Footpad dermatitis in Dutch broiler flocks: Prevalence and factors of influence

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ABSTRACT In some European countries, footpad dermatitis (FPD) is measured as an indicator of broiler welfare. Prevalence and seasonal variation of FPD was determined within broiler flocks (fast-growing breeds) in the Netherlands. Samples were taken from 386 Dutch flocks at 8 slaughterhouses during a period of one year. Prevalence of footpad dermatitis was related to background information gathered using a food chain certification scheme to identify possible factors of influence. On average, 35.5% of the broilers had no lesions, whereas 26.1% and 38.4% had mild or severe lesions, respectively. Season, age, thinning of flocks, slaughter age, breed, slaughterhouse, and the interaction between thinning and slaughter age significantly affected severity of FPD. Peak flock FPD scores occurred in flocks where 1-d-old chicks were placed in March and December, whereas flocks placed in warm months, between June and August, displayed lower flock FPD scores. Generally, birds sent to slaughter when thinning a flock displayed less severe FPD than birds from completely depopulated flocks. Severity of FPD decreased with age. Because poultry farmer, hatchery, veterinary practice, and feed manufacturer were included in the model as random factors, it was only possible to assess their contribution relative to each other. The broiler farmer had the largest contribution. Also, a large contribution was found for hatchery, perhaps indicating that broiler quality is important. No relationship was observed between FPD and mortality. Across farms, less severe FPD was observed on farms using antibiotics. However, within farms, FPD was more common in flocks where antibiotics had been used compared with flocks that did not require antibiotic treatment. In conclusion, footpad dermatitis was frequently observed in Dutch fast-growing broiler flocks, and many factors had significant effects on severity of FPD, such as breed, thinning of flocks, age at slaughter, slaughter plant, and hatchery.

Key words: broiler, footpad dermatitis, prevalence, seasonal effect

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Introduction

Footpad dermatitis (FPD), also called pododermatitis or footpad lesion, is a condition of inflammation and necrotic lesions on the plantar surface of the bird’s feet (Greene et al., 1985). It is likely that FPD causes pain and therefore has a negative effect on bird welfare, and because of its association with litter quality, it also reflects other welfare aspects (Haslam et al., 2007). It is therefore considered to be an important welfare indicator in broilers (Ekstrand et al., 1998; Meluzzi et al., 2008b).

Presently, broiler welfare is receiving increasing attention across Europe, which is illustrated by the European Council Directive laying down minimum rules for the protection of chickens kept for meat production (Council Directive, 2007, 2007/43/EC). In addition to requirements on administration, light intensity and light schedule, air quality, and training of the farmer, the Council Directive also places a restriction on the stocking density for broiler chickens to a maximum of 42 kg/m² (if all requirements are fulfilled and the mortality rate is kept below the maximum level stated in the Directive, and if national legislation permits). Denmark and Sweden included FPD as an additional welfare indicator in their own broiler welfare legislation (Berg and Algers, 2004; Pedersen, VFL, Aarhus, Denmark, personal communication), and in the Netherlands this will be done by the end of 2012 (Anonymous, 2009).

Wet litter is the most important factor causing FPD, and many factors may determine litter quality (Shepherd and Fairchild, 2010). It is known that there may be a seasonal effect on prevalence of FPD (Ekstrand and Carpenter, 1998b). Elevated humidity levels may result in wet litter and increase the incidence of FPD (Shepherd and Fairchild, 2010). Mainly the winter season has been associated with higher levels of FPD (Ekstrand and Carpenter, 1998a; Dawkins et al., 2004; Shepherd and Fairchild, 2010). Other potentially influencing factors are breed, feed manufacturer, and stocking density (Haslam et al., 2007; Shepherd and Fairchild, 2010) and slaughter plant (Pagazaurtundua and Warriss, 2006b).
To obtain more information concerning the prevalence of FPD and the seasonal and other influencing factors of FPD in Dutch broilers, we monitored FPD in commercial flocks sent to slaughter over the course of one year. Only flocks with standard, fast-growing breeds (achieving a weight of about 2.5 kg by 42 d of age; EFSA, 2010) were included in the study. Prevalence of FPD could be related to background information gathered using a food chain certification scheme to identify possible factors of influence. Footpad dermatitis was related to potentially influencing factors such as slaughter plant, feed manufacturer, and farm (Pagazaurtundua and Warriss, 2006b; Haslam et al., 2007; Shepherd and Fairchild, 2010), but it could also be determined if veterinary practice, mortality, farm, hatchery, thinning, or depopulation and the use of antibiotics were related to severity of FPD. This information can be used to develop tools to reduce FPD in commercial flocks.

