1 **A meta-analysis approach to evaluate the effects of early group housing on calf performance,**
2 **health and behavior during the preweaning period**
3
4 **Supplemental Document**
5
6**Supplemental Table S1.** Percentage (%) of studies for each characteristic included in the systematic review
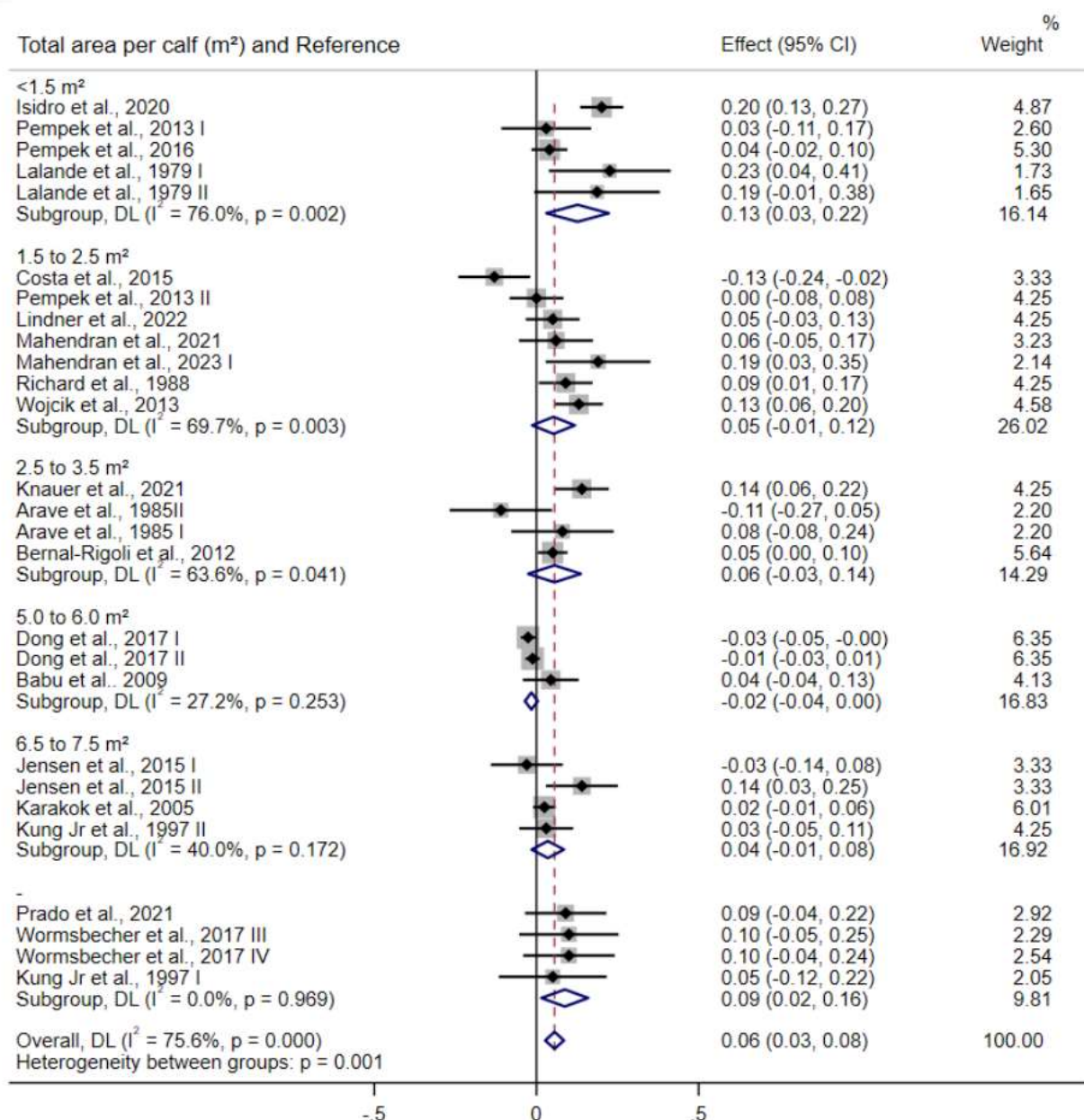7(n=81) for the main covariates.

