Associations between animal-based measures at 11 wk and slaughter data at 20 wk in turkey toms (*Meleagris gallopavo*)

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ABSTRACT To monitor animal welfare on a commercial scale, systematic collection and evaluation of slaughterhouse data is the most feasible method. However, we need to know whether slaughterhouse data retrospectively and reliably reflect information about the birds' welfare on-farm. The aim of this study was therefore to investigate associations between animal-based welfare measures in flocks of turkey toms at 11 wk of age recorded with the transect walk and slaughter data at 20 wk of age. A total of 20 commercial flocks of turkey toms were visited, where an observer walked the transects in a random order and recorded the total number of birds per transect that were immobile, lame, with visible head, tail, or wing wounds, small, featherless, dirty, sick, terminal, or dead. Slaughterhouse data were provided for each flock. Univariate and multivariate linear regression models were used to investigate the associations between on-farm and slaughterhouse measures. Increased prevalence of immobile toms at week 11 resulted in more birds rejected at slaughter owing to leg issues ($P = 0.02$) and airsacculitis ($P < 0.001$). More lame birds on-farm were associated with an overall higher rejection rate at slaughter ($P < 0.001$). Flocks with more featherless birds had significantly more birds being rejected at slaughter owing to skin issues ($P = 0.02$). More dirty birds at week 11 resulted in more birds being rejected owing to airsacculitis at slaughter ($P < 0.001$). A higher mortality on-farm was associated with more birds rejected for being too small ($P = 0.04$). In conclusion, significant associations between animal-based measures of turkey toms as assessed by the transect walk method on-farm at 11 wk and slaughter data at 20 wk were identified.

Key words: turkey, tom, animal welfare, on farm, slaughterhouse

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INTRODUCTION

The modern poultry industry involves billions of animals, therefore reliable, as well as feasible, welfare measures are needed to document and improve animal welfare. Assessing welfare on-farm, preferably using animal-based welfare indicators, provides a valid view of how the animals cope with their physical and social environment (Veissier et al., 2008; Blokhuis et al., 2010; Phythian et al., 2013). On-farm welfare assessment also allows the farmer to make changes and improve the welfare for the current flock. The transect walk is one such validated and practical method for assessing animal-based welfare indicators on-farm in large flocks of broilers (Marchewka et al., 2013; BenSassi et al., 2018, 2019) and turkeys (Marchewka et al., 2015, 2019; Ferrante et al., 2019).

In commercial turkey production systems, the sexes are typically kept separately in the same barn, divided by a barrier. Here, hens are reared for 12 wk, whereas turkey toms are reared for around 20 wk, depending on the hybrid and target weight (Chartrin et al., 2019). When turkeys of both sexes reach the age of 12 wk, hens are depopulated from the barn, and the barrier is removed. From that time, toms get access to the entire barn, which drastically reduces animal density. Those last day before the hens are slaughtered are often considered the most challenging time in terms of animal welfare for both sexes (Marchewka et al., 2019), as the barn is at its maximum capacity with regards to the number of animals, ventilation capacity, litter quality, and animal care (Martrenchar et al., 1999). Based on the data obtained from the transect walk, the most commonly observed welfare challenges at the age of 12 wk in flocks

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of hens and toms were dirty, featherless, tail wounds, and wing wounds, regardless of sex (Marchewcka et al., 2019).

However, several studies showed that toms may have poorer welfare compared with hens. Marchewka et al. (2019) reported that toms at the age of 12 wk had significantly more tail wounds, sick birds, and more terminal birds compared with hens. A higher prevalence of indicators of poor welfare such as lameness in toms at 18 wk of age compared with hens at the same age was reported by Vermette et al. (2016). Furthermore, Ferrante et al. (2019) found more lameness, wounds, and dirtiness at the end of production cycle in toms at 20 wk compared with the end of production cycle in hens that are at 12 wk of age.