**MATERIALS AND METHODS**

**Data Collection**

Footpad dermatitis was examined between April 2010 and April 2011 in 386 broiler flocks at 8 major Dutch slaughterhouses. Together these slaughterhouses process about 70% of the birds processed in the Netherlands. Every week, 2 of the 8 slaughterhouses were visited, resulting in one monthly visit per slaughterhouse.

During each visit, the feet of 100 broilers were collected from each flock (a flock was defined as all birds originating from the same broiler house). Two samples of 50 feet were taken when approximately one-third and two-thirds of the flock had passed the slaughter line, as recommended in Swedish and Danish welfare legislation (Pedersen, VFL, Aarhus, Denmark, personal communication). Feet were taken from the slaughter line after the birds passed the scalding tank and the feet were separated from the carcass. Samples were only collected from Dutch flocks with standard, fast-growing chickens; that is, achieving approximately 2.5 kg of BW by 42 d (EFSA, 2010), and housed at commercial stocking densities of 39 to 42 kg/m², and thus produced under the European Broiler Directive (Council Directive, 2007, 2007/43/EC). Collected feet were taken to the lab and stored (−20°C) until required for further analyses approximately one week after collection. They were assessed macroscopically by 2 trained assessors using the so-called Swedish footpad scoring system (Ekstrand et al., 1998). Scores were 0 = no lesion, slight discoloration of the skin, or healed lesion; 1 = mild lesion, superficial discoloration of the skin, and hyperkeratosis; 2 = severe lesion, epidermis is affected, blood scabs, hemorrhage, and severe swelling of the skin. Individual FPD scores were supplemented with flock FPD scores using the formula derived from the Swedish and Danish guidelines for broilers (Pedersen, VFL, Aarhus, Denmark, personal communication): Flock FPD score (%) = 100 × [(0.5 × the total number of feet with score 1) + (2 × the total number of feet with score 2)]/the total number of scored feet. The flock FPD score ranges from 0 (all feet having no lesions) to 200 (all feet having score 2).

All information on the food chain information form that accompanies each flock sent to slaughter was stored in a database, including farm identity, house number, date of placement in the house, veterinary practice, feed supplier, hatchery, breed, age at slaughter, depopulation method (thinning or complete depopulation), mortality (first week and total mortality), vaccinations, and use of antibiotics.

**Statistical Analysis**

Data analysis was performed for the percentage of animals with class 0, 1, and 2 in a flock. Season, breed, age, slaughterhouse, and depopulation method were analyzed integrally in one model, and nonsignificant interactions were not included in the final model. Because the data set was not fully orthogonal, a pre-analysis was conducted using frequency tables including all possible combinations of breed, feed manufacturer, slaughterhouse, and hatchery; as confounding of these factors could be possible (but was not expected for other factors included in the model). This showed that confounding factors remained limited and confounding was only present when some infrequently used breeds were introduced.

