Establishing coefficients for the weight of kidney knob and channel fat (KKCF) and diaphragm skirt in lamb carcases

Background

Following consultation with the industry in 2018, Defra are considering drafting legislation for mandatory sheep carcase classification and price reporting. The consensus of the consultation, including a meeting of industry representatives on 24th October 2018, was the agreement on a standard dressing specification, with one allowable derogation being the removal of kidney knob and channel fat (KKCF). Removal of KKCF by a plant will require each carcase to have an adjustment applied to correct the weight back to the standard carcase weight (dressing specification) through the use of a coefficient for official price reporting. AHDB was asked to carry out a trial to provide independent evidence to inform a decision on the appropriate approach to applying a coefficient. During the planning for the trial a question was raised over whether retaining or removal of the Diaphragm skirt (DS) would also be optional in the new dressing specification so, to inform the discussion, weights were also collected for this.

Objectives

1. To determine the weight of KKCF and diaphragm skirt across a range of lamb (new and old season), representative of the national population.
2. To evaluate the relationship between the weight of KKCF and diaphragm skirt and carcase characteristics.
3. To recommend appropriate approaches to applying weight adjustments (coefficients) for KKCF and DS when they are removed from the carcase before weighing.

Summary of results, recommendations and options for future weight coefficients

The change in weight of the KKCF and diaphragm skirt with carcase weight, fat class and conformation were examined. Given that:

(a) the two parts respond differently to these carcase parameters; and

(b) the decision has not been made on whether diaphragm removal will be included in any derogation from the future dressing specification,

It was decided to focus on the prediction of the weight of the two parts separately for the final analysis.

Kidney Knob and Channel fat (KKCF)

The simplest approach to estimating KKCF would be to apply a fixed weight deduction across all carcases, but this clearly results in a high level of under prediction in individual carcases (particularly the fatter ones), although the lowest levels of overprediction. Applying a fixed percentage of cold carcase weight does not improve this markedly, nor does a regression on carcase weight alone, reflecting the importance of carcase fatness (unsurprisingly) in determining KKCF weight.

Examining the relationship between classification scores and KKCF weight, because of the inconsistent relationship with conformation class, it is recommended that consideration is given to defining KKCF coefficients based on cold carcase weight and fat class only. The narrowest range of errors in predicted weights (between over and under prediction) was observed when using a percentage of carcase weight adjustment for each fat class using the current 7-point scale (see table 1, row highlighted in green). This also gives the highest correlation and a relatively low result for over predicting the weight of KKCF at a maximum of 444g, although use of regression reduces this further. Condensing the fat scale to a 5-point scale reduced the performance slightly, with the underprediction very similar but a higher maximum over-prediction and slightly lower correlation (see table 1, row highlighted in orange).

Adding carcase weight to regression approaches gave little added benefit over use of fat score alone.

Given the importance of fat class in determining KKCF weight, an alternative, simpler, approach would be to use a fixed weight adjustment based on fat class (using the average figures for each fat class, as per table 6a) but this was not as good a predictor as other methods.

Table 1: Summary of the options for setting a coefficient for kidney knob and channel fat (KKCF)

Approach	Prediction model	Average over/(under) prediction of weight (g)	Maximum over prediction (g)	Maximum under prediction (g)	R^2
Fixed weight	417g	0.1	388	1339	x
Fixed % of cold carcase weight	2.0545% of CW	(0.02)	421	1251	0.29
Fixed weight by fat class	Table 6a values*	47	516	991	0.41
Fixed % by fat class (7-point scale)	Table 6b percentages**	0.6	444	915	0.55
Fixed % by fat class (5-point scale)	Table 6c percentages**	(0.23)	438	1052	0.51
Regression on cold carcase weight	$0.8269\ CW^2 – 0.1724\ CW + 71.168$	0.01	794	1189	0.29
Regression on fat score	$7.6474F^2 - 49.59F + 320.71$	(0.01)	423	997	0.47
Regression on carcase weight and fat score	$0.758\ CW^2 - 12.672\ CW + 6.873\ F^2 – 50.876\ F + 315$	(0.07)	546	970	0.53

Notes: Table 6 values* = using the average value for each fat classification score. Table 6b percentages** = using the percentages from table 6b or 6c applied to each carcase weight according to its fat class.