Although the transect walk is a practical tool, it is not feasible to visit all turkey flocks before slaughter for welfare audits by, for example, veterinarians, sanitary agents, or certificate providers. Animal welfare can also be monitored using registrations from the slaughterhouse, which is both practical and feasible when scoring large number of animals, as was described for broilers (EFSA, 2012). However, it needs to be documented that the slaughter data provide valid retrospective information on the birds' welfare on-farm, as validated and feasible indicators can be used to document and improve animal welfare in commercial production systems (EFSA, 2012). This can be investigated by exploring associations between slaughter data and measures of welfare on-farm in the same flocks. In flocks of turkey toms at 19 wk, Marchewka et al. (2015) found a positive correlation between lameness on-farm and rejections and dead on arrival at slaughter a week later. Similar results were found in flocks of turkey hens at 11 wk, where Marchewka et al. (2020) reported that more lameness on-farm resulted in increased rejection owing to leg and joint issues at slaughter a week later. BenSassi et al. (2019) found that data from the transect walk shortly before slaughter correlated with slaughter data in 30 broiler flocks. These findings show that slaughterhouse data may be used to provide reliable information of animal welfare on-farm, at least when welfare on-farm is assessed close to the time of slaughter.

However, recent studies in broiler chickens indicate that the transect walk has the potential to detect and predict slaughter data based on observed welfare challenges as early as at 3 wk of birds' age. Indeed, BenSassi et al. (2018) assessed broiler welfare on-farm using transect walk in broiler flocks at 3, 5, and 6 wk of age and found significant correlations between welfare measures at all ages and slaughter data such as mortality and footpad dermatitis (**FPD**). However, when it comes to turkey toms, the associations between welfare on-farm, measured at the potentially challenging time of 11 wk of age, and slaughter data recorded 8 to 9 wk later are currently unknown.

The relationships between animal-based welfare measures on-farm and slaughter data should be investigated to assess if the latter provides valid information on the birds' welfare on-farm. This is important as more emphasis is being put on the poultry industry to develop and operationalize objective measures of welfare on-farm. Such associations would show that the transect walk can be used at different ages in turkeys and still provide relevant information on animal welfare and production outcomes, making it a more flexible and feasible tool for the industry.

Therefore, the aim of this study was to investigate associations between animal-based welfare measures in flocks of turkey toms at 11 wk of age recorded with the transect walk method and routinely recorded slaughterhouse data at 20 wk of age, to ascertain if slaughter data provide reliable information on animal welfare several week before slaughter.

MATERIALS AND METHODS

The study was conducted between November 2017 and March 2018 on 16 different commercial turkey farms in the eastern part of Norway. On 4 of the farms, 2 consecutive flocks were visited, giving a total of 20 different flocks of toms included in the study. All flocks consisted of both hens and toms, which were kept separately but in the same barn, with toms occupying approximately 60% of the area. Both hens and toms were assessed using the transect walk on the same day, but only data from the toms will be presented here. Results from the transect walk in hens and toms have been reported previously (Marchewka et al., 2019, 2020). The farms were randomly selected from the slaughter lists, and all flocks were visited when the birds were between 11th and 12th week of age. Farmers were contacted a few week before the visit, and participation in the study was voluntary.

Animals and Housing

All the farms in the study received their birds (hybrid: BUT 10) from the same hatchery and sent their birds to the same slaughterhouse (Nortura Hærland). All farms were located within 3 h' drive from the slaughterhouse. The birds were housed as per Norwegian legislation with a maximum density of 38 kg/m^2. Birds were not beak or toe trimmed. At the time of this study, all commercial turkeys in Norway were the same hybrid (BUT 10). The toms were slaughtered at an average of 20 wk and 14 kg carcass weight. All flocks were managed using standardized protocols with regards to ventilation, temperature, litter, and feed. All barns were fully enclosed and insulated, with automatic mechanical ventilation and artificial lighting, without natural light sources. The maximum light intensity provided in the animal area was on average18.8 $\pm$ 3.1 lux, whereas minimum light intensity was on average 11 $\pm$ 0.6 lux (Table 1). The photoperiod program started with continuous light for the first 48 h (day 0–1), followed by increased dark period length and from day 7 the birds had 8-hour continuous darkness until the day of slaughter.