Data were analyzed using IRCLASS in Genstat (v.12, VSN International, Hemel Hempstead, UK; Keen, 2002). Fixed effects were season [Fourier parameters; i.e., \( \sin(t) \) and \( \cos(t) \) in the model below], breed, age, depopulation method (thinning or complete depopulation) including the interaction between age and depopulation method, and slaughterhouse. Random effects were farm, veterinary practice, hatchery, and feed manufacturer, as these factors were insufficiently balanced to be included as fixed effects in the model. For random factors, only relative contributions could be determined based on the estimated variance component (which is a measure of variance within factors). Therefore the final statistical model was

\[
Y = \beta_0 + \beta_1 \times \sin(t) + \beta_2 \times \cos(t) + \alpha \times \text{breed} + \gamma \times \text{age} + \phi \times \text{depopulation method} \\
+ \delta \times \text{slaughterhouse} + (\gamma \phi) \times \text{interaction} \\
+ \text{(age \times \text{depopulation method})} + \xi_f, \xi_v, \xi_h, \xi_{fc}, \xi_{fr}, \xi_{vc}, \xi_{vh}, \xi_{hr}
\]

where \( Y \) = FPD scores in a flock; \( \beta_0 \) = overall mean; \( \beta_1 \), \( \beta_2 \) = parameter estimations for the course of seasonal effects.

\[
t = \frac{2\pi}{365} \times d,
\]

where \( d \) = day number; age = effect of age at slaughter using the classes: 1 = \(< 38 \text{ d} \), 2 = 38–41 d, 3 = \(> 41 \text{ d} \).
d. $\xi_{f}, \xi_{v}, \xi_{h}, \xi_{fc} \sim N(0; \sigma^2) = \text{random effects of farm,}
\text{veterinary practice, hatchery, and feed manufacturer. It was assumed}
\text{that the effects were randomly distributed. Rest variance is not assessed}
\text{in analyses of ordinal responses but follows directly from the distribution}
of classes. For some factors, causal relationships were not clear,
\text{thus if these factors were cause or effect of FPD. These factors, mortality in}
\text{the first week, total mortality, and the use of antibiotics, were analyzed}
\text{separately and not included in the final statistical model. The model}
\text{used for this analysis was a mixed model for ordinal response}
\text{with antibiotics or mortality as fixed effect in the model.}

In the results section, prevalence of FPD and seasonal variation are shown
\text{by original means or flock FPD score or both. Predicted means of the model}
\text{are used to illustrate the effect of the different factors included as fixed}
\text{effects in the model as well as the relationship between severity of FPD}
\text{and antibiotics.}

\section*{RESULTS}

\subsection*{General}

From 386 flocks, 139 combinations of breed-hatchery-feed company-slaughterhouse
\text{were found. Only Cobb/Ross mixed flocks (originating from a Cobb male and a}
\text{Ross female) and Ross male flocks showed fixed hatchery-feed manufacturer-
\text{slaughterhouse combinations.}

\subsection*{Prevalence of FPD}

In total, footpad lesions were scored for 38,600 birds
\text{from 386 flocks of Dutch fast-growing commercial broilers taken from 138}
\text{different farms. On average, 35.5\% of the footpads examined had no lesions}
\text{(score 0), 26.1\% displayed mild lesions (score 1), and 38.4\% had severe}
\text{lesions (score 2). Figure 1 shows the flock FPD score per farm in relation}
\text{to the percentage of farms scored. Flock FPD increased more or less linearly}
\text{over the entire scale (from 0–200 points). Seventy-eight percent of the flocks}
\text{had more than 40 points and 55\% had more than 80 points, which are the cut-off}
\text{points used in Danish and Swedish legislation to warn farmers or enforce a}
\text{reduction in stocking densities (Pedersen, VFL, Aarhus, Denmark, personal}
\text{communication).}

\subsection*{Seasonal Variation}

A significant ($P < 0.001$) seasonal effect on FPD was
\text{found (Figure 2). Flocks of which 1-d-old broilers were placed between June
\text{and August had the lowest levels of severe FPD and the lowest FPD score, whereas}
\text{flocks where 1-d-old chicks were placed in March and December showed the highest}
\text{levels. Figure 3 shows the average temperature and precipitation levels in the}
\text{Netherlands of the sampling months. No exceptional weather conditions occurred
\text{during the sampling period. Lowest flock FPD scores were found in months
\text{with the highest environmental temperatures; that is, between June and August.}
\text{Seasonal variation was lowest for score 1, and variation in severe FPD (score 2)
\text{and intact feet (score 0) was about 13\% between the best and worst season}
\text{according to the model (predicted seasonal variation according to the model not shown).}