CW = cold carcase weight, F = fat score on 15-point fat scale.

Diaphragm Skirt

The summary of results in table 2 shows that cold carcase weight is a good predictor of diaphragm skirt weight. The conformation score (based on the 15-point scale) gives a lower over prediction at 115g. Overall, a prediction based on carcase weight is not improved greatly by adding conformation or fat class into the equation, and either a standard percentage of carcase weight, or regression on carcase weight alone would be easy to apply and to understand.

Table 2: Summary of options for setting a coefficient for diaphragm skirt

Approach	Prediction model	Average over/(under) prediction of weight (g)	Maximum over prediction (g)	Maximum under prediction (g)	R^2
Fixed weight	129	(0.4)	120	208	x
Fixed % of cold carcase weight	0.6378% of CW	(0.04)	136	164	0.22
Regression on cold carcase weight	$0.2168\ CW^2 - 0.756\ CW + 53.213$	0.02	188	152	0.23
Regression on fat score	$1.2014\ F^2 - 13.361\ F + 156.16$	0.0	127	207	0.04
Regression on conformation	$0.1423\ C^2 + 2.4026\ C + 95.944$	0.0	115	202	0.07
Regression on carcase weight, fat score and conformation	$1.427\ CW + 0166\ CW^2 - 15.905\ F + 0.942\ F^2 + 0.242\ C + 0.078\ C^2 + 83$	0.0	180	151	0.26

Note: CW = cold carcase weight, F = fat score on 15-point fat scale, C = conformation score on 15-point conformation scale

Methods

Lamb abattoirs for data collection were identified based on throughput as well as the range of weights and classifications which are processed. Location was also taken into consideration to enable collection of data from carcases representative of the national population.

In total, 3 abattoirs were visited on 2 separate occasions during 2019; February/March to sample old season lambs and June/July to sample new season lambs. During each visit, a minimum of 250 lambs were targeted as seen in the classification grids below. In addition, a representative weight distribution was targeted. As well as recording data for lambs, where there was the opportunity, information was also collected from a selection of ewes, but there was an insufficient sample size to undertake a meaningful analysis of these.

To mirror the likely future dressing standard, carcases were presented as close as practically possible to the standard: without the head (severed at the atlantooccipital joint), the feet (severed at the carpometacarpal or tarso-metatarsal joints), the tail (severed between the sixth and seventh caudal vertebrae), the udder/cod fat, genitalia, liver and the pluck. The kidneys and kidney fat are usually included in the carcases for standard presentation and it was ensured that these were left intact for weighing for the purposes of the study.

The degree to which the skirt was left intact varied considerably and skirt weights presented here cannot be said to be the true anatomical weight, but reflect the weight of skirt as left in the carcase on high speed production lines.

Target numbers per plant for old seasons Lambs (January - February sampling)

	1	2	3L	3H	4L	4H/5	Total
E							10
U		5	20	15			50
R		20	70	35	7		130
O		10	20	5			45
P							5
Total	5	45	115	60	15	9	

Target numbers per plant for new season lambs (June-July sampling)

	1	**2**	**3L**	**3H**	**4L**	**4H/5**	**Total**
E							15
U		5	30	20			60
R		20	70	30	5		130
O		5	15	5			30
P							5
Total	5	40	130	60	10	5	

Total lamb target numbers per plant

	1	**2**	**3L**	**3H**	**4L**	**4H/5**	**Total**
E							25
U		10	50	35			110
R		40	140	65	12		260
O		15	35	10			75
P							10
Total	10	85	245	120	25	14	

Note: where totals are given for fat class, or conformation, and not individual cells, they could come from any cell in the grid in that column or line.