The animals were fed a standard commercial turkey diet with pelleted feed from 1 of 2 feed mills, Felleskjøpet

(Kromat Kalkun) or Norgesfôr (Harmoni Kalkun). All birds had continuous access to water from water nipples or cups. The day-old poults were housed in smaller pens (circular pens, aproximately 2-m diameter) during the first 10 d. The floors were concrete with a layer of wood shavings (Table 1). At the time of the study, no systematic environmental enrichments were provided for the birds. The houses differed in sizes, from 612 to 2,330 m^2. Information on the housing and management of the flocks examined in the present study is presented in Table 1.

The temperature started at 38°C on day 0, was gradually reduced to 20°C at day 40, and then kept stable at 16 C from day 49 until slaughter. The farmers aimed to keep the RH between 50 and 70% from day 0 until slaughter. The flocks were inspected twice daily by the farmer, and any terminally ill birds were humanely culled.

Data Collection

Information on the bird population at the beginning of the production cycle, at 11 wk of age, and at slaughter in the 20 flocks included in the study is presented in Table 2.

Each of the 20 flocks were visited during the 11th week of life, using the transect walk method described in Marchewka et al. (2015). Information on the design of the transect walks in the 20 flocks included in the study is presented in Table 3.

During transect walk, an assessor walks the house along predetermined paths counting the incidences of birds representative of predefined welfare indicator categories (Table 4). The method requires no animal handling and allows for the visual assessment of the entire flock. During this study, the data collection was carried out by 2 observers, both with experience in observing turkeys. Before data collection started, the 2 observers were trained by experts in the transect method and then visited several turkey flocks together using the transect walk. The experience from these trials showed good interobserver agreement in the scoring. During data collection, the observers divided all the flocks included in the study between each other, so that the observers scored different flocks.

At the start of each farm visit, flock housing and management information was provided by the farmer. During data collection, each transect was kept approximately 2.5 m wide, and the number of transects was based on the width of the barn (Table 3). Transect widths were limited by the location of feeder and drinker lines (for central transects) or the wall and adjacent drinking line (for wall transects). Consecutive transect walks were performed in random order and in alternating direction: starting either at the entrance wall or at the opposite of the entrance wall. Sequential observations of contiguous transects were avoided to minimize the possibility of double-counting birds that may have moved from adjacent scored transects min before. The observers walked slowly through the set transect to minimize disruption of the birds during scoring while recording the frequencies of the birds with welfare deficiencies.

The overall litter quality in the area were scored using the description in the Welfare Quality (2009) protocol for poultry, ranging from 0, completely dry and flaky, to 5, sticks to boots once the cap or crust is broken. Depending on the flock size, the transect took about 30 min up to 1 h to complete for each flock.

In 8 of the visited flocks, producers separated a small part of the rearing area in the barn to place any unfit birds that required treatment or separation from the

Table 1. Information on factors related to the housing and management in the 20 flocks included in the study.

Flock	Barn length (m)	Barn width (m)	Sick pen[1]	Max light (lux)	Min light (lux)	Dusk (yes/no)	Litter quality[2]	Water/feed ratio
1	69	18	Yes	-	-	Y	-	1.6
2	75	22	No	-	-	N	3	1.8
3	36	17	Yes	210	1	N	3	-
4	85	28	Yes	12	10	Y	2	-
5	60	22	No	8	5	N	4	1.6
6	101	18	No	8	6	Y	3	1.6
7	59	20	No	4	1	Y	3	1.7
8	108	44	Yes	6	4	Y	3	1.6
9	50	18	No	4	1	Y	2	1.4
10	69	18	No	2	0	N	4	1.7
11	70	18	Yes	3	0	Y	3	1.7
12	50	18	Yes	3	1	N	3	1.4
13	75	16	No	8	5	N	2	1.8
14	75	30	Yes	8	5	J	2	1.6
15	39	13	No	12	3	N	2	1.8
16	88	16	No	8	2	Y	3	1.5
17	69	18	Yes	-	-	Y	2	1.6
18	36	17	No	8	2	N	3	1.7
19	75	22	No	10	3	Y	3	2
20	60	22	No	6	3	Y	3	1.7