\subsection*{Other Factors Affecting FPD Levels}

\textbf{Thinning or Depopulation and Age.} A significant
\text{effect was found for thinning or depopulation, age, and for the interaction between}
depopulation method and age on severity of FPD (all $P < 0.001$). In general,
\text{birds delivered to the slaughter house at thinning showed lower FPD scores compared
\text{with completely depopulated birds. Severity of lesions decreased as age}
\text{to slaughter increased (Table 1). A significant interaction was found between age
\text{and depopulation method. Birds thinned at a young age (<38 d) had less severe
\text{FPD than older depopulated flocks.}

\textbf{Breed.} A significant effect of breed on severity of FPD
\text{was found ($P < 0.001$). Hubbard Flex broilers displayed

\textbf{Figure 1.} Distribution of farms over footpad dermatitis (FPD) scores
\text{(FPD score = 100\% × [(0.5 × the total number of feet with score 1) +}
\text{(2 × the total number of feet with score 2)]/the total number}
of scored feet).
the lowest FPD levels, whereas Ross males displayed the highest severity of lesions (Figure 4). It should be noted, however, that the influence of birds with a Ross female and Cobb male (Cobb/Ross) and Ross males displayed results confounded in specific hatchery-feed manufacturer-slaughterhouse combinations.

**Slaughterhouse.** A significant effect of slaughterhouse on severity of FPD was also found ($P < 0.001$). Differences between individual slaughterhouses are illustrated in Figure 5, which shows the predicted means for all slaughterhouses where feet were scored.

**Random Terms.** Farmer ($n = 138$), veterinary practice ($n = 30$), hatchery ($n = 15$) and feed manufacturer ($n = 18$) were all included as random terms in the final model. Table 2 shows their relative variance components. Higher values indicate increased relative influence of the factor. Table 2 shows that the farmer has a relatively large effect, followed by hatchery, veterinary practice, and feed manufacturer. Feed manufacturer had the lowest estimated variance component. This does not, however, imply that the contribution of this factor is negligible, but that the relative contribution of other mentioned factors is greater.

**DISCUSSION**

Data collected during this project focused on the prevalence of FPD in fast-growing broilers in the Netherlands, its seasonal variation, and possible factors of influence. Severe lesions were observed in 38.4% of the broilers, whereas on average 35.5% had no lesions. Comparison of prevalence with studies from other countries is difficult due to differences in time and methods of assessment. Pagazaurtundua and Warriss (2006b) assessed flocks with fast-growing birds at UK slaughter plants and found a prevalence of 18.1% for severe FPD in 2002 and 2003 and a prevalence of 14.1% severe FPD in flocks with fast-growing birds examined in 2004 (Pagazaurtundua and Warriss, 2006a). A recent study in France showed much higher levels of severe FPD (about 70%), but in that study, a wider range of

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**Table 1.** Predicted means for depopulation method and slaughter age

<table>
<thead>
<tr>
<th>Item</th>
<th>&lt;38 d</th>
<th>38–41 d</th>
<th>&gt;41 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds sent to slaughter at thinning</td>
<td>0.883</td>
<td>0.847</td>
<td></td>
</tr>
<tr>
<td>Depopulated birds</td>
<td>1.664</td>
<td>0.994</td>
<td>0.995</td>
</tr>
</tbody>
</table>

1 Flocks were analyzed in 3 separate age groups. At 41 d of age and older, only depopulated birds were scored. Range of standard error of differences between pairs: 0.042–0.092.

