

Supplementary Materials

Effect of three husbandry systems on environmental impact of organic pigs in Europe

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Equation 1: P-losses into water bodies.

$$P_{Losses} \text{ [kg/ha/y]} = \text{Livestock density [kg BM/ha]} * 1,0909 * 10^{-4}$$

with

P_{Losses} = hypothetical P-Losses (kg/ha/y)

BM = body mass (live weight; kg)

Table S1: Characteristics of farms (median, minimum, maximum at time of farm visit) per system (IN, POUT, OUT; n=number of farms). Data collected at farm level served as basis for calculation of environmental impacts at production chain level. Production chains either consisted of farrow-to-finish farms or were combined of individual farms covering only parts of the production chain.

	IN (n=34)	POUT (n=28)	OUT (n=12)
Farm size (ha)	42 (3 – 360)	77 (7 – 500)	59 (11 – 680)
Sows (SO) / farm	39 (26-73)	141 (52-216)	53 (37-248)
Weaners (WE) / farm	82 (47-140)	250 (80-400)	49 (17-350)
Fatteners (FA) / farm	141 (82-300)	338 (74-720)	154 (51-1166)
Slaughtered fatteners [n/1yr]	367 (4 – 1827)	1700 (0 – 16000)	260 (15 – 11016)
Age at weaning [days]	42 (39 – 90)	49 (39 – 90)	50 (42 – 70)
Conventional breed (C)	23	23	0
Traditional breeds (T)	0	1	6
Mixed breeds (C and T or crosses)	11	4	6
Countries	Germany (13), Austria (12), Switzerland (7), Italy (2)	Denmark (11), France (4), Germany (3), Austria (3), Italy (3), Switzerland (2), Czech Republic (1), United Kingdom (1)	United Kingdom (7), Italy (4), Austria (1)

Table S2: Emission factors for NH₃, N₂O, N₂ and NO₃ in outdoor paddocks.

	NH ₃ -N (kg/kg N)	N ₂ O-N (kg/kg N)	N ₂ -N (kg/kg N)	NO ₃ -N (kg/kg N)
Emission factor [kg/kg tot N excreted]	0.113	0.001	0.003	0.263

Table S3: Emission factors for housing and manure management systems depending on floor type and manure type, litter quality, storage period, spreading according to *Rigolot et al.* [29].

	NH ₃ -N (kg/kg N)	N ₂ O-N (kg/kg N)	N ₂ -N (kg/kg N)
Floor type and manure management			
Slatted floor: slurry (removal after each batch)	0.242	0.002	0.006
Solid flooring: solid manure	0.142	0.002	0.006
Deep litter depending on litter quality:			
- very good	0.080	0.012	0.589
- good	0.100	0.024	0.496
- poor	0.220	0.038	0.305
- very poor	0.440	0.008	0.116
Criteria manure storage* variation factor			
Solid manure (manure pile)	0.07	0.01	0.03
Slurry storage:			
- covered	0.05	0.001	-
- uncovered- storage period <180 days	0.05	0.001	-
- uncovered- storage period > 180 days	0.10	0.001	-
- uncovered- storage period 180-365 days	0.15	0.001	-
Manure spreading			
Solid manure and compost [kg/kg applied manure]	0.05	0.0010	0.05
Slurry spreading – broadcast spreading [kg/kg applied slurry]	0.20	0.0024	0.05
Slurry spreading – injection [kg/kg applied slurry]	0.08	0.00126	0.05

Table S4: Characteristics of the animal production stages by system.