[1]In 8 of the flocks, producers separated a small part of the rearing area in the barn to place any unfit birds that required treatment or separation from the whole flock, called the sick pen. The stocking density was calculated excluding the areas designated for the sick pens.

[2]The litter quality was scored using the description in Welfare Quality (2009) protocol for poultry, ranging from 0—completely dry and flaky—to 5—sticks to boots once the cap or crust is broken.

Table 2. Information on the bird population at the beginning of the production cycle, at 11 wk of birds' age and BW at slaughter in the 20 flocks included in the study.

Flock	Birds placed on day 1 (n)	Mortality at 11 wk (%)	Birds at 11 wk (n)	Stocking density at 11 wk (birds/m^2)	Average BW at slaughter (g)
1	3,200	4.0	3,071	2.5	13,096
2	4,266	3.3	4,124	2.5	13,417.5
3	1,346	1.8	1,321	2.2	15,814
4	5,600	1.2	5,534	2.4	15,715
5	3,400	4.4	3,250	2.5	14,096
6	4,363	0.9	4,325	2.4	14,508.5
7	2,910	5.2	2,759	2.3	14,920
8	5,600	4.3	5,361	2.5	14,621
9	1,850	2.3	1,808	2.0	13,923.5
10	3,400	5.4	3,216	2.6	12,842
11	3,100	2.3	3,029	2.4	13,806
12	2,212	1.4	2,181	2.4	13,918
13	2,820	3.2	2,730	2.3	13,461
14	5,564	3.3	5,380	2.4	14,677
15	1,100	2.9	1,068	2.1	13,223
16	4,100	3.1	3,973	2.8	12,646.5
17	3,223	7.1	2,994	2.4	13,120
18	1,510	3.0	1,465	2.4	15,276
19	5,200	7.7	4,800	2.9	12,389
20	3,400	1.3	3,355	2.5	14,000

whole flock, called the sick pen. The stocking density was calculated excluding the areas designated for the sick pens.

Slaughterhouse Data

Data from the slaughterhouse were sent to us shortly after slaughter and included the following for each flock: birds delivered to the slaughterhouse (n), mortality (including culled birds) (%), dead on arrival (%), average carcass weight (g), birds rejected (n), total rejected (%), and percentage of rejected birds in 10 different categories – peritonitis, heart, skin issues, legs/joints issues, liver, airsacculitis, odor, machine or technical processing issues, small, poorly bled, and total FPD calculated for 100 scored birds with number of birds in each category on a 4-point scale/flock by multiplying all birds with score 0 (n0) by 0, all birds with score 1 (n1) by 1, all birds with score 2 (n2) by 2, and all birds with score 3 (n3) by 3: $\sum = (n0*0) + (n1*1) + (n2*2) + (n3*3)$, resulting in a flock score between 0 and 300. If the flock was slaughtered over several day, the results were merged to a mean for the flocks. It is the procedure commonly used at slaughterhouses. Slaughterhouse routine registrations obtained for the 20 flocks in the study are presented in Table 5.

Statistical Analysis

Animal-based welfare indicators collected on-farm during the transects were used as dependent variables (Table 4), whereas slaughterhouse data (Table 5) were considered as independent variables. During the transect walk conducted at each visit in the barn, frequency of birds falling within each category of the animal-based welfare indicators was noted as the frequency of it for each of the transects. Birds found by the assessors in these sick pens have been evaluated as per the indicators

Table 3. Information on the design of the transect walks in the 20 flocks included in the study.