Target weight band numbers

Weight band (kg)	Total number
<14	5
14-15.9	15
16-17.9	40
18-19.9	70
20-21.9	60
22-23.9	25
24-25.9	5
26+	5

Independent classifiers identified suitable carcases following online classification and put them to one side for sampling. The carcase number, classification and cold carcase weight were recorded and a plant operative was assigned to remove the KKCF and diaphragm skirt. Both KKCF and diaphragm skirt were weighed and recorded separately from each other by AHDB staff, on scales sensitive to the nearest 1-2g.

For regression analysis, fat and conformation classes were converted to the 15-point scale. This is particularly important for fat class as the sub-classes prevent the scale from being linear and conversion gives an approximated linear scale. In both cases this will allow the equation to take account of the greater definition provided by the 15-point scale, where it is used.

Fat class	15pt Fat
1	2
2	5
3L	7.5
3H	8.5
4L	10.5
4H	11.5
5	14

Conformation class	15pt conformation
E	14
U	11
R	8
O	3
P	2

Results and discussion

The minimum target of 250 carcases per visit was achieved, with a total of 1545 carcases recorded. To account for discrepancies between operatives and plant processes, carcases with only one kidney or without the full diaphragm skirt intact were removed, resulting in 1400 carcases with suitable data for analysis.

The distribution of classifications can be seen in table 3. As anticipated, a large proportion of the carcases came from the conformation classes U and R and fat classes 3L and 3H but it was also possible to capture information from a wider range, with more carcases falling into the more extreme classifications in the sample than anticipated. The average weight of carcases within each classification, shown in table 4, suggests that carcases are heavier in higher fat classes rather than the lower classes and also heavier in the more muscular conformation classes rather than the poorer conformed carcases.

Overall averages for carcase weight and weights of the parts of interest are given in table 5.

Table 3: Total number of carcases recorded (new and old season) within each classification score

	1	2	3L	3H	4L	4H	5	Total
E		21	50	37	25	5		138
U	14	41	115	158	53	15	2	398
R	34	126	225	207	69	26	3	690
O	26	67	51	19		3	1	167
P	5	2						7
Total	**79**	**257**	**441**	**421**	**147**	**49**	**6**	**1400**

Table 4: Average carcase weight (kg) within each classification score

	1	2	3L	3H	4L	4H	5
E		22	23	23	24	24	
U	19	20	21	22	23	24	24
R	18	18	20	21	22	23	25
O	17	16	18	19		24	25
P	12	14					

Table 5: Summary of carcase attributes

	Weight	% carcase weight
Carcase (cold weight)	20.3kg	
KKCF	417g	2.0546
Diaphragm skirt	129g	0. 6378

To visualise the results, average KKCF and diaphragm skirt were calculated separately across the classification grid, as seen in tables 6 and 7. Typically, the average of both the KKCF and diaphragm skirt weights increased as the fat class increased (1 to 5). When looking at conformation, however, KKCF is a little more variable with higher average weights seen at O than U for 5 of the 6 fat classes, and KKCF weight does not increase consistently with conformation class. Tables 6b and 6c present the average weight of KKCF as a percentage of the carcase weight for the 7- and 5-point fat scales.

Contrasting to the KKCF, diaphragm skirt weights follow a clearer trend with increasing conformation (P to E) corresponding to an increasing weight (except within fat class 4H where sample numbers are small).