	System	n ¹	Min.	Q25%	Mean	Median	Q75%	Max.
Sows								
piglets born per litter (life born + still born)	IN	21	11.2	12.0	13.1	13.3	14.0	14.8
	POUT	28	6.0	12.0	12.7	13.5	14.0	16.5
[n, 1yr mean] ²	OUT	10	6.0	7.0	9.2	8.80	12.0	12.5
piglets weaned per sow per year [n, 1yr mean] ²	IN	23	13.0	16.6	18.8	19.4	21.0	23.8
	POUT	30	5.0	16.2	18.4	19.4	20.9	25.0
	OUT	10	7.5	10.0	14.3	13.5	18.6	22.8
sow replacement rate [%, 1yr mean] ²	IN	23	12.0	20.0	28.4	30.0	32.0	53.0
	POUT	30	0.0	25.0	34.6	30.5	43.0	87.0
	OUT	10	3.0	10.0	19.0	17.0	35.0	35.0
age at culling [n farrowings] ¹	IN	20	4.0	5.0	5.6	6.0	6.5	7.0
	POUT	28	2.0	4.0	5.4	5.0	8.0	10.0
	OUT	7	2.0	2.0	5.6	7.0	8.0	8.0
live weight at culling [kg at culling] ²	IN	23	197	227	238	233	253	275
	POUT	30	187	200	245	240	277	325
	OUT	10	173	193	220	204	250	300
Weaners								
weight at weaning [kg, 1yr mean] ²	IN	23	6.0	10.0	10.5	10.0	11.5	15.0
	POUT	30	5.5	10.0	12.9	13.5	13.5	28.0
	OUT	10	5.5	10.0	14.0	15.0	18.0	20.0
weight at end of post-weaning period [kg, 1yr mean] ²	IN	23	24.0	25.0	28.7	28.0	30.0	42.0
	POUT	30	23.0	30.0	30.4	30.0	32.5	40.0
	OUT	10	25.0	30.0	32.0	32.5	35.0	35.0
mortality rate weaners [%, 1yr mean] ²	IN	23	0.0	1.0	4.9	3.0	5.0	20.0
	POUT	30	0.0	3.0	4.5	5.0	5.0	20.0
	OUT	10	0.0	0.0	2.7	2.0	4.0	10.0
Fattening pigs								
live weight at slaughter [kg, 1yr mean] ²	IN	23	110	122	130	131	140	147
	POUT	10	86	113	125	117	127	187
	OUT	29	87	105	137	124	187	200
Mortality rate fattening pigs [%, 1yr mean] ²	IN	23	0.0	1.0	1.3	1.0	2.0	4.0
	POUT	10	0.0	2.0	2.4	2.0	4.0	6.0
	OUT	29	0.0	0.0	1.8	0.5	5.0	5.0

¹ Number of observations differs from number of production chains/systems, as not each parameter was available for all farms; ² Numbers of observations differ from number of production chains/systems due to 3 farms calculated with means for the environmental impact of the missing animal production stage at farm level (2 production chains calculated with average environmental impact for piglet production; 1 production chain calculated with average environmental impact of the fattening stage).

Table S5: Characteristics of dietary nutrient content and feed consumption by system. The values reflect an average dietary content over all diets fed to the animal group. FCR=Feed conversion rate, n=Number of production chains.

Parameter	System	n	Min.	Q25%	Median	Q75%	Max.
Pregnant and lactating sows							
Feed per sow [kg/year]	IN	23	923	1059	1277	1419	1733
	POUT	30	675	1440	1680	1946	2236
	OUT	10	827	1379	1468	1604	1825
ME MJ/kg	IN	23	11.8	12.3	12.5	13.0	13.1
	POUT	30	10.6	12.5	12.7	12.9	13.7
	OUT	10	9.6	9.6	12.9	13.3	14.7
CP [g/kg]	IN	23	124	148	153	162	185
	POUT	30	124	142	151	160	171
	OUT	10	112	123	154	164	165
total P [g/kg]	IN	23	4.0	5.1	5.5	6.0	6.6
	POUT	30	3.3	4.5	5.5	5.9	7.8
	OUT	10	0.8	3.0	3.3	4.6	6.1
Weaners							
Feed per weaner produced [kg/weaner]	IN	23	18	28	39	45	60
	POUT	30	12	33	39	45	99
	OUT	10	21	34	50	70	111
ME MJ/kg	IN	23	12.0	12.6	12.8	13.2	13.5
	POUT	30	12.0	12.8	13.1	13.3	13.5
	OUT	10	9.5	9.5	12.8	13.4	14.7
CP [g/kg]	IN	23	138	171	180	184	207
	POUT	30	130	173	185	190	208
	OUT	10	112	144	158	198	198
total P [g/kg]	IN	23	3.7	5.0	5.8	6.0	6.9
	POUT	30	3.4	4.7	5.8	6.2	8.9
	OUT	10	0.8	3.5	3.5	5.4	6.4
Fattening pig							
Feed per fattening pig produced [kg/fattener]	IN	23	220	259	331	387	494
	POUT	29	158	251	300	364	1132
	OUT	10	209	217	393	871	986
Fattening pig FCR [kg/kg pig]	IN	23	