Flock	Transects per barn (nr)	Transect width (m)	Birds per transect (estimated n)	Birds age at transect walks (day)
1	8	2.3	384	82
2	8	2.8	516	78
3	7	2.4	189	76
4	10	2.8	553	77
5	8	2.8	406	78
6	6	3.0	721	79
7	8	2.5	345	75
8	15	2.9	357	76
9	8	2.3	226	80
10	8	2.3	402	80
11	8	2.3	379	77
12	8	2.3	273	80
13	7	2.3	390	78
14	11	2.7	489	76
15	6	2.2	178	83
16	7	2.3	568	76
17	8	2.3	374	83
18	7	2.4	209	83
19	8	2.8	600	82
20	8	2.8	419	80

Table 4. Description of the birds' behavior and appearance in each of the welfare indicator categories. Individual turkeys could be classified as belonging to more than 1 category (Marchewka et al., 2015).

Indicator	Description
Immobile	Bird not moving when approached or after being gently touched. Birds are only able to move by propping themselves up on their wings.
Lame	Bird walks with obvious difficulty. One or both legs are not placed firmly on the ground. Bird is moving away from the observer but stopping after 2–3 paces to rest. Bird has legs shaking syndrome.
Head wounds	Bird has visible marks on the head, snood, beak, or neck related to fresh or older wounds.
Wing wounds	Bird has visible fresh or older, including bleeding, wounds on the back, and/or wings.
Tail wounds	Bird has visible wounds around tail, or on its sides, including fresh, older, or bleeding wounds.
Dirty	Very clear and dark staining of the back, wing, and/or tail feathers of the bird, not including light discoloration of feathers from dust, covering at least 50% of the body area.
Featherless	Missing feather on the majority of the back area, or back and wings.
Small	Easily distinguishable females (in male area) or individuals that were approximately ½ the size of an average bird in the flock.
Sick	Bird showing clear signs of impaired health with small and pale comb, red watery eyes, and disarranged feathers usually found in resting position. Birds with a pendulous crop hanging in front of the breast or with missing or deformed body parts (excluding birds with leg deformations accounted for as lamed), with clearly different (pale/yellowish) body color.
Terminal ill	Bird with enormous wounds or lying on the ground with head rested on the ground or back, usually with half closed eyes. Bird has to breathe visibly.
Dead	Dead birds found during the transect

used in the transect walk method. In the data set, their frequency was distributed evenly between transects and added to the transect total. Total frequency of birds falling within each welfare indicator category was calculated per barn. We calculated all variables as a proportion where x was the frequency of birds with particular animal-based welfare indicators in each transect divided by N, total number of birds in the transect. The N, so the total number of birds in the transect was calculated dividing the known flock population size in each particular barn on the day of the transect walks by the number of conducted transects, assuming that birds were randomly distributed through the house. The welfare indicator value in each barn was calculated as an average frequency of each welfare indicator across all assessed transects. The data were collected on a handheld computer on-farm and transferred to an Excel v.13 spreadsheet and further to the statistical analysis software SAS v.9.4 (SAS Institute Inc., 2013). The outcome variables were analyzed for associations with any of the independent variables. The outcome variables were normally distributed across the sample population, thus linear univariate regression was used. Residuals were predicted and checked for normality. Associations with P-value <0.2 were further analyzed in a multivariate linear regression analysis. Models were obtained by backward exclusion until all associations obtained reached P-value <0.05. Interactions between independent variables were tested in the final models and were not detected. Residuals were predicted and plotted in normal quantile plots, and coefficients of determination (R^2) were calculated and used to choose the model that explains the variability of the response data. The likelihood ratio test was used to observe the

Table 5. Slaughterhouse routine registrations obtained for the 20 flocks in the study.

