ABSTRACT The present study demonstrates the prevalence of footpad lesions in turkeys and their level of expression in both live birds and in carcasses. In clinical investigations of 11,860 turkeys (5,740 males, 6,120 females) of the strain British United Turkeys Big 6, individuals of all the observed flocks showed alterations to the plantar skin. In general, the degree and severity of skin alterations were higher in the 16th week of life than in the 6th or 11th week of life. Epithelial necrosis, however, was already apparent in about 45% of individuals in the 6th week of life. At this point, deep lesions on the footpad surface were still rare findings. In the 11th week of life, such skin changes were apparent in 14.7% of males and 25.7% of hens. In general, the feet of male turkeys were less affected by footpad damage than those of females in the subsequent fattening period. In hens, the prevalence of lesions of the footpads at wk 16 of age was 60.0%, almost twice as high as in males of the same age group (33.8%). A comparison of the findings from the right and left feet showed that the state of the 2 extremities was correlated (Spearman correlation: r = 0.830). During the visual inspection of 16,200 slaughtered turkeys (7,800 males, 8,400 hens), almost all carcasses studied showed alterations to the footpad skin. Only 2.1% of males and 0.6% of females were without lesions. The most frequently observed lesions measured up to 2 cm in diameter (males: 59.2%; hens: 57.7%). Pronounced skin lesions of the footpad (males: 21.1%; females: 29.5%) and necrosis of the superficial epithelium (males: 17.5%; females: 12.1%) were less common. Foot abscesses were diagnosed only sporadically (males: 0.1%; females: 0.1%).

Key words: fattened turkey, footpad dermatitis, turkey management, animal welfare

INTRODUCTION Various diseases are widespread in commercial fattened turkey flocks, affecting various organs such as the respiratory system, the circulatory system, the gastrointestinal tract, the locomotion system, and particularly the integument and its appendages (Hafez, 1999). Different factors are known to be responsible for the development of pathological lesions of the plantar skin. In combination with high stocking densities and suboptimal housing conditions, including a lack of environmental stimuli and an insufficiently stable climate as well as genetic disposition, resulting from a disproportionate focus on rapid BW gain and high body mass, has led to akinesia. Long periods of rest in turn predispose the birds to pathological changes in the integument, especially breast skin changes and footpad lesions. In summary, management deficiencies, such as poor litter quality, thus appear to be one of the main causes of footpad lesions in turkeys, which may impair animal welfare.

The aim of this study was to determine the prevalence of footpad lesions in British United Turkeys (BUT) Big 6 turkeys of both sexes during fattening on commercial farms under conventional conditions. To this end, 2 yr of extensive surveys were carried out for livestock management, bird health, and carcass quality. The first results of the study, which relate to the management surveys and the prevalence of skin lesions (with the exception of footpad dermatitis and breast skin lesions), have been published elsewhere (Krautwald-Junghanns et al., 2009, 2010). In the present study, the prevalence...
of footpad lesions was documented in both living turkeys and the carcasses of slaughtered birds.

**MATERIALS AND METHODS**

The investigations were carried out on 24 turkey farms with flock sizes of 1,700 to 16,800 individuals, and in 7 processing plants. Only turkeys of the BUT Big 6 strain were examined. All birds were beak trimmed. According to information given by the farm managers, the stocking densities were based on the limits permitted in Germany [turkey males: 58 kg/m², turkey hens: 52 kg/m²; Bundeseinheitliche Eckwerte für eine freiwillige Vereinbarung zur Haltung von Jungmasthühnern (Broiler, Masthähnchen) und Mastputen. Stand: 1999].

**Clinical Investigation**

In clinical studies, data were collected from 11,860 turkeys (5,740 males, 6,120 females) from 66 flocks. In most cases, 60 female or male animals were subjected to a visual and palpatory examination in the 6th, 11th, and 16th week of life. One investigation (farm 9, turkey males, 16 wk old), however, was finished prematurely after severe unrest in the flock. In this case, data from only 40 turkeys were collected. The clinical assessment of the footpads was similar to the scoring system proposed by Mayne (2005) and Hocking et al. (2008). It defined the following 5 categories by which the condition of the footpads was evaluated: 1 = no abnormalities found; surface of the skin of the footpads shows no alterations; 2 = hyperkeratosis: moderate hypertrophy of the plantar skin; reticulate scales are elongated, but not dark colored; 3 = hyperkeratosis with crusts of dirt: pronounced hypertrophy of the plantar skin; crusts of dirt that cannot be removed without damaging the plantar skin; 4 = epithelial necrosis: dark colored necrosis of the reticulate scales; 5 = lesions of the plantar skin, foot abscess, or both: ablation of the outer layer of the epidermis, facultative swelling of the footpad and perhaps of the digits, foot abscess, or their combination. The assessment of the footpads was performed by 2 scientists.