**FPD, Use of Antibiotics, and Mortality**

A separate analysis was conducted to examine the relationships between FPD, mortality, and the use of antibiotics. No relation was found between FPD and first week mortality or total mortality. The average mortality in the first week was 1.16%, average total mortality as reported by the farmers was 2.88%.

Footpad dermatitis was associated with antibiotic use, which was scored as yes (antibiotics used at any moment) or no (no antibiotics used at all). Across farms, flocks that had been treated with antibiotics tended to have less FPD than flocks without antibiotics ($P = 0.055$, trend; see Table 3). It was found that antibiotics had been used in 302 out of 386 flocks (78%). However, within farms, FPD was lowest in flocks where no antibiotics had been given ($P < 0.001$). This implies that antibiotic usage has a predictive value regarding severity of FPD: When a farm uses antibiotics in a flock, that flock is likely to have higher FPD levels, compared with the normal FPD levels on that farm.

**Table 2.** Estimated variance components of random factors in the final model

<table>
<thead>
<tr>
<th>Factor</th>
<th>Estimated variance component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmer</td>
<td>1.444</td>
</tr>
<tr>
<td>Hatchery</td>
<td>0.597</td>
</tr>
<tr>
<td>Veterinary practice</td>
<td>0.287</td>
</tr>
<tr>
<td>Feed manufacturer</td>
<td>0.151</td>
</tr>
</tbody>
</table>

1 The larger the estimated variance component, the greater the relative influence of this factor.
Factors, that is, ventilation, temperature, feed, water (Fairchild, 2010), wet litter itself is affected by many factors are influencing the incidence of FPD. Although more and fewer FPD lesions. This suggests that several sex between years. These data can, therefore, only be re-
duced ventilation when it gets colder (Shepherd and Fairchild, 2010). However, it should be noted that we measured FPD over only a one-year period. Because of differences in environmental temperature and humid-
ity, it is possible that the seasonal variation may differ between years. These data can, therefore, only be re-
garded as an indication of possible seasonal variation.

Season had a considerable effect on severity of FPD. The statistical model indicated a variation in severe FPD (score 2) of approximately 13%, depending on the month in which the 1-d-old chicks had been placed. Flock FPD scores varied almost 40 points over the whole year. Seasonal effects have also been reported in other countries (Ekstrand and Carpenter, 1998a; Dawkins et al., 2004; Haslam et al., 2007; Meluzzi et al., 2008a). Severity of FPD is reduced in warm, dry seasons and elevated in cooler months. This may result from elevated litter humidity, for example, due to reduced ventilation when it gets colder (Shepherd and Fairchild, 2010). However, it should be noted that we measured FPD over only a one-year period. Because of differences in environmental temperature and humidity, it is possible that the seasonal variation may differ between years. These data can, therefore, only be regarded as an indication of possible seasonal variation.

There was no clear bimodal distribution of flocks with more and fewer FPD lesions. This suggests that several factors are influencing the incidence of FPD. Although wet litter is probably the main cause (Shepherd and Fairchild, 2010), wet litter itself is affected by many factors, that is, ventilation, temperature, feed, water spillage, litter type, and intestinal disease (Ekstrand et al., 1997; Berg, 2004; Haslam et al., 2007; Meluzzi et al., 2008a; Shepherd and Fairchild, 2010).

In our study several other factors affected severity of FPD, such as breed, depopulation method (thinning), age at slaughter, and hatchery. Several previous studies also indicated effects of breed (Ekstrand et al., 1998; Kestin et al., 1999; Sanotra et al., 2003; Allain et al., 2009). Method of depopulation, age, and the interaction between depopulation and age all significantly affected FPD severity. Specifically, birds depopulated at a young age had high FPD levels, whereas thinned birds displayed the lowest FPD levels, and FPD levels in depopulated birds decreased with age. Farms that send their birds to slaughter at an early age and do not apply thinning generally apply elevated stocking densities (De Jong, Wageningen UR Livestock Research, Lelystad, the Netherlands, unpublished observation), thereby increasing the risk of wet litter and FPD (Shepherd and Fairchild, 2010). This may explain the high FPD levels in young depopulated flocks. When flocks are thinned, stocking density decreases, and as a consequence, litter quality may improve and FPD decrease. This may explain the lower FPD levels with increasing age, although studies are not consistent in this respect (Berg, 2004). Another explanation may be that older birds are less active and increase time spent rest-
ing (e.g., Alvino et al., 2009). When resting, hocks and chest are more often in contact with litter than the feet, which may possibly reduce the risk for severe FPD.