Variable	Mean (SD)	Min–max
Birds delivered to the slaughterhouse (n)	2,270.1 (563.49)	902–3,094
Mortality (%)	5.48 (3.45)	1.74–14.89
DOA (%)	1.5 (1.21)	0–4
Birds accepted (n)	2,182.28 (556.66)	869–3,035
Average carcass weight (g)	13,973.50 (985.36)	12,389–15,814
Birds rejected (n)	87.83 (49.07)	32–241
Partial rejections:		
Peritonitis (%)	0.001 (0.004)	0–0.02
Heart (%)	0.42 (0.3)	0.13–1.26
Skin issues (%)	0.89 (0.61)	0.04–2.7
Legs/joints (%)	0.17 (0.18)	0–0.79
Liver (%)	0.15 (0.11)	0–0.37
Airsacculitis (%)	1.25 (1.05)	0–8.99
Odor (%)	0.04 (0.05)	0–0.25
Machine/technical (%)	0.74 (0.84)	0.05–3.78
Small (%)	0.01 (0.02)	0–0.11
Fecal contamination (%)	0.51 (0.39)	0.05–1.85
Poorly bled (%)	0.02 (0.03)	0–0.11
Total FPD[1] (n)	143.24 (51.46)	36–228

Abbreviation: DOA, dead on arrival.
[1]Total footpad dermatitis (FPD): 100 scored animals on a 4-point scale/flock: $\sum = ([n0*0] + [n1*1] + [n2*2] + [n3*3])$, resulting in flock score between 0 and 300.

improvement of the multiple regression models by inclusion and exclusion of independent variables. Akaike's information criterion and Schwarz's Bayesian information criterion were used to compare maximum likelihood of reduced and full models. The selection of the final models was based on the smaller values of the information criterion.

RESULTS

Descriptive Flock Data

The slaughterhouse registrations for the 20 flocks are presented in Table 5. The most common reason for rejections of individual birds was airsacculitis, occurring in on average 1.25% of birds but in some flocks reaching up to 8.99% of toms.

The most commonly observed animal-based welfare indicators in the toms as assessed by the transect method on-farm were dirty birds (0.362% ± 0.170), featherless (0.353% ± 0.105), tail wound (0.265% ± 0.059), and wing wounds (0.240% ± 0.044) (Table 6).

Associations Between Animal-Based Welfare Measures On-Farm and Slaughterhouse Data

The regression models and results are presented in Table 7. Increased prevalence of immobile toms at week 11 was associated with more birds being rejected because of leg issues ($P = 0.02$, r = 0.07) and airsacculitis ($P < 0.0001$, r = 0.02) at the slaughterhouse. More lame birds on-farm were associated with a higher total rejection rate at slaughter ($P < 0.0001$, r = 0.002), however, with less fecal contamination ($P = 0.0006$; r = −0.06). Higher presence of featherless birds on-farm was associated with significantly more birds being rejected at slaughter because of skin issues ($P = 0.02$, r = −0.47). More dirty birds at week 11 was associated with more birds rejected because of airsacculitis at slaughter at 20 wk ($P < 0.0001$, r = 0.29). A higher mortality on-farm was associated with more birds rejected for being too small ($P = 0.04$, r = 60.4).

Table 6. Prevalence of toms observed with different welfare indicators in the flocks of toms at 11 wk of age (n = 20) (mean ± SE).

Variable	Mean[1] (%)	SEM
Immobile	0.016	0.011
Lame	0.103	0.040
Head wounds	0.093	0.029
Wing wounds	0.240	0.044
Tail wounds	0.265	0.059
Dirty	0.362	0.002
Featherless	0.353	0.105
Small	0.002	0.170
Sick	0.001	0.001
Terminal ill	0.000	0.000
Dead	0.004	0.002

[1]Mean values were calculated as the frequency of birds with particular welfare indicator divided by the total number of birds per transect, averaged across all transects in a barn.

Positive associations were identified between small birds and sick birds with those rejected at slaughter because of fecal contamination (P=<0.0001; r = 0.02 and $P < 0.0001$; r = 0.01, respectively).

