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HERD-LEVEL RISK FACTORS FOR LAMENESS, LEG INJURIES, THIN BODY CONDITION AND MASTITIS ON ALGERIAN DAIRY FARMS

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ABSTRACT

This present study aims to investigate the relationship of herd characteristics and management practices with the prevalence of clinical and severe lameness, hock and knee injuries, thin cows, and mastitis at the herd level on Algerian dairy farms. Altogether 1210 dairy cows from 107 farms were examined and the clinical aspects related to studied affections were recorded. Multivariable regression models were built to analyse the relationship between the risk factors and the occurrence of health indicators. Overlay, the health outcomes were multifactorial, with pasture access ($P<0.001$), scraping frequency ($P<0.01$), and floor regularity ($P=0.05$) as the main factors causing lameness. Factors associated with both hock and knee injuries (score≥2) were lower cow number ($P<0.01$), more days spent on pasture ($P<0.001$), and poorer straw amount for bedding ($P<0.001$). Some farming practice, in particular, providing proper amount of concentrate feeds ($P<0.001$), higher scraping frequency ($P<0.01$), thicker bedding ($P<0.001$), and having younger dairy cows ($P=0.058$), were associated with a lower within-herd prevalence of thin cows. While, more days on pasture increased the percentage of under-conditioned cows ($P<0.01$). The inadequate hygienic conditions of the floor ($P<0.001$), improper milking procedures ($P<0.05$), and shorter dry period ($P<0.05$) increased the clinical mastitis occurrence. Our results highlighted the specific management practices responsible for increasing health risks and provided useful information for the farmers and veterinarians to make preventive and controlling strategies for lameness, leg injuries, low body condition and mastitis on dairy farms.

Key words: Algeria; dairy cow; hock lesions; lameness; management practice; mastitis

INTRODUCTION

Animal health is one of the daily concerns of breeders. It has a direct impact on animal welfare, the working conditions of the farmers, and the technical and economic performance of farms. Mastitis and lameness are, respectively, in the first and third positions of the most important diseases, reproductive disorders come in second position [17]. They account for nearly 37% of the dairy unit's health expenditure [17]. They are considered as the most important livestock related diseases with essential impact on the dairy farm's performance: a drop in productivity, early culling, discarding milk during processing, and increasing open days and low fertility, increasing veterinary costs, negative repercussions on working time and working conditions, a shortfall in the price of milk; therefore, they represent half of the economic impact generated by herd diseases [13, 21, 22]. Moreover, these diseases appear as priority targets to reduce the use of antibiotics in dairy herds. The analysis of the incidence of the predisposing factors associated with these diseases; such as temporal, genetic, breeding practices and behavioural factors represents an important point of descriptive epidemiology of these diseases and they have been the subject of several recent studies [10, 34]. In addition, the dairy cattle body condition has significant implications on the health and performance of dairy cows. In contrast, inappropriate body condition score (BCS) has been associated with lameness [24], hypocalcaemia [38], low milk production, and fertility [39, 40], whereas, negative energy balance is mainly due to nutrition deficiency. Guaranteeing farm performance and animal welfare depends on better prevention of these diseases. There are many risk factors, but the living environment of dairy cows is a central element.

In the literature, vast information is available about the main health disorders affecting dairy cows. However, it remains difficult for a farmer to control overall health in his herd because controlling one disease can exacerbate the situation with another. As a result, a global assessment of the health status is the best strategy for improving animal welfare, taking into account the major disorders.

This present study was conducted to investigate the relationship of herd characteristics and management practices with the prevalence of clinical and severe lameness, hock and knee injuries, thin cows, and mastitis on dairy farms in eastern Algeria.

MATERIALS AND METHODS

Farm selection and description

This study was conducted on 107 Algerian dairy farms from Souk Ahras region, one of the best ranked dairy-producing region in Algeria. The farms were visited once by the same assessor from October 2020 through March 2021.

Two predominate types of climates in the study area: sub-humid in the north with an average annual precipitation of 700 mm and semi-arid in the south with a precipitation of 250 mm per year. Montbeliard cattle dominate the studied farms, with a mean herd size of 22 ± 13 (min = 7, max = 91). The cows were mainly kept in a tied housing system with a concrete floor, and 90.1 % of farms used straw for bedding as the amount was 0.3–3.8 kg per cow every day after removing the contaminated one. Dry cows were housed under the same conditions. Cows were milked two times a day. The average milk production was 15.6 litres per cow per day, and most farms used the resting pen for milking purposes. Cows had 220 days of pasture access on average per year. Besides, they received green or hay fodder and were supplemented with a varied amount of commercial concentrate and a vitamin-mineral mixture, with a feeding frequency of 2–3 times a day and a feeding interval of 7.6 h.