Table 6a: Average weight of kidney knob and channel fat (KKCF) (g) within each classification score

	1	2	3L	3H	4L	4H	5	Overall
E		293	411	443	615	712		449
U	233	280	359	432	582	745	1272	424
R	261	271	380	479	609	845	1173	428
O	228	263	378	477		983	1572	350
P	152	243						178
Overall	238	272	378	458	600	810	1272	418

Table 6b: Average of kidney knob and channel fat (KKCF) percentage of carcase weight by fat class (7-point scale)

	1	2	3L	3H	4L	4H	5
Overall	1.38	1.51	1.89	2.16	2.67	3.42	5.18

Table 6c: Average of kidney knob and channel fat (KKCF) percentage of carcase weight by fat class (5-point scale)

	1	2	3	4	5
Overall	1.38	1.51	2.02	2.86	5.18

Table 7: Average weight of diaphragm skirt (g) within each classification score

	1	2	3L	3H	4L	4H	5	Overall
E		128	155	157	164	169		154
U	137	158	125	141	156	211	270	143
R	133	129	117	114	132	155	251	122
O	114	111	103	99		107	118	108
P	68	72						69
Overall	124	128	122	127	146	171	235	129

The effect of cold carcase weight was also examined separately. Based on the results in tables 6 and 7, it is not surprising to see that the average weight of both KKCF and diaphragm skirt also increase as weight bands increase (figure 1 and 2). At the lower weights (<14 – 18-19.9 kg) there are smaller differences in average KKCF and diaphragm skirt, but the differences become more noticeable as the weight bands get heavier, suggesting a quadratic relationship (shown in figures 3 and 4). The lowest carcase weight in this trial was 7.7kg and the highest was 36.9kg.