Description		Number of studies	Studies (%)
Journal	Journal of Dairy Science	34	42.0
	Applied Animal Behaviour Science	16	19.8
	PLoS ONE	8	9.9
	Others	23	28.4
Country	United States	22	27.2
	Canada	21	25.9
	United Kingdom	10	12.3
	Denmark	9	11.1
	China	6	7.4
	Others	13	16.0
Genetic Group	Holstein	54	69.2
	Holstein-Friesian	8	10.3
	Ayrshire	4	5.1
	Friesian	2	2.6
	Jersey	1	1.3
	Crossbred	3	3.8
	Mixed (more than 1 group in the study)	6	7.7
Milk allowance	Low (< 6L per day)	18	29.0
	Medium (6 to 9L per day)	40	64.5
	High (> 9L per day)	4	6.5
Weaning age	Less than 8 weeks (< 53 d old)	22	30.6
	8 weeks (between 53 and 63 d old)	39	54.2
	More than 8 weeks (> 63 d old)	11	15.3
Sex	Female	38	48.1
	Male	19	24.1
	Female and Male	22	27.8
Rearing type	Indoor	65	81.3
	Outdoor	15	18.8
Pen area per calf	< 1.5 m²	8	10.3
	1.5 to 2.5 m²	40	51.3
	2.5 to 3.5 m²	9	11.5
	3.5 to 5.0 m²	10	12.8
	5.0 to 6.5 m²	2	2.6
	6.5 to 7.5 m²	1	1.3
	> 7.5 m²	8	10.3
Group type / size	Pairs	47	58.0
	Group of 3 to 6 calves	22	27.2
	Group of 7 to 15 calves	4	4.9
	Complex group with adults	8	9.9

8Not applicable results for studies were excluded for each characteristic.

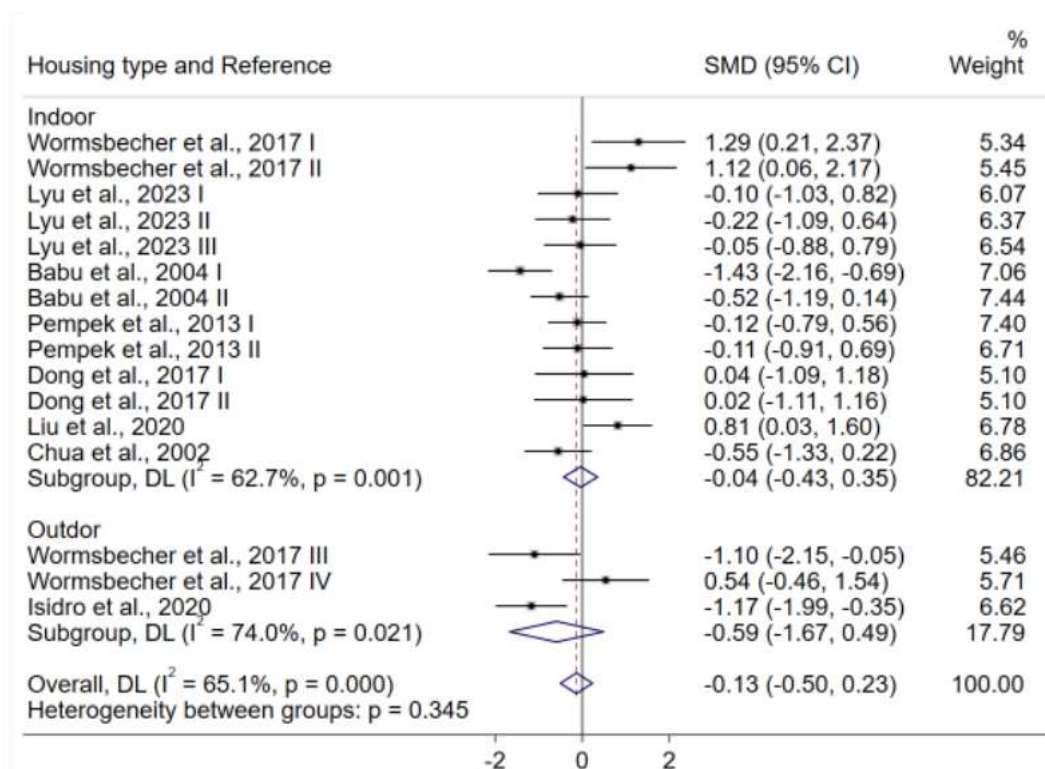9**Supplemental Table S2.** Definitions of posture and behaviors of calves.