DISCUSSION

The aim of this study was to investigate associations between animal-based welfare measures in flocks of turkey toms at 11 wk of age, recorded with the transect walk method on-farm and routinely recorded slaughter data at 20 wk of age. Briefly, we found several significant associations between animal-based measures on-farm and slaughterhouse data 9 wk later.

The most commonly observed animal-based welfare challenge on-farm was dirty birds, averaging 0.36% per flock. High incidences of dirty birds at the farm level were associated with higher rejection because of airsacculitis at slaughter. Airsacculitis is one of the most common health issues in turkeys, leaving the affected birds weak and lethargic (Russel, 2003). Thus, this relationship could be because of weak birds spending more time resting in the litter, resulting in dirtier plumage (de Jong et al., 2014). It is also possible that a dirty environment may increase risk of airsacculitis in the flock because it is caused by bacteria such as *Escherichia coli*, *Mycoplasma gallisepticum*, *Mycoplasma synoviae,* or *Mycoplasma meleagridis* (Ficken et al., 1989), which are known to develop better in dirty and wet litter (Soliman et al., 2018).

Another commonly observed welfare challenge in the present study was featherless areas on the birds. The etiology behind featherless areas is not fully understood, but previous studies reported that featherlessness is a common issue in both turkey hens and toms (Marchewka et al., 2019). Featherless areas may partly be due to severe feather pecking, a type of injurious pecking known to occur in turkeys (Dalton et al., 2013). Our results show that the flocks with more featherlessness at 11 wk had more birds being rejected because of skin issues at slaughter, similar to what BenSassi et al. (2019) reported in broilers. This rejection category includes wounds, infections, and contact dermatitis, and we do not know whether the featherless birds are the same birds that were rejected because of wounds on the skin or infections and dermatitis. However, poor plumage and bald patches will render the skin more vulnerable for injuries because of pecks and scratches, leaving the bird more likely to be rejected at slaughter. Our results could indicate that from the age of 11 wk, featherlessness developed into more severe wounds seen on the backs of birds and caused rejections related to skin injuries at the slaughter plant. This relationship needs further studies before any conclusions can be made. Moreover, wounds are a possible entry route for pathogens, for example *E. coli*, especially when the feather cover is not full around the back end and scratching can enable bacterial infections (Gornatti-Churria et al., 2018). As featherlessness was a relatively common issue on the farms and seems to be repeatedly present in

Table 7. Significant regression models for the welfare of turkey toms on-farm based on the slaughterhouse production and welfare conditions.

Response variable	Slaughterhouse parameter	R-Square	Coefficient (r)	SEM	t Value	Pr > |t|	95% Confidence limits	
Immobile	Leg	0.7964	0.07691	0.02964	2.59	0.0189	0.01437	0.13944
	Airsacculitis		0.02186	0.00272	8.04	<0.0001	0.01612	0.02759
Lame	Total rejections	0.8139	0.01912	0.00231	8.27	<0.0001	0.01425	0.02400
	Fecal contamination		−0.05646	0.01355	−4.17	0.0006	−0.08506	−0.02787
Head wound	Poorly bled	0.1933	1.79033	0.86218	2.08	0.0524	−0.02105	3.60170
Wing wound	no model selected							
Tail wound								
Small	Fecal contamination	0.6289	0.02170	0.00393	5.52	<0.0001	0.01345	0.02996
Featherless	Skin issues	0.2756	−0.46779	0.17878	−2.62	0.0175	−0.84340	−0.09219
Dirty	Airsacculitis	0.6105	0.28848	0.05432	5.31	<0.0001	0.17437	0.40259
Sick	Fecal contamination	0.6289	0.01085	0.00196	5.52	<0.0001	0.00672	0.01498
Terminally ill	no model selected							
Dead	Machine/technical	0.6568	0.01054	0.00180	5.87	<0.0001	0.00677	0.01431
Mortality %	Small	0.2162	60.41120	27.11487	2.23	0.0389	3.44497	117.37744

the results of the on-farm studies, further studies should investigate this causality to improve welfare and reduce unnecessary rejections.