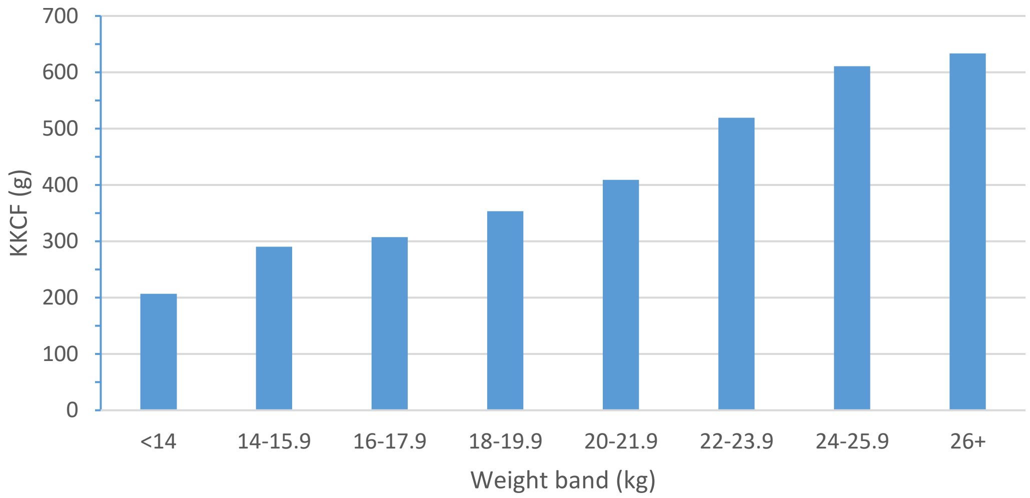

Figure 1: Average weight of KKCF (g) for difference carcase weight bands

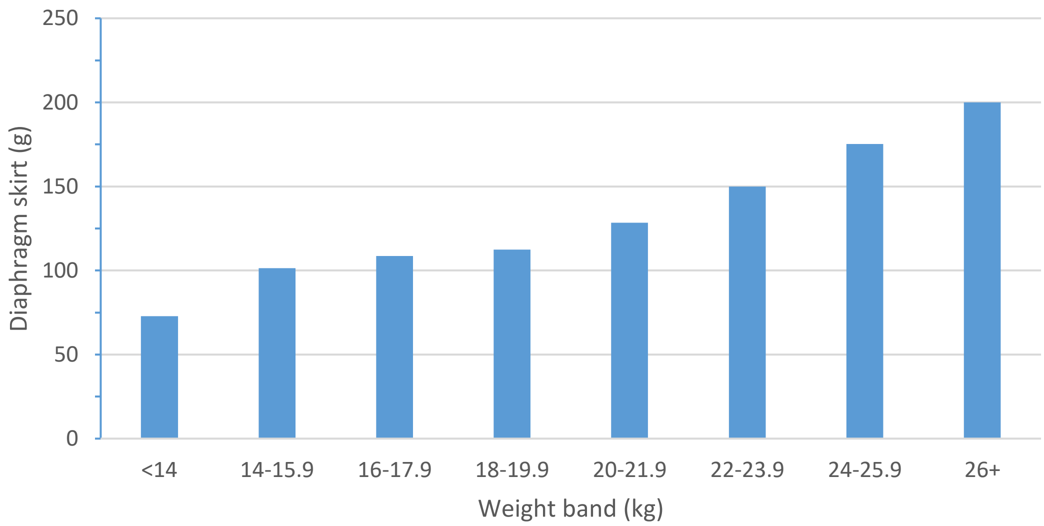

Figure 2: Average weight of diaphragm skirt (g) for different carcases weight bands

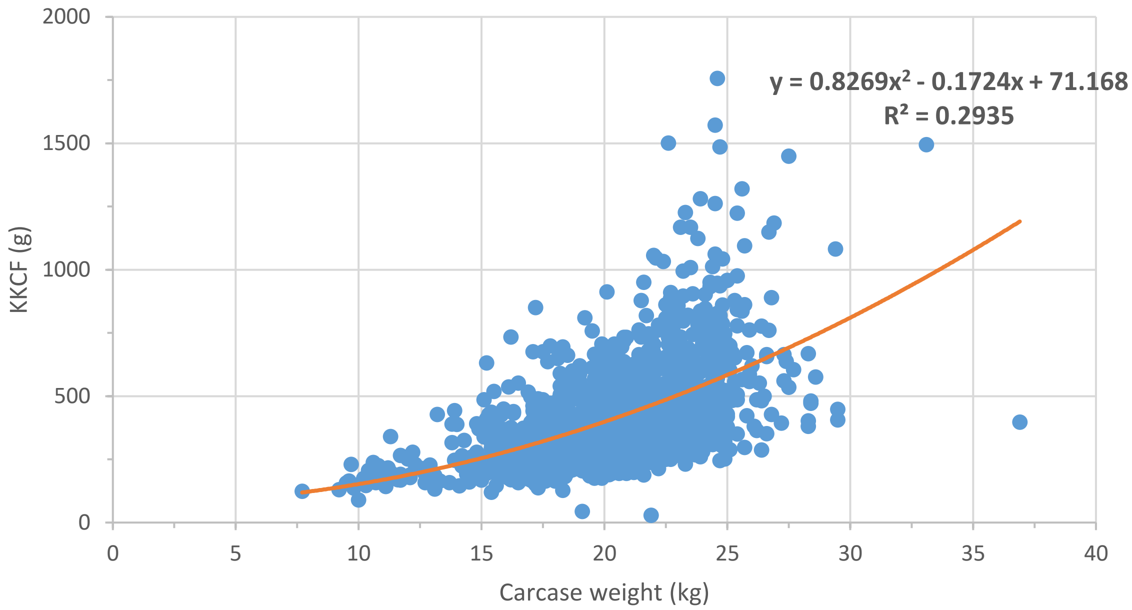

Figure 3: Quadratic regression for KKCF (g) against carcase weight (kg)