**Meat Inspection**

Inspection was performed on 54 processing occasions with 16,200 carcasses (7,800 males, 8,400 females). The inspections were carried out directly on the evisceration line on 300 birds of flocks that had previously been clinically investigated. Assessment of the footpads used a scoring system similar to that presented by Clark et al. (2002). The footpad status was divided into 5 categories, analogous to the clinical assessment: 0 = surface of the skin of the footpads shows no alterations; 1 = epithelial necrosis; 2 = ablation of the outer layer of the epidermis up to 2 cm in diameter; 3 = wide ablation of the outer layer of the epidermis; facultative swelling of the footpad and perhaps of the digits; 4 = foot abscess. The assessment of the health status of the footpads was always performed by the same scientist.

**Statistical Analysis**

Statistical analysis of the data was performed with SPSS (version 15.0, SPSS Inc., Chicago, IL) and StatXact-8 (Cytel Inc., Cambridge, MA). Results with a 2-sided P-value less than 5% were considered significant. For prevalence rates, asymptotic 95% CI were calculated. The two rates differ in the above sense significantly if the corresponding 95% CI do not overlap. The statements are currently exploratory because this approach cannot be adjusted for multiple testing.

**Clinical Findings**

In clinical studies, changes in the plantar skin, such as hyperkeratosis or necrosis of the superficial epithelium or ulcerative lesions, were found in individuals of all the flocks visited. In all flocks, a significant age-related deterioration in health status of the footpads was obvious. The degree and severity of plantar skin alterations were generally higher in the 16th week of life than in the 6th and 11th week of life. However, extensive epithelial necrosis was already being detected in the 6th week of life (see Table 1). In general the feet of male turkeys were less affected by footpad lesions in the subsequent fattening period than were the feet of females of the same age group (Figure 1 and Table 1). Compared with 6-wk-old turkeys, deep lesions of the plantar skin were detected in the 11th week of life on at least 1 foot, with a significantly higher prevalence in males (14.7%) and hens (25.7%). In the 16th week of life, the detection rate of deep lesions in males increased to 33.8%. The prevalence of footpad lesions in hens was 60.0%, almost twice as high as in male turkeys of the same age group. A comparison of the right and left feet showed that the footpad condition of the 2 extremities was correlated (Spearman correlation: r = 0.830, P < 0.0005). The Cohen kappa coefficient, which measures the compatibility between the left and right legs, was 0.72 (P < 0.0005). No systematic difference was observed between the right and left legs (McNemar-Boker test, with a P-value of 0.432). Regarding the prevalence of epithelial necrosis and deep lesions between the different farms, partly significant differences were determined.

Because of the relatively short duration of the project and the spot-check visits of the turkey flocks, seasonal influences on the prevalence of footpad lesions in the 16th week of life (e.g., high RH of air) could not be established with certainty. Mutual relationships with individual management parameters, such as type of housing, environmental enrichment, length of the fat-
tening period, and flock size, also could not be demonstrated statistically.

Scar formation in the area of the footpads was detected in 1,975 individuals. In terms of age groups, scarred footpads were rare in the 6th week of life [2.40% (95% CI: 1.91, 2.89)]. With age, their prevalence increased to 15.36% (95% CI: 14.23, 16.48) in the 11th week of life and 32.28% (95% CI: 30.82, 33.74) in the 16th week of life; that is, corresponding scar formation in the footpad skin was found in approximately every third animal.

**Meat Inspection**

The results of the postmortem inspections showed that almost all animals examined at processing demonstrated more or less pronounced footpad lesions (Table 2). Only 2.1% of the turkey males and 0.6% of the turkey hens had footpads without skin lesions. The majority of birds had footpad lesions up to 2 cm in diameter, with a prevalence of 80.3% in males and 87.2% in hens, whereas pronounced lesions of the plantar skin were diagnosed in 12.1% of males and 17.5% of females. Foot abscesses occurred only with relatively low prevalence (males: 0.1%; females: 0.1%).