Increased prevalence of immobile toms at week 11 was associated with more birds rejected because of leg issues at slaughter. A similar relationship is reported in turkey hens (Marchewka et al., 2020) and broilers (BenSassi et al., 2018, 2019), suggesting that poor leg health on-farm is reflected in this rejection category. This is also supported by Marchewka et al. (2015) who found that bird rejections (whole or part, without further division of this category to leg issues) were correlated positively with lameness in 19-week-old turkey toms. Lameness in poultry is multifactorial and can have infectious, developmental, and degenerative causes (e.g., Julian, 2005), and we do not know the causes behind observed immobility in examined flocks, whether it was owing to infection, lameness, or a combination of several factors. Lameness is a well-know welfare challenge in turkey production (Martrenchar et al., 1999), especially in toms (Vermette et al., 2016), and can have both infectious and noninfectious causes (Erasmus, 2018), which in serious cases may lead to immobility. Although the immobile birds observed at 11 wk are likely to be culled before slaughter at 20 wk of age, an increased number of immobile birds at 11 wk could have been a symptom of underlying challenges they faced in the environment, including bacterial infections. This is further supported by the fact that increased lameness on-farm was related to more total rejected birds. Contrary to previous studies, we did not find any associations between FPD and farm measures such as litter quality (Mayne et al., 2007) or lameness (da Costa et al., 2014). FDP is a common welfare issue in turkey throughout the production period (Mayne et al., 2007), but as the transect method does not include FPD, we do not know the prevalence of FPD at the time of observations. However, as the prevalence of FPD differed substantially between flocks, this relationship should be investigated further in a larger number of flocks.

Neither tail wounds nor wing wounds were associated with any slaughterhouse measures in the present study. On average, 0.25% of the observed toms had tail wounds or wing wounds at 12 wk, which can be caused by scratches from other birds, by injurious pecking or a combination of these. Prevalence of such wounds have been reported to increase with higher stocking density (Marchewka et al., 2019), which could mean that the prevalence is reduced in the week after we observed the flocks, when animal density is reduced for toms after the hens are depopulated, thus reducing any associations with slaughter registrations at 20 wk.

A higher mortality on-farm was associated with more birds rejected for being too small. An increased percentage of small birds may indicate compromised health and welfare on-farm, owing to either general housing or management problems or bird health problems, resulting in increased mortality (Weeks et al., 2000; Butterworth et al., 2002; BenSassi et al., 2019). Several of the known turkey diseases cause malabsorption, dehydration, reduced feed intake, reduced growth, poor feed conversion, and increased mortality (Chapman, 2008). In 19-week-old toms, prevalence of 0.89 to 0. 92% small birds was identified (Marchewka et al., 2015), suggesting that this indicator may deteriorate with increasing age.

The transect walk is reported to be effective to detect changes in the welfare status of broiler chickens during the growing period, and the flock welfare condition is reflected in the slaughter outcomes (BenSassi et al., 2018). Therefore, transects may be useful to improve bird management by providing farmers with specific quantitative information about the flocks' issues, so precise mitigation strategies could be implemented to correct or minimize on-farm problems. In the present study, rejections at slaughter because of leg issues, skin issues, and airsacculitis were associated in a meaningful way with measures of welfare on-farm (immobile, featherless, and dirty, in the respective order), suggesting not only a level of sensitivity but also specificity for certain animal-based welfare measures.

In conclusion, we found several significant and relevant associations between animal-based measures at 11 wk and slaughter data at 20 wk. The results support the use of slaughter data for providing relevant and reliable information on certain welfare issues on-farm in turkey tom flocks. Furthermore, the transect walk can be used at different ages in turkeys and still provide relevant information on animal welfare and production outcomes, making it a more flexible and feasible tool for the industry.

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DISCLOSURES

The authors declare no conflicts of interest.

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