Dairy herd-related risk factors

Direct observation and interview with the farm manager were carried out to collect information regarding herd characteristics, feeding practices, prevention against disease, milking procedures, and condition of the floor and livestock areas (Tables 1 and 2).

Herd characteristics

Milking herd size was obtained by interview with the farm manager. Information regarding lactation period length, dry period length and herd average parity were collected from the data available in the records and through interview with the farmer.

Feeding practices

Concentrate feed, pasture access, feeding method, and feeding frequency were collected through interview with the farm manager. Feeding method was characterised as balanced ration when the cows received calculated feed ration based on stage and number of lactation, estimated ration when dry cows received a reduced amount of concentrate without calculation, or standard ration when all animals fed the same ration regardless of their physiological stages and their production.

Condition of the floor and livestock areas

Litter provision and cleaning frequency were collected through interview with the farm manager. Lying down and rising, floor regularity, floor slipperiness, light intensity, air quality, and sharp objects and obstacles were noted after direct observation. Cattle on each farm were observed when lying down and rising of their own volition; their behaviour was judged as unrestricted, mildly restricted or

Table 1. Descriptive statistics of quantitative risk factors involved in the studied dairy farms (n = 107)

Variable	Mean ± SD	Median (Q1–Q2)
Herd characteristics		
Herd size (HS; heads)	13 ± 9	11 (8–15)
Lactation period length (LPL; days)	319.2 ± 35	314.8 (292.4–334.6)
Dry period length (DPL; days)	59.6 ± 18.9	60.8 (45.6–76)
Herd average parity (HAP; lactations' number)	3.2 ± 1.2	3.1 (2.4–3.8)
Feeding practices		
Concentrate feed (CF; $kg.cow^{-1}.day^{-1}$)	6.8 ± 2.3	7 (5–9)
Pasture access (PA; days)	226.6 ± 59.3	220 (180–289)
Condition of the floor and livestock areas		
Litter provision (LP; $kg.cow^{-1}.day^{-1}$)	1.6 ± 0.9	1.6 (1–2.2)

Table 2. Descriptive statistics of qualitative breeding practice related risk factors involved in the studied dairy farms (n = 07)

Variable	Category
Feeding practices	
Feeding method (FM)	Estimated ration; Standard ration; Balanced ration
Feeding frequency (FF; $time.day^{-1}$)	2; 3
Prevention against disease	
Main calving location (MCL)	Isolated pen; Pasture; In barn with herd
Checking uterus involution(CUI)	No; Occasional; Systematic
Frequency of hoof trims (FHT)	Never; If necessary
Hoof trimming personnel (HTP)	None; Dairy personnel; Professional
Vaccination (V)	No; Yes
Deworming (D)	No; Yes
Milking procedures	
Teat preparation before milking (TPBM)	Wet towel; Washing; Pre-dipping
Teat drying (TD)	No; Collective towel; Individual towel
Subclinical mastitis screening (SMD)	No; Yes
Condition of the floor and livestock areas	
Cleaning frequency (CFr; $time.day^{-1}$)	1; 2; > 2
Lying down and rising (LDR)	Restricted; Mildly restricted; Unrestricted
Floor regularity (FR)	Uneven; Plane
Floor slipperiness (FS)	Not slippery; Slippery
Light intensity (LI)	Weak; Sufficient; Good
Air quality and air flow (AQAF)	Bad; Medium; Good air quality
Sharp objects and obstacles (SOO)	No; Yes

restricted depending on the ease with which animal can lie down and rise from a lying position. Light intensity was evaluated as weak, sufficient or good based on the luminosity in the facility. Moreover, air quality ranges from good to bad depends on the accumulation of gaseous effluents for example, ammonia and hydrogen sulphide.

Prevention against disease

Information regarding the main calving location, checking uterus involution, frequency of hoof trims, hoof trimming personnel, vaccination against diseases (FMD, rabies, anthrax) and deworming (anthelmintics) were recorded following interview with the farmer.

Milking procedure

The method of teat preparation before milking (humid towel, washing, pre dipping), whether teat drying with collective towel, individual towel or not practiced, and if there was any subclinical mastitis screening were all recorded through interview with the farmer.

Evaluation of cows

A total of 1210 cows were examined on 107 farms, of which 76% were lactating and 24% dry cows. On farms with more than 20 cows, at least 15 cows were selected at random, in farms with 13–20 cows, at least 10 cows were examined, and in farms with 12 or fewer cows all were selected.

The cows were evaluated for lameness, hock and knee injuries, body condition score (BCS) and clinical mastitis. The locomotion score proposed by Thomsen et al. [47] was noted on a 5-point scale with clinical lameness scores ≥ 3, and severe lameness scores ≥ 4. Hock and knee injuries were scored using a 4-point scale based on the tarsal and carpal joints condition [18]. Then, a cut-off score (≥ 2) was used to estimate the prevalence of cows with injuries within and across herds. BCS was measured to all observed cows according to the system developed by Vasseur et al. [49]. The scale ranges from 1 to 5 for very thin and very fat cows, respectively. The percentage of cows with BCS ≤ 2 was recorded as a cut-off score representing a thin cow. The clinical mastitis included three levels: severe, moderate and mild [36]. The three levels were evaluated according to the general health condition (fever, anorexia, or lethargy), signs of udder inflammation (swelling, heat, or hardness) and abnormal appearance of milk (watery, clots, or pus), respectively. All these cases were considered as clinical mastitis and were included in the calculation of the prevalence of this health issue per herd.

Statistical analysis

All statistical analyses were performed by IBM SPSS version 26.0. Descriptive statistics were presented as means, standard deviation (SD) and medians with interquartile range (IQR; 1st–3rd quartiles) for quantitative parameters and frequency and percentages for qualitative parameters. The farm was considered a sampling unit, with the outcomes of interest being the percentage of clinically lame cows ($3 \leq$ score < 4), severely lame cows (≥ 4), percentage of cows with hock injuries (≥ 2), percentage of cows with knee injuries (≥ 2), percentage of cows that were thin (BCS ≤ 2), and percentage of clinical mastitis. Variables with less than 5% per category were not considered for analysis. Multivariable analyses included six linear regression models that were constructed to evaluate influence of housing and management factors on health parameters. First, each predictor was screened by univariable nonparametric analysis. Because several numerical health outcomes were not distributed normally according to the Shapiro-Wilk test, the Spearman test was used in the case of quantitative independent variables and the Kruskal-Wallis and Mann-Whitney tests in the case of categorical variables. Factors with $p < 0.2$ in the screening were included in subsequent modelling.

Independent variables were also tested for multicollinearity. If two predictors were highly correlated ($r > 0.65$), the one with the strongest correlation with the dependent variable in the univariable analysis was selected. Then, a multivariable linear regression model was constructed for each outcome using Stepwise backward procedures. In the final models, only factors with a P-value < 0.1 were chosen. The normality distributions of the residuals were examined by the Kolmogorov-Smirnov test ($P = 0.2$).

RESULTS

Fig. 1 shows the mean proportion of affected animals by thin body condition score, lameness, hock and knees injuries and clinical mastitis within the 107 studied dairy herds. The results of the present survey allow us to rank the diseases from the most to the least incident as follows:

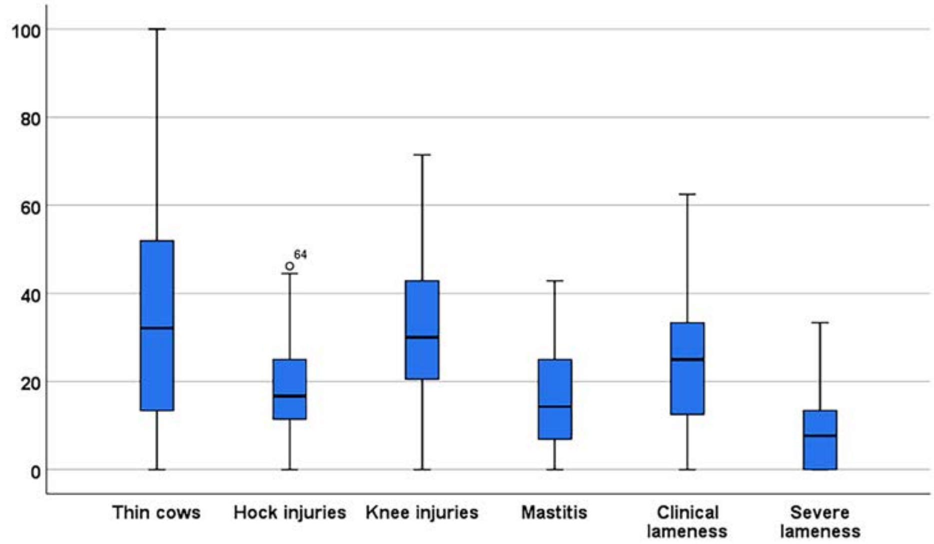

Fig. 1. Box-plots of the health outcomes in 107 dairy cattle herds from the eastern Algeria

Table 3. Results of univariable analysis for preselection of quantitative predictors in the multivariable regression models

Factors	P-value					
	Thin cows	Hock injuries	Knee injuries	Clinical mastitis	Clinical lameness	Severe lameness
Herd characteristics						
HS	0.493	< 0.001*	< 0.001*	0.107*	0.003*	0.059*
LPL	0.002*	–	–	0.010*	–	–
DPL	< 0.001*	–	–	< 0.001*	–	–
HAP	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
Feeding practices						
CF	< 0.001*	< 0.001*	0.001*	0.001*	0.008*	0.002*
PA	0.006*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
Condition of the floor and livestock areas						
LP	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*

HS – Herd size (heads); LPL – Lactation period length (days); DPL – dry period length (days); HAP – herd average parity (lactations' number); CF – Concentrate feed (kg.cow^{-1}.day^{-1}); PA – Pasture access (days); LP – Litter provision (kg.cow^{-1}.day^{-1})
* – Factors included in subsequent multivariable analysis (P < 0.2).

body condition (leanness), knee injuries, clinical lameness, hock injuries, clinical mastitis, and severe lameness. The median of thin cows (BCS ≤ 2) was 32.1 % (Q1 = 13.4, Q2 = 51.9). The overall median proportion of lame cows was 25 % (Q1 = 12.5, Q2 = 33.3), of which 7.7 % (Q1 = 0, Q2 = 13.4) had severe lameness. The median prevalence of hock injuries was 16.7 % (Q1 = 11.4, Q2 = 25), and of knee injuries was 30 % (Q1 = 20.5, Q2 = 42.9). The median prevalence of clinical mastitis was 14.3 % (Q1 = 6.9, Q2 = 25).

Tables 3–6 present univariable analysis for preselection of quantitative and qualitative risk factors in the multiple regression analysis.

Table 4. Results of univariable analysis for preselection of qualitative predictors regarding feeding practices and milking procedures in the multivariable regression models

Risk factor	P-value					
	Thin cows	Hock injuries	Knee injuries	Clinical mastitis	Clinical lameness	Severe lameness
Feeding method						
Estimated ration Standard ration Balanced ration	0.003*	–	–	–	–	–
Feeding frequency						
2 3	< 0.001*	0.704	0.365	0.317	0.375	0.581
Teat preparation before milking						
Wet towel Washing Pre-dipping	–	–	–	< 0.001*	–	–
Teat drying						
No Collective towel Individual towel	–	–	–	0.001*	–	–
Subclinical mastitis screening						
No Yes	–	–	–	< 0.001*	–	–

* – Factors included in subsequent multivariable analysis (P < 0.2).

Table 5. Results of univariable analysis for preselection of qualitative predictors regarding prevention against disease in the multivariable regression models

Risk factor	P-value					
	Thin cows	Hock injuries	Knee injuries	Clinical mastitis	Clinical lameness	Severe lameness
Main calving location						
In a calving pen At pasture In barn with herd	< 0.001*	0.020*	0.012*	0.002*	0.014*	0.009*
Checking uterus involution						
No Occasional Systematic	< 0.001*	–	–	–	–	–
Frequency of hoof trims						
Never If necessary	–	–	–	–	0.763	0.671
Hoof trimming personnel						
None Dairy personnel Professional	–	–	–	–	0.306	0.198*
Vaccination						
No Yes	0.044*	–	–	–	–	–
Deworming						
No Yes	0.937	–	–	–	–	–

* – Factors included in subsequent multivariable analysis (P < 0.2).

Table 6. Results of univariable analysis for preselection of qualitative predictors regarding condition of the floor and livestock areas in the multivariable regression models

Risk factor	P-value					
	Thin cows	Hock injuries	Knee injuries	Clinical mastitis	Clinical lameness	Severe lameness
Cleaning frequency						
1 2 >2	< 0.001*	0.009*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
Lying down and rising						
Restricted mildly restricted unrestricted	0.038*	0.006*	0.036*	0.007*	0.044*	0.039*
Floor regularity						
Uneven Plane	–	0.015*	0.063*	< 0.001*	0.043*	0.064*
Floor slipperiness						
Not slippery Slippery	–	< 0.001*	< 0.001*	–	0.018*	0.002*
Light intensity						
Weak Sufficient Good	–	0.001*	0.01*	–	0.016*	0.015*
Air quality and air flow–						
Bad Medium Good air quality	< 0.001*	< 0.001*	0.011*	< 0.001*	< 0.001*	< 0.001*
Sharp objects and obstacles						
No Yes	–	< 0.001*	0.004*	< 0.001*	< 0.001*	< 0.001*

* – Factors included in subsequent multivariable analysis (P < 0.2).

Lameness models

Among the 16 variables tested during the univariable step, 15 were retained in the multivariable model. Finally, 8 variables were associated with lameness (Table 7). Other variables that were not meet the criteria but considered for inclusion in the model included frequency of hoof trims and hoof trimming personnel. Furthermore, herd-level factors associated with clinical lameness were lesser days of access to pasture (P<0.001), lower frequency of floor cleaning (P<0.01), lower daily liter quantity (P=0.017), and concentrate feeds (P=0.062). Hoof trimming performed by dairy personal was associated with more occurrence of lameness compared with that performed by professionals (P=0.07). In addition, dairy farms with poor air quality (P<0.001),

Table 7. Results of multivariable linear regression model regarding percentage of clinical lameness (R2 = 0.657, R2 adjusted = 0.625, F = 20.635; n = 107)

Model	Estimate	SE	t	P-value
(Constant)	55.489	8.420	6.590	< 0.001
PA	–0.128	0.019	–6.679	< 0.001*
LP	–3.006	1.234	–2.435	0.017*
CF	–1.037	0.549	–1.889	0.062*
HTP (reference: Professional)				
Dairy personnel	3.846	2.097	1.834	0.070*
CFr (reference: >2)				
1	8.979	2.943	3.051	0.003*
AQAF (reference: Good)				
Bad	12.055	3.010	4.004	< 0.001*
Medium	5.015	2.379	2.109	0.038*
SOO (reference: None)				
Yes	5.351	2.666	2.008	0.047*
FR (reference: Plane)				
Uneven	5.204	2.627	1.981	0.050*

PA – Pasture access (days); LP – Litter provision (kg.cow^{-1}.day^{-1}); CF – Concentrate feed (kg.cow^{-1}.day^{-1});
HTP – Hoof trimming personnelCFr – Cleaning frequency; AQAF – Air quality and air flow; SOO – Sharp objects and obstacles; FR – Floor regularity
*– Herd-level factors significant at P < 0.1 that were retained in the final model

Table 8. Results of final multivariabl e linear regression model regarding percentage of severe lameness (R2 = 0.655, R2 adjusted = 0.619, F = 18.245; n = 107)

Model	Estimate	SE	t	P-value
(Constant)	9.882	6.156	1.605	0.112
PA	–0.041	0.012	–3.323	< 0.001*
HAP	1.587	0.599	2.648	0.009*
CF	–0.580	0.333	–1.739	0.085*
LP	–2.541	0.740	–3.435	< 0.001*
MCL (reference: Isolated pen)				
In barn with herd	2.579	1.180	2.186	0.031*
FR (reference: Plane)				
Uneven	3.302	1.561	2.116	0.037*
CFr (reference: >2)				
1	3.197	1.804	1.773	0.079*
AQAF (reference: Good)				
Bad	2.878	1.499	1.920	0.058*
HTP (reference: Professional)				
Dairy personnel	2.635	1.263	2.086	0.040*
SOO (reference: None)				
Yes	6.710	1.601	4.190	< 0.001*

PA – Pasture access (days); HAP – Herd average parity (lactations' number); CF – Concentrate feed (kg.cow^{-1}.day^{-1}); LP – Litter provision (kg.cow^{-1}.day^{-1}); MCL – Main calving location; FR – Floor regularity; CFr – Cleaning frequency; AQAF – Air quality and air flow; HTP – Hoof trimming personnel; SOO – Sharp objects and obstacles
*– Herd-level factors significant at P < 0.1 that were retained in the final model.

uneven floor (P=0.05), and sharp objects and obstacles (P=0.047) were more likely to have a higher prevalence of severe lameness. From the 16 variables that met criteria in the univariable screening for severe lameness, 10 were retained in the final model (Table 8). Other variable that did not meet the criteria but was considered for inclusion in the model included frequency of hoof trims. Dairies with high average parity (P<0.01), low access pasture (P<0.01), amount of concentrate feeds (P=0.085) and litter provision (P<0.001), uneven floor (P=0.037), improper scraping frequency (P=0.079), main calving location in barn with herd (P=0.031), poor air quality (P=0.058), hoof trimming by dairy personnel (P=0.040), and sharp objects and obstacles (P<0.001) were more likely to have a higher prevalence of severe lameness.

Hock and knee injury models

Fourteen variables were screened by univariable analysis for the prevalence of hock injuries, with 6 being retained in the final multivariable model (Table 9). Hock injury was positively affected by parity (P<0.001) and weak (P=0.078) or medium light intensity in the cowshed (P<0.032), however was negatively affected by herd size (P<0.01), litter provision (P<0.001), pasture access (P<0.001), and concentrates amount (P=0.017). Among the 14 variables introduced in the multivariable model for knee injuries, 7 were introduced in the final model (Table 10). Knee injuries were positively associated with parity (P=0.06), restricted lying down/rising movements (P=0.091), bad air quality (P=0.076), and scraping frequency (P=0.041) and were negatively associated with herd size (P<0.001), litter provision (P<0.001), and pasture access (P<0.001).

Thin cow models

A total of 16 explanatory variables were retained in the multivariable model of the prevalence of thin cows, of which seven were found to be associated with the outcome (Table 11). The prevalence of thin cows was greater in farms with older cows (P=0.058), more pasture access (P<0.01), longer lactation period (P<0.01), lower concentrates amount (P<0.001), litter provision (P<0.001), and scraping frequency (P<0.01). Moreover, cows that received a balanced ration had lesser occurrence of being thin than others received estimated (P<0.01) or standard ration (P<0.01).

Mastitis models

Six factors showed the significance of the risk factor for mastitis likelihood where the percentage of mastitis increased with fewer days of access to pasture (P<0.001), lesser dry period (P=0.019), and scraping frequency (P<0.001). Other factors that showed the significance of the risk factor for mastitis occurrence were washing teat (P<0.01) or using humid towel (P<0.001) before milking compared with pre dipping and teat drying with a collective towel (P<0.016) in comparison with individual towel (Table 12).

Table 9. Results of Final multivariable linear regression model regarding percentage of hock injuries (R2 = 0.671, R2 adjusted = 0.648, F = 28.816; n = 107)

Model	Estimate	SE	t	P-value
(Constant)	42.821	5.594	7.655	< 0.001
HS	−0.208	0.073	−2.867	0.005*
HAP	2.338	0.648	3.610	< 0.001*
PA	−0.085	0.012	−7.201	< 0.001*
CF	−0.876	0.360	−2.435	0.017*
LP	−3.015	0.800	−3.770	< 0.001*
LI (reference: Good)				
Weak	3.819	2.142	1.783	0.078*
Sufficient	3.177	1.457	2.181	0.032*

HS – Herd size (heads); HAP – Herd average parity (lactations' number); PA – Pasture access (days); CF – Concentrate feed ($kg.cow^{-1}.day^{-1}$); LP – Litter provision ($kg.cow^{-1}.day^{-1}$); LI – Light intensity
*– Herd-level factors significant at P < 0.1 that were retained in the final model

Table 10. Results of final multivariable linear regression model regarding percentage of knees injuries (R2 = 0.621, R2 adjusted = 0.594, F = 23.162; n = 10

Model	Estimate	SE	t	P-value
(Constant)	64.465	6.437	10.014	< 0.001
HS	–0.462	0.119	–3.878	< 0.001*
PA	–0.101	0.017	–5.832	< 0.001*
HAP	1.934	1.018	1.900	0.060*
CF	-7.557	1.177	-6.420	< 0.001*
LDR (reference: unrestricted)				
Restricted	4.459	2.615	1.705	0.091*
CFr (reference: >2)				
1	6.408	3.087	2.076	0.041*
AQAF (reference: Good)				
Bad	3.811	2.123	1.795	0.076*

HS – Herd size (heads); PA – Pasture access (days); HAP – Herd average parity (lactations' number);
CF – Concentrate feed (kg.cow^{-1}.day^{-1}); LDR – Lying down and rising; CFr – Cleaning frequency; AQAF – Air quality and air flow.
*Herd-level factors significant at P < 0.1 that were retained in the final model

Table 11. Results of final multivariable linear regression model regarding percentage of thin cows (R2 = 0.706, R2 adjusted = 0.682, F = 29.184; n = 107)

Model	Estimate	SE	t	P-value
(Constant)	44.330	19.190	2.310	0.023
LPL	0.118	0.044	2.669	0.009*
PA	0.076	0.028	2.699	0.008*
HAP	2.954	1.538	1.920	0.058*
CF	–6.574	0.853	–7.706	< 0.001*
LP	–7.444	1.814	–4.103	< 0.001*
FM (reference: Balanced ration)				
Estimated ration	–18.895	6.825	–2.769	0.007*
Standard ration	–23.757	7.754	–3.064	0.003*
CFr (reference: >2)				
1	12.506	4.458	2.805	0.006*

LPL – Lactation period length (days); PA – Pasture access (days); HAP – Herd average parity (lactations' number);
CF – Concentrate feed (kg.cow^{-1}.day^{-1}); LP – Litter provision (kg.cow^{-1}.day^{-1}); FM – Feeding method; CFr – Cleaning frequency
* – Herd-level factors significant at P < 0.1 that were retained in the final model

Table 12. Results of final multivariable linear regression model regarding percentage of mastitis (R2 = 0.58, R2 adjusted = 0.546, F = 16.936; n = 107)

Model	Estimate	SE	t	P-value
(Constant)	26.533	4.759	5.575	< 0.001
DPL	-0.105	0.044	-2.378	0.019*
PA	-0.090	0.014	-6.390	< 0.001*
TPBM (reference: Pre-dipping)				
Wet towel	10.051	2.464	4.080	< 0.001*
Washing	6.898	2.238	3.082	0.003*
TD (reference: Individual towel)				
Collective towel	4.921	2.000	2.461	0.016*
CFr (reference: >2)				
1	12.480	2.806	4.448	< 0.001*
2	7.328	1.942	3.773	< 0.001*
AQAF (reference: Good)				
Bad	4.059	1.872	2.168	0.033*

DPL – Dry period length (days); PA – Pasture access (days); TPBM – Teat preparation before milking; TD – Teat drying; CFr – Cleaning frequency; AQAF – Air quality and air flow
* – Herd-level factors significant at P < 0.1 that were retained in the final model

DISCUSSION

The current study was performed to explore potential associations between animal-based health indicators (lameness, BCS, legs injuries, and mastitis) and farm characteristics regarding herd, housing, and management practices.

Lameness

Lameness is widely reported as one of the important welfare impairments facing the dairy cow, with several housing characteristics and management practices influencing the prevalence of lameness. Pasture was negatively associated with the prevalence of clinical and severe lameness on Algerian dairy farms. The benefits of pasture for hoof health and mobility have been shown in several studies, as cows in pasture-based systems had less dirty hind limbs and demonstrated lower lameness compared to those in zero-grazing systems [1, 25]. Furthermore, the daily amount of litter was found to be negatively related to the prevalence of lameness. It must be thermally insulated from the ground, cushioned, and keep the bedding area dry to avoid excessive bacterial development [45, 51]. Factors such as poor bedding and abrasive floors reduced lying time [48], increased the risk of hoof horn lesions [20], and lameness in dairy cows [15]. Furthermore, a higher herd average parity was associated with severe lameness. Previous reports supported this result [12, 42] with a particular result from Dippel et al. [12], suggesting that heifers showed lesser lameness than older cows. As expected, less scraping frequency was a potential risk factor for lameness, which was confirmed by another study [28]. Floor dirtiness exposes legs to contamination by manure and promotes softening of hoofs and bacterial transmission [34, 37]. However, having a hygienic condition reduces the occurrence of digital infection and lameness [9, 37]. In contrast, the current study found that farms where hooves are trimmed by dairy personnel have more lame cows than farms where hooves are trimmed by professional. Proper hoof trimming prevents the appearance of overgrown hoof, improves even postures, and straightens the limbs [16, 43]. In addition, it is very important to check the floor condition in order to highlight any protruding and irregular parts that could injure the animal's hooves [16, 34].

Providing a lower amount of concentrates was associated with a higher prevalence of severe lameness. Moreover, nutrition deficiency increased the possibility of poor body condition in the studied cows. According to many authors, dropped BCS was a factor causing lameness [19, 29]. Leaner cows have lesser fat thickness of digital cushion, which is associated with reduced protective function as a shock absorber and therefore increased the hoof lesion and lameness [6, 35].

One of the strongest associations occurred with the calving location. A lower proportion of severely lame cows were on farms where cows calved in a separate pen compared with farms where cows calved in the main pen with the herd. According to OIE [51], calving areas should be thoroughly cleaned and covered with fresh bedding before each calving. Alternatively, we can assume that farmers who have better care for their cows use a calving pen when they are about to calve, and the association with the proportion of lame cows could come from these management practices. Among the risk indicators, good air quality decreased the percentage of lame cows. Ventilation serves the purpose of renewing the ambient air in order to evacuate the gases and humidity present in the building and to partially regulate the interior temperature, however, with poor ventilation, litters are always humid and often difficult to keep clean, which promotes the proliferation of pathogens on the bedding [33].

Hock and knee injuries

Herein, the prevalence of knee injuries was higher than hock injuries, which may be explained by the lying behavior of cows, where both knees are in contact with the floor at the same time, whereas cows have to put their hocks alternately on the floor, thus, decreasing the pressure on their tarsal joints. Common risk factors for both hock and knee lesions were herd size, access to pasture, amount of bedding, and herd average parity. Risk factors that differed for skin lesions on the hock and the knee were the amount of concentrates, light intensity, lying down/rising behaviours, scraping frequency, and air quality. Farms that allowed cow grazing had a lesser prevalence of hock lesions than farms with a zero grazing system [1]. During longer periods in housing, cows are more likely to come into contact with barn objects, therefore, they are in greater danger of injuries. According to Heyerhoff et al. [23] and Kester et al. [26], lack of bedding and abrasive surfaces are strongly related to hock and knee lesions, which indicate that thick bedding prevents cattle from serious integument damage. Furthermore, several authors showed that the prevalence of hock lesions increased with age and parity [27, 41], whereas others found no association [3].