Analogous to the clinical examination, the findings of the meat inspection showed that the footpads of females were damaged more than those of males ($P < 0.001$). Regarding the prevalence of epithelial necrosis and deep lesions of the plantar skin, some significant differences between the individual farms were detected.

**DISCUSSION**

Footpad lesions are a widespread problem in commercial turkey flocks (Ekstrand and Algers, 1997; Berk, 1999; Martrenchar, 1999; Martrenchar et al., 2002). The results of this study confirm this finding because in clinical studies, lesions of the plantar skin, such as hyperkeratosis, superficial epithelial necrosis, and ulcerative changes, were found in individuals of all the fattened turkey flocks visited. By the 6th week of age, immediately after stabling in the fattening unit, about 45% of all turkey chicks showed necrosis of the superficial epithelium. In the 16th week of life, about one-third of the turkey males and almost two-thirds of the turkey hens showed deep lesions of the plantar skin. Superficial epithelial necrosis was found in about one-half of the turkey males and about one-third of the turkey females. Clinically normal footpads were diagnosed in only about 4.0% of the turkey males and 0.4% of the turkey hens. The footpads were judged in more detail on the evisceration line: almost all the individuals of the studied turkey flocks showed lesions of the plantar skin.

The present results show in general that the footpads of turkey hens were harmed more frequently and more seriously than those of male turkeys. Poor litter quality, especially excessive litter moisture, is postulated to

| Table 1. Numerical share and percentage of footpad lesions in male and female turkeys of different age groups in the clinical inspections1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Age (wk of life) | Sex | No abnormalities found | Hyperkeratosis | Hyperkeratosis with crusts of dirt | Epithelial necrosis | Lesions of the plantar skin |
| | Left | Right | Left | Right | Left | Right | Left | Right | Left | Right |
| 6th | Male n 157 | 165 | 8.2 | 8.6 | 8.6 | 8.6 | (6.7, 9.9) | (7.1, 10.4) | (26.9, 32.2) | (27.4, 32.8) | (15.8, 20.3) | (13.8, 18.1) | (41.4, 47.2) | (42.6, 48.4) | (0.0, 0.6) | (0.0, 0.5) |
| | Female n 63 | 63 | 8.6 | 8.6 | 8.6 | 8.6 | (6.7, 9.9) | (7.1, 10.4) | (26.9, 32.2) | (27.4, 32.8) | (15.8, 20.3) | (13.8, 18.1) | (41.4, 47.2) | (42.6, 48.4) | (0.0, 0.6) | (0.0, 0.5) |
| 11th | Male n 85 | 75 | 8.4 | 8.4 | 8.4 | 8.4 | (6.7, 9.9) | (7.1, 10.4) | (26.9, 32.2) | (27.4, 32.8) | (15.8, 20.3) | (13.8, 18.1) | (41.4, 47.2) | (42.6, 48.4) | (0.0, 0.6) | (0.0, 0.5) |
| | Female n 7 | 7 | 8.4 | 8.4 | 8.4 | 8.4 | (6.7, 9.9) | (7.1, 10.4) | (26.9, 32.2) | (27.4, 32.8) | (15.8, 20.3) | (13.8, 18.1) | (41.4, 47.2) | (42.6, 48.4) | (0.0, 0.6) | (0.0, 0.5) |
| 16th | Male n 65 | 74 | 8.4 | 8.4 | 8.4 | 8.4 | (6.7, 9.9) | (7.1, 10.4) | (26.9, 32.2) | (27.4, 32.8) | (15.8, 20.3) | (13.8, 18.1) | (41.4, 47.2) | (42.6, 48.4) | (0.0, 0.6) | (0.0, 0.5) |
| | Female n 6 | 9 | 8.4 | 8.4 | 8.4 | 8.4 | (6.7, 9.9) | (7.1, 10.4) | (26.9, 32.2) | (27.4, 32.8) | (15.8, 20.3) | (13.8, 18.1) | (41.4, 47.2) | (42.6, 48.4) | (0.0, 0.6) | (0.0, 0.5) |

1Numerical data in parentheses are 95% CI.
be a factor in the development of contact dermatitis (Youssef et al., 2009). Sex differences in the prevalence of footpad lesions may be due to the different number of individuals per unit area found in the fattening of turkey males and females in Germany (males: approximately 2.8 individuals/m²; females: approximately 5.1 individuals/m²). This is reflected in the amount of excrement per unit area. The resulting increase in litter moisture is potentially a cause of the higher prevalence of footpad dermatitis in flocks of turkey hens detected not only in the present study, but also in the study by Rudolf (2008). Furthermore, litter quality is influenced by the stability of the climate (stable temperature, air turnover), which is likewise affected by the density of individuals per unit area.