Posture	Definition
Standing	The calf is standing with all 4 legs on the ground.
Lying	The calf is resting on the ground; head may be supported or unsupported by the neck.

Behaviors	Definition
Consuming milk	The calf is ingesting milk either by sucking on the teat or by drinking from a bucket; may include sucking on the teat without the ingestion of milk
Feeding	The calf is consuming grain/concentrate from a bucket
Interacting with pen	The calf has its tongue out of its mouth and it is in contact with fixtures or the calf is biting any fixtures of the pen; may include bucket if milk is not available at the time of observation
Playing	The calf is engaged in a gallop, leap, buck-low, buck-high, buck-kick, or turn
Self-grooming	The tongue of the calf is out of its mouth and in contact with its own body

10Behaviors defined based on Pempek *et al.* (2013).

Supplemental Figure S1. Forest plot with subgroup analysis of the effects of pen area per calf (<1.5; 1.5 to 2.5m²; 2.5 to 3.5m²; 5.0 to 6.0m²; 6.5 to 7.5m²) on average daily gain [Effect = weighted mean difference (WMD)]. The x-axis shows the effect of WMD. Diamonds to the left of the solid line represent a reduction in the measure, whereas diamonds to the right of the line indicate an increase. Each diamond represents the mean size effect for that study, and the diamond's size reflects the study's relative weighting to the overall size effect estimate with larger diamonds representing greater weight. The lines connected to the diamond represent the upper and lower 95% confidence interval for the group housing effect. The dotted vertical line represents the overall size effect estimate. The diamond at the bottom represents the mean response across the studies, and the solid vertical line represents a mean difference of zero or no effect. Note: Weights and between-subgroup heterogeneity tests are from random-effects model.

Housing type and Reference	SMD (95% CI)	% Weight
Indoor		
Wormsbecher et al., 2017 I	1.29 (0.21, 2.37)	5.34
Wormsbecher et al., 2017 II	1.12 (0.06, 2.17)	5.45
Lyu et al., 2023 I	-0.10 (-1.03, 0.82)	6.07
Lyu et al., 2023 II	-0.22 (-1.09, 0.64)	6.37
Lyu et al., 2023 III	-0.05 (-0.88, 0.79)	6.54
Babu et al., 2004 I	-1.43 (-2.16, -0.69)	7.06
Babu et al., 2004 II	-0.52 (-1.19, 0.14)	7.44
Pempek et al., 2013 I	-0.12 (-0.79, 0.56)	7.40
Pempek et al., 2013 II	-0.11 (-0.91, 0.69)	6.71
Dong et al., 2017 I	0.04 (-1.09, 1.18)	5.10
Dong et al., 2017 II	0.02 (-1.11, 1.16)	5.10
Liu et al., 2020	0.81 (0.03, 1.60)	6.78
Chua et al., 2002	-0.55 (-1.33, 0.22)	6.86
Subgroup, DL (I^2 = 62.7%, p = 0.001)	-0.04 (-0.43, 0.35)	82.21
Outdor		
Wormsbecher et al., 2017 III	-1.10 (-2.15, -0.05)	5.46
Wormsbecher et al., 2017 IV	0.54 (-0.46, 1.54)	5.71
Isidro et al., 2020	-1.17 (-1.99, -0.35)	6.62
Subgroup, DL (I^2 = 74.0%, p = 0.021)	-0.59 (-1.67, 0.49)	17.79
Overall, DL (I^2 = 65.1%, p = 0.000)	-0.13 (-0.50, 0.23)	100.00
Heterogeneity between groups: p = 0.345		

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25 **Supplemental Figure S2.** Forest plot with subgroup analysis of the effects of housing type 26 (indoor and outdoor) on lying behavior (Effect = standard mean difference (SMD)). The x-axis 27 shows the effect of SMD. Diamonds to the left of the solid line represent a reduction in the 28 measure, whereas diamonds to the right of the line indicate an increase. Each diamond represents 29 the mean size effect for that study, and the diamond's size reflects the study's relative weighting to 30 the overall size effect estimate with larger diamonds representing greater weight. The lines 31 connected to the diamond represent the upper and lower 95% confidence interval for the group 32 housing effect. The dotted vertical line represents the overall size effect estimate. The diamond at 33 the bottom represents the mean response across the studies, and the solid vertical line represents a 34 mean difference of zero or no effect. Note: Weights and between-subgroup heterogeneity tests are 35 from random-effects model.
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