The current study included plants that differed in weight of the birds processed. However, there was no relation between bird weight at processing and severity of FPD for a slaughter plant. Pagazaurtundua and Wariss (2006b) have also indicated differences between slaughterhouses. As bird rearing conditions in the current study were very similar (with respect to stocking densities, bird types, and housing conditions) these were not responsible for differences between slaughterhouses in FPD level. Therefore, explanations for the differences between slaughterhouses have to be sought elsewhere in relation to potentially confounding effects, such as slaughterhouses working with specific farms or exerting effects through specific demands on the quality of the chickens. At this moment, no data are available to explain the differences between slaughter houses, and this deserves further research.

The factor “poultry farm” had a relatively large effect on the severity of FPD lesions. Broiler farms may differ considerably in FPD levels, even if they use similar breeds, feeding companies, hatcheries, slaughterhouses, and veterinary practices. It is known that management influences FPD levels (Shepherd and Fairchild, 2010), which explains the large effect of individual farms on FPD levels.

Another main factor influencing the severity of FPD was hatchery. It had a larger effect than veterinary practice or feed manufacturer. The role of hatchery in FPD is still unclear and deserves further investigation.

Table 3. Predicted means from the model analyzing the effect of antibiotic use (AB) across farms (SE of differences 0.014), and within farms (SE of differences 0.031), where the latter involves a covariate for farm effect

<table>
<thead>
<tr>
<th>Item</th>
<th>Across farms</th>
<th>Within farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flocks with AB</td>
<td>0.3433</td>
<td>0.5908</td>
</tr>
<tr>
<td>Flocks without AB</td>
<td>0.4766</td>
<td>0.4715</td>
</tr>
</tbody>
</table>

Figure 5. Predicted means for the different slaughterhouses where footpad dermatitis was scored. Range of standard error of differences between pairs: 0.050–0.498.
Possibly differences in chick quality between hatcheries plays a role, as this may for instance affect the susceptibility of the broilers to diseases. For example, it is known that first-week mortality is related to brooding, hatching conditions, and breeder age (Yassin et al., 2009). Previous research has indicated that feed composition, particularly protein content, may play a role in the degree and severity of lesions (Ekstrand et al., 1998; Shepherd and Fairchild, 2010). Data from this study showed that feed manufacturer had smaller effects on severity of FPD than farmer and hatchery. One explanation for the relatively small effect of feed manufacturer may be that differences in feed composition between feed manufacturers may not be substantial, and farmers can influence feed composition by diluting the feed with (whole) wheat.

Separate analyses showed no relationship between FPD and mortality in the first week, but a relationship with the use of antibiotics was found. Across farms, flocks having received antibiotics had lower FPD scores, probably associated with an improved health status. Antibiotics are often used for treatment or prevention of intestinal problems, which cause wet litter and a higher risk for FPD (Shepherd and Fairchild, 2010). However, within farms, use of antibiotics had a negative relationship with FPD lesions, indicating that increasing antibiotic usage compared with the farm standard is associated with health problems and a higher incidence of FPD.

In conclusion, the results of this study showed that prevalence of FPD in Dutch broiler flocks is high and that several factors, such as season, breed, age of the birds, depopulation method, farmer, and hatchery are of influence on FPD levels. Some of these factors require further investigation, such as the large effect of hatchery. Other factors such as depopulation method, breed, and slaughter age of the birds are possible management tools to decrease the risk for FPD.

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