.06	0.50	linear	additive
Jönköping	6.1 ± 10.2[a]	–	–	–	–
Kronoberg	49.5 ± 50.4[c]	64.96 – 0.29	0.29	–	–
Kalmar	26.0 ± 26.1[a]	35.56 – 0.18	0.43	linear	multiplicative
Gotland	25.1 ± 28.6[a]	19.79 + 0.11	0.14	–	–
Blekinge	30.4 ± 32.1[a]	30.40 + 0.04	0.39	linear	multiplicative
Kristianstad	59.1 ± 55.3[d]	64.61 – 0.07	0.25	linear	multiplicative
Malmöhus	40.6 ± 45.2[b]	33.00 + 0.20	0.47	linear	additive
Halland	31.7 ± 35.1[a]	29.80 + 0.04	0.05	–	–
Älvsborg	11.3 ± 18.3[a]	–	–	–	–
Skaraborg	19.0 ± 32.4[a]	36.52 – 0.30	0.30	linear	additive
Örebro	3.4 ± 8.1[a]	–	–	–	–
Västmanland	5.1 ± 4.9[a]	–	–	–	–

Duncan's multiple range test: different superscripts indicate statistically significant ($p<0.05$) differences. Procedures not carried out when n (number of weeks where data were reported) was <30. * Intercept + slope (weeks).

cases, the seasonal indexes were multiplicative, i.e. the seasonal adjustment was made by multiplying the index into the deseasonalized series. In other cases the seasonal indexes were additive, i.e. the seasonal adjustment was made by adding the index onto the deseasonalized series (Tables 1, 2 and 3). In general, a multiplicative model should be used when the size of the seasonal pattern in the data (time series) depends on the level of the data. This model assumes that as data increase, so does the seasonal pattern (amplitude) (*Minitab for Windows* 1996). In additive models, this is not the case.

The improvement in correlation seen when lagging the foot-pad score data one month can be explained if foot-pad dermatitis starts to occur when the birds are only 2-3 weeks old (*Greene et al.* 1985, *Ekstrand & Algers* 1997) as a reaction to the litter conditions several weeks before time of slaughter (at approximately 5 to 6 weeks of age), when the lesions were recorded in this study. Seasonal effects on contact dermatitis in broiler flocks reared in regions with high relative air humidity during autumn and winter months have previously been described by *McIlroy et al.* (1987) and *Bruce et al.* (1990). Similar results have also been achieved under experimental conditions (*Weaver & Meijerhof* 1991). Our study supports the hypothesis about an association between high relative air humidity, wet litter and foot-pad dermatitis. However, in a previous Swedish study *Elwinger* (1995) found no effect of season on the frequency of foot-pad changes in broilers reared at stocking densities of 25-35 kg/m^2, although he did record a higher relative humidity inside the broiler houses during the winter than during the summer, and also a lower dry matter content in the litter during wintertime.

We found substantial differences in the development over time of the foot-pad scores for the different regions, slaughterhouses and feed

Table 2. Distribution of total foot-pad score (mean ± stdev) for the broiler flocks in this study, by feed supplier. Trend line equations* for weekly means and adjusted R-square values are given, and significant time trends/seasonality indicated.

Feed company	Number of flocks served	Mean	Trend line equation*	Adj. R^2	Trend ($p<0.05$)	Seasonality ($p<0.05$)
F1	1154	31.8 ± 32.9^c	30.13 + 0.07	0.08	–	–
F2	461	24.9 ± 28.6^b	20.10 + 0.10	0.02	–	–
F3	745	31.7 ± 35.3^c	29.69 + 0.04	0.08	–	–
F4	1371	25.4 ± 25.6^b	35.35 – 0.19	0.39	linear	additive
F5	1699	56.1 ± 54.5^d	60.09 – 0.06	0.23	linear	multiplicative
F6	155	61.6 ± 52.6^d	73.11 – 0.26	0.38	–	–
F7	863	25.7 ± 33.5^b	42.02 – 0.33	0.72	linear	multiplicative
F8	540	16.1 ± 29.4^a	24.70 – 0.18	0.31	linear	additive

Duncan's multiple range test: different superscripts indicate statistically significant ($p<0.05$) differences.
* Intercept + slope (weeks).

