

1 **Table S1.** Data collection and scores for welfare assessment of cows on farm, according to
2 WQ protocol (2009).

Principles and measurements		Scores		Description
FEEDING				
Body condition score (% of lean cows)	BCS	0		regular BCS
		1		very lean
		2		very fat
Water provision (cm per cow)	WP	cm per cow		length of troughs in cm
Cleanliness of water points (qualitative)	CWP	0		clean
		1		partly dirty
		2		dirty
Functioning of water points (qualitative)	FWP	0		drinkers working correctly
		2		drinkers are malfunctioning
HOUSING				
Time needed to lie down (sec)	TNLD	seconds to lie down		time to lie down (seconds)
Collisions (%)	%C	0		no collision
		2		collision
Animals lying partly or completely outside (%)	FALPC	%		number of animals
Dirtiness of lower legs (% of dirty)	DLL	0		no dirt or minor splashing
		2		separate or continuous plaques of dirt
Dirtiness of hindquarters (% of dirty)	DHQ	0		no dirt or minor splashing
		2		separate or continuous plaques of dirt
Dirtiness of udder (% of dirty)	DU	0		no dirt or minor splashing
		2		separate or continuous plaques of dirt
Presence of tethering (% of tie-stall)	PT	0		loose housing system
		2		tie stall system
Outdoor loafing area (qualitative)	OLA	0		yes
		2		no
Access to pasture (qualitative)	AP	0		yes
		2		no
HEALTH				
Percentage of lameness (%)	LAM	0		not lame
		2		severely lame
Animals with integument alteration (%)	INT	0		no
		1		mild
		2		severe
Coughing (no. per cow)	C	number of cows		sudden and noisy expulsion of air
Nasal discharge (%)	ND	0		no evidence of nasal discharge
		2		evidence of nasal discharge
Ocular discharge (%)	OD	0		no evidence of ocular discharge
		2		evidence of ocular discharge
Hampered respiration (%)	HR	0		no evidence of hampered respiration
		2		evidence of hampered respiration
Diarrhoea (%)	D	0		no evidence of diarrhoea
		2		evidence of diarrhoea
Vulvar discharge (%)	VD	0		no evidence of vulvar discharge
		2		evidence of vulvar discharge
Somatic cell count (% above 400000)	SCC	0		somatic cell count below 400.000
		2		somatic cell count of 400.000 or above
Horned cows (%)	HC	%		% horned cows
Procedure for disbudding/dehorning (qualitative)	DEH	0		no dehorning or disbudding
		1		disbudding using thermocautery
		2		disbudding using caustic paste
		3		dehorning of cattle
Anaesthesia/analgesia for DEH		0		use of anaesthetics
		2		no use of anaesthetics
		0		use of analgesics
		2		no use of analgesics
Tail docked cows (%)	TDC	%		% tail docked cows
Procedure for tail docking (qualitative)	TD	0		no tail docking
		1		tail docking using rubber rings
		2		tail docking using surgery
		0		use of anaesthetics
Anaesthesia/analgesia for DEH		2		no use of anaesthetics
		0		use of analgesics
		2		no use of analgesics
		0		no use of analgesics

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1 **Table S2.** Feeding, housing and health assessment, according to WQ protocol (2009), of
2 individual farms included in the study.

Farm	Housing system	Welfare principles					
		FEEDING		HOUSING		HEALTH	
1	Cubicles	54.3	acceptable	78.7	enhanced	35.1	acceptable
2	Cubicles	40.3	acceptable	82.8	excellent	37.4	acceptable
3	Cubicles	54.1	acceptable	82.8	excellent	37.3	acceptable
4	Cubicles	47.2	acceptable	93.3	excellent	40.2	acceptable
5	Cubicles	43.6	acceptable	100	excellent	37.3	acceptable
6	Cubicles	55.1	enhanced	87.5	excellent	32.7	acceptable
7	Cubicles	8.8	not classified	81.7	excellent	32.4	acceptable
8	Cubicles	61.1	enhanced	59.1	enhanced	29.4	acceptable
9	Cubicles	53.5	acceptable	58.2	enhanced	32.2	acceptable
10	Cubicles	31.1	acceptable	78.7	enhanced	31.4	acceptable
11	Cubicles	50.1	acceptable	59.1	enhanced	40.2	acceptable
12	Cubicles	46.4	acceptable	72.1	enhanced	34.7	acceptable
13	Deep litter	23.2	acceptable	70.9	enhanced	33.5	acceptable
14	Deep litter	36.9	acceptable	70.9	enhanced	32.3	acceptable
15	Deep litter	9.7	not classified	81.7	excellent	41.1	acceptable
16	Deep litter	68.6	enhanced	65.4	enhanced	36.0	acceptable
17	Deep litter	62.7	enhanced	87.5	excellent	30.6	acceptable
18	Deep litter	60.8	enhanced	82.8	excellent	42.8	acceptable
19	Deep litter	37.5	acceptable	77.9	enhanced	50.8	acceptable