Within a flock, a relatively consistent manifestation of skin changes was usually observed, particularly in the 11th and 16th week of life. Between the individual flocks, however, various significant differences in the frequency of epithelial necrosis and footpad lesions at different ages were documented. However, these differences between the flocks could not be statistically attributed to a particular characteristic in terms of management. Nevertheless, some farms performed better and others performed worse than the average in all investigations and all fattening periods with the same turkey strain. Flock management obviously has a crucial role in the severity of pathological changes in the plantar skin.

The moisture content of the litter is reported to play a central role in the development of footpad lesions (Mayne et al., 2004, 2006; Rudolf, 2008; Youssef et al., 2009). Swelling of the outer layer of the epidermis of the plantar skin results in impairment of its barrier function and can develop into footpad dermatitis because it allows the penetration of infectious agents (Jordan, 1990; Feldhaus and Sieverding, 2001; Schmidt et al., 2003). The inflammation mainly affects the plantar skin but, in severe cases, can extend to the toe pads (Hafez et al., 2005). According to Mayne et al. (2007b), keeping turkeys on wet litter for more than 48 h is sufficient to create deep lesions on the skin of the foot and toe pads. Such skin lesions may heal within 15 d but with scarring, if the turkeys are transferred to dry litter (Mayne et al., 2007b). Such scarring is recognizable because the characteristic granular texture of the reticulate scales usually found on the underside of the foot and toe pads is missing (Platt, 2004; Platt et al., 2004). The healed surfaces show bright, strikingly smooth skin. Such tissue repair must therefore be regarded as a significant change in the original structure of the footpad epidermis after a radical skin lesion reaching the subepidermal skin layers of the footpad (Rudolf, 2008). Große Liesner (2007) suggested that in addition to the high body mass, strong growth of the birds, and environmental factors, genetic predisposition is responsible for the development and healing of the footpad dermatitis because strain-specific differences could be identified. Spindler (2007) indicated that highly ulcerative lesions on the skin of the footpad

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Figure 1. Percentage of footpad lesions per age group in male and female British United Turkeys Big 6 turkeys. Results of the clinical investigations.

Table 2. Prevalence of footpad lesions in turkey males (n = 7,800) and turkey hens (n = 8,400)

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1Results of the meat inspection. Numerical data in parentheses are 95% CI.
must be painful, and the author associated them with lameness. Lameness is a known indicator of pain sensation (Hafez, 1996). However, it must be noted that the plantar skin of both feet usually shows very similar lesions. Thus, a unilateral burden on a limb is no way of avoiding pain (Ekstrand and Algers, 1997). It is therefore expected that, in the case of marked pathological lesions on the footpads, the turkeys would tend to decrease their activity, which may result in reduced feed intake (Martland, 1984; Mayne et al., 2007a). However, this could not be established statistically in our clinical studies, especially because most birds examined had a good nutritional status. Duncan et al. (1991) showed that mature turkey males, which were treated for 6 d with anti-inflammatory steroids, demonstrated significantly higher locomotion activity and increased sexual activity. Buchwalder and Huber-Eicher (2005) achieved similar results through the application of analgesics. According to Buda et al. (2002), sensory nerve endings of mechanoreceptors and pain receptors were present in the footpads of turkeys. The results of macroscopic assessments of the footpads are not necessarily consistent with histopathological findings (Mayne et al., 2007a). A correlation between reduced BW gain and footpad lesions was given only with histopathological findings and not based on macroscopic findings. Nevertheless, even at the macroscopic level, intact footpads must be the aim in keeping turkeys, and undoubted, serious footpad dermatitis must at least be classified as damage concerning bird welfare. Effective artificial selection for traits such as high BW and musculature often leads to negatively correlated responses in other traits (Hafez, 1996; Glodek, 2001; Hörning, 2008). Therefore, the conditions under which today’s commercially oriented heavy turkey strains have been kept to prevent footpad lesions must be analyzed in further investigations.

ACKNOWLEDGMENTS

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