Table 3. Distribution of total foot-pad score (mean ± stdev) for the broiler flocks in this study, by slaughterhouse. Trend line equations* for weekly means and adjusted R-square values are given, and significant time trends/seasonality indicated.

Slaughterhouse	Number of flocks slaughtered	Mean	Trend line equation*	Adj. R^2	Trend ($p<0.05$)	Seasonality ($p<0.05$)
S1	1091	26.6 ± 24.3^b	31.02 – 0.10	0.29	–	–
S2	457	25.1 ± 28.6^b	19.79 + 0.11	0.14	–	–
S3	114	50.0 ± 37.9^c	37.51 + 0.21	0.35	linear	additive
S4	2705	39.6 ± 46.4^c	48.43 – 0.16	0.47	linear	additive
S5	298	30.6 ± 43.6^b	53.91 – 0.45	0.39	linear	additive
S6	740	11.1 ± 20.3^a	18.02 – 0.13	0.39	linear	additive
S7	480	36.6 ± 24.4^c	28.37 + 0.16	0.28	–	–
S8	148	110.5 ± 67.6^d	119.72 – 0.19	0.09	linear	additive
S9	15	57.6 ± 59.4^c	–	–	–	–
S10	523	38.0 ± 36.3^c	27.77 + 0.21	0.51	–	–
S11	417	41.3 ± 38.5^c	64.33 – 0.46	0.38	linear	additive

Duncan's multiple range test: different superscripts indicate statistically significant ($p<0.05$) differences. Procedures not carried out when n (number of weeks where data were reported) was <30. * Intercept + slope (weeks).

suppliers included in this study. These differences may, for example, be due to variation in feed composition over time, as different regions are supplied by different feed companies which all develop their own feed. If a certain feed causes more wet droppings this is likely to result in wetter litter, and thus to a higher prevalence of foot-pad dermatitis in the flocks in question, as has previously been described by *McIlroy et al.* (1987) for other types of contact dermatitis in broilers, and by *Schulze Kersting* (1996) for foot-pad dermatitis. The differences in the efficacy of the foot-health programme in different regions might also possibly be linked to other local factors such as management advice given by local advisors at the different slaughterhouses.

We conclude that there are several benefits from

using time series analysis for this type of investigation. It is a useful tool for evaluating the effects of intervention programmes, and can also be applied for projecting the future development of disease status in a stable population.

Acknowledgements

The authors thank the Swedish Meteorological and Hydrological Institute (SMHI) for supplying the weather data and the Swedish University of Agricultural Sciences and the Swedish Poultry Meat Association for funding this project.

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Sammanfattning

Tidsmässiga aspekter på trampdynedermatit hos svenska slaktkycklingar.

Denna studie syftade till att analysera de tidsmässiga aspekterna på förekomsten av trampdynedermatit

("fotskador") hos svenska slaktkycklingar. Informationen om lidandets prevalens och omfattning baseras på material insamlat under två år inom ett fothälsoprogram som omfattat drygt 97% av de svenska slaktkycklingbesättningarna. Inom ramen för programmet har upplysningar om uppfödare, hybrid, foderleverantör, län, slakteri, slaktdatum och ett antal andra variabler inhämtats. De säsongsmässiga effekterna har utvärderats med hjälp av klassisk multiplikativ analys för tidsserier (classical multiplicative decomposition analysis). Studien visar att det har skett en signifikant nedgång i förekomsten av grava fotskador under de första två åren av fothälsoprogrammet. Vid analys av utvecklingen över tiden fann vi en trend-cyklisk komponent på 10.4% och en säsongskomponent på 48.7%, resulterande i ett totalt justerat R^2-värde på 58.5% för den totala trampdynepoängen. Det fanns dock stora skillnader mellan de olika slakterierna, foderleverantörerna och regionerna. Tidsserieanalys befanns vara en användbar metod för denna typ av utvärdering av effekterna av ett interventionsprogram, och kan även användas för att projicera en framtida utveckling av sjukdomsläget i en stabil population.

(Received July 16, 1997; accepted January 15, 1998).

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