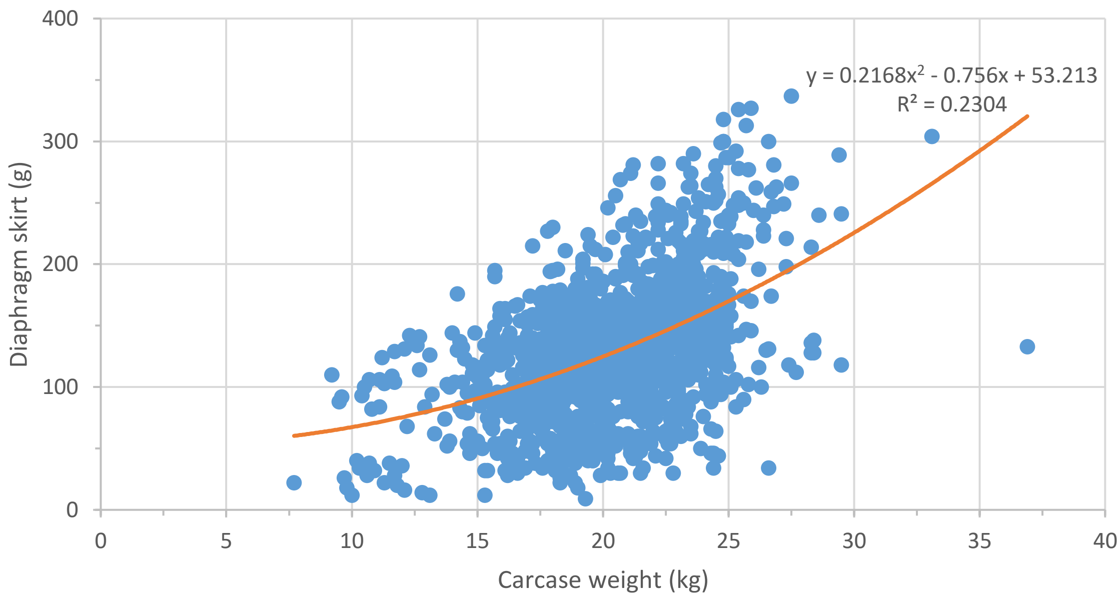

Figure 4: Quadratic regression for diaphragm skirt (g) against carcase weight (kg)

Carcase weight and fat class are important for KKCF in particular. Table 8 illustrates the relative importance of both.

Table 8. Average KKCF weight by carcase weight band and fat class

	1	2	3L	3H	4L	4H	5	Overall
<14	165	195	276					206
14-15.9	217	258	325	453				290
16-17.9	235	261	321	382	632			308
18-19.9	256	272	350	392	509	654		353
20-21.9	275	293	380	434	533	684		409
22-23.9	289	324	442	514	634	729	1501	519
24-25.9	245	377	495	563	624	924	1227	611
26+		326	445	638	712	1177		634
Overall	**238**	**272**	**378**	**458**	**600**	**810**	**1272**	**417**

To suggest the most appropriate method for KKCF and diaphragm skirt weight adjustments, the errors associated with different approaches were examined with results summarised in tables 1 and 2. Initially, fixed (average) weights were set, for both KKCF and diaphragm skirt (at 417g and 129g respectively) and the percentage of carcase weight was determined at 2.0546% for KKCF and 0. 6378% for diaphragm skirt. Statistical analysis using Analysis of Variance, and taking KKCF plus diaphragm skirt as the dependent variable, showed that carcase weight, fat class and conformation class are all significant predictors of the combined weight.

Further analysis took place to look at the relationship between the measured factors and KKCF/diaphragm skirt. These were examined individually – carcase weight and fat score, as well as conformation score for diaphragm skirt. As seen in tables 1 and 2, fat score had a more marked impact on KKCF weight (r^2 = 0.47 by regression) than carcase weight, whereas carcase weight had a more noticeable effect on diaphragm skirt (r^2 = 0.23) than fat score. When carrying out regression to look at these variables in combination, carcase weight and fat score together have the most impact on KKCF weight (r^2 = 0.53) and carcase weight, fat score and conformation score have influence the diaphragm skirt weight the most (r^2 = 0.26).

For each method of estimated the weight, the predicted value was compared with the actual value to give the r^2 values given.

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