In the literature, poor nutrition can lead to a deficit of minerals and other essential elements for tissue recovery, causing swelling and eventual necrosis [4]. On the other hand, thin cows have less fat and thin protective tissues, so they are at greater risk of wounds in the joint areas, especially while lying down on hard floors [29]. Cattle in housing which do not have adequate access to natural light must be provided with additional lighting that follows the natural periodicity and adequate for their well-being. Access to surrounding areas should be well lighted [51], because the walkways and alleys often contain foreign materials and sharp objects that may induce traumatic lesions [7]. Moreover, all cattle in a pen must have enough space to simultaneously lie down and rest [51]. Restricted space allowances in the resting areas and around the feed bunk possibly promote agonistic behaviours; therefore, these conditions promote slips and falls as a result of rapidly moving to avoid dominant cows. Also, the frequency of scraping has a strong impact on the cleanliness of alleys, stalls, and cows [31]. Meanwhile, a dirty environment weakens the protective effect of the skin by promoting its maceration and the development of bacteria.

Thin cows

We observed an increase in thin cow prevalence as the days in pasture increased. Mee and Boyle [32] observed that an insufficient grass allowance at pasture may be a risk for negative energy balance and weight loss. Throughout pasture season, cows may need additional nutrition indoors to balance their diet [14]. At the herd level, feeding deficiency increased the likelihood of poor body condition in the studied farms. DesRoches [11] observed that low values of BCS (<2.5) indicate that dietary supplies don't fulfil energy needs.

A lower amount of bedding was significantly linked to a higher proportion of cows with poor body condition. Tucker et al. [48] demonstrated that a lack of straw bedding and discomfort during rest reduced lying times, which may have an effect on BCS [5, 50]. Dairy farms that used balanced rations had fewer thin cows than those on which the farmer used estimated or standard rations because balanced rations supply the proper amount and proportions of nutrients during different stages of lactation and gestation. OIE [51] reported that cattle must have access to a balanced feed ration, quantitatively and qualitatively adapted and in accordance with their physiological needs.

Mastitis

In the present study, mastitis in Algerian animals is believed to be associated with some of the herd characteristics and management practices, including the length of the dry period, number of days in pasture, teat preparation before milking, teat drying, scraping frequency, and ventilation. Collier et al. [8] reported that shortening or omitting the dry period possibly influence the mammary health and promote the occurrence of mastitis. Furthermore, intramammary infections are considerably increased during late gestation in continuously milked cows [2]. Interestingly, the mastitis percentage was lower in "younger herds," i.e. herds with a lower average parity. Aged or multiparous animals are more vulnerable to a variety of diseases, including mastitis [46]. Pasture access for cows was negatively associated with the prevalence of clinical mastitis. Lesser grazing has been linked with poor hygiene conditions in cows [25, 37], as well, Schreiner and Ruegg [44] recorded a significant association between udder dirtiness and the probability of intramammary infection. Our findings on the effect of scraping frequency on udder health back up previous findings that increased scraping frequency reduced mastitis pathogen contamination [30]. In the farms where teat preparation included pre-dipping, the prevalence of mastitis was lower when compared to the other farms using humid towels. Besides, teat drying with individual towels would reduce the percentage of mastitis compared to collective towels. Adequate sanitation of milking practices and proper attention to mammary gland hygiene are important measures that should be respected to prevent udder infection.

CONCLUSIONS

This study's findings highlight common factors for health outcomes in particular; parity, litter amount, and cleaning frequency were commonly associated with lameness, hock and knee injuries, thin cows, and mastitis in Algerian dairy farms. Furthermore, grazing reduced lameness, tarsal and carpal joint lesions, whereas increased pasture access had a negative impact on cow body condition. The hygienic conditions, in particular during milking, the floor condition and the livestock areas showed a significant impact on the occurrence of clinical mastitis. Also, the results of the study showed a lower percentage of cows with hock and knee joint injuries on the farms that used thicker straw bedding. Finally, these findings can be used to obtain improvements in dairy cattle health through improving husbandry and management practices and eliminating the potential sources of lameness, integument damage, and intramammary infections.

CONFLICT OF INTEREST

The authors declare there is no conflict of interest.

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