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Table S3. Pearson correlation matrix between welfare measurements

	very lean cows (%)	length of trough per cow (cm)	clean water points (%)	malfunctioning of water points (%)	time needed to lie down (s)	animals colliding with equipment (%)	animals lying outside resting area (%)	animals with dirty lower legs (%)	animals with dirty hind quarters (%)	animals with dirty udder (%)	animals with severe lameness (%)	animal with no integument alteration (%)	animals with mild integument alteration (%)	animals with severe integument alteration (%)	no. of coughs per animal	animals with nasal discharge (%)	animals with ocular discharge (%)	animals with hampered respiration (%)	animals with diarrhoea (%)	animals with vulvar discharge (%)	animals with SCC above 400,000* horned cows (%)	tail docked cows (%)
very lean cows (%)																						
length of trough per cow (cm)	0.15																					
clean water points (%)	0.23	0.37																				
malfunctioning of water points (%)	0.14	-0.12	-0.44																			
time needed to lie down (s)	0.19	0.31	0.11	-0.05																		
animals colliding with equipment (%)	0.09	0.19	0.23	0.07	0.49*																	
animals lying outside resting area (%)	-0.26	-0.25	0.17	-0.17	-0.08	-0.12																
animals with dirty lower legs (%)	-0.33	-0.19	-0.29	0.43	-0.26	-0.37	0.25															
animals with dirty hind quarters (%)	-0.39	-0.35	-0.50*	0.51*	-0.29	-0.32	0.27	0.91*														
animals with dirty udder (%)	-0.37	-0.26	-0.19	0.08	-0.18	-0.39	0.49*	0.82*	0.84*													
animals with severe lameness (%)	0.22	0.04	0.42	0.08	-0.05	0.28	0.44	-0.03	-0.08	0.06												
animal with no integument alteration (%)	0.26	-0.13	-0.36	0.20	0.14	0.06	-0.78*	-0.24	-0.20	-0.42	-0.25											
animals with mild integument alteration (%)	-0.28	0.26	0.42	-0.31	-0.16	-0.12	0.65*	0.23	0.15	0.40	0.17	-0.97*										
animals with severe integument alteration (%)	-0.17	-0.16	0.17	0.05	-0.08	0.06	0.88*	0.22	0.26	0.39	0.36	-0.88*	0.74									
no. of coughs per animal	-0.24	0.06	0.14	-0.14	0.39	0.49*	-0.13	-0.25	-0.21	-0.21	-0.20	0.17	-0.19	-0.10								
animals with nasal discharge (%)	0.30	-0.34	0.15	0.26	-0.38	0.06	0.28	0.20	0.17	0.06	0.24	-0.25	0.14	0.43	-0.14							
animals with ocular discharge (%)	0.50*	-0.38	0.04	0.19	0.45	0.02	0.22	-0.03	0.03	0.14	0.28	0.08	-0.22	0.22	-0.05	0.11						
animals with hampered respiration (%)	0.40	-0.14	0.13	-0.13	0.45	-0.19	0.28	-0.12	-0.12	0.11	-0.10	-0.12	0.03	0.27	0.01	0.07	0.68*					
animals with diarrhoea (%)	-0.03	-0.44	0.07	-0.07	-0.35	-0.17	-0.17	0.35	0.38	0.39	-0.11	0.15	-0.13	-0.16	0.01	0.44	-0.01	0.01				
animals with vulvar discharge (%)	0.05	0.16	0.20	-0.20	0.03	0.28	0.57*	-0.05	-0.08	0.08	0.56*	-0.57*	0.54*	0.53*	-0.24	0.09	-0.04	0.03	-0.32			
animals with SCC >400,000*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
horned cows (%)	-0.30	0.20	-0.33	0.62*	-0.02	-0.21	-0.22	0.43	0.49*	0.22	-0.21	0.09	-0.04	-0.17	-0.18	-0.30	-0.22	-0.27	-0.06	-0.28	-	-
tail docked cows (%)	-0.26	0.36	0.16	-0.16	0.11	0.16	0.12	0.11	0.03	0.10	0.18	-0.42	0.46*	0.26	-0.11	-0.32	-0.16	-0.08	-0.25	0.43		0.08

*Significant correlations ($p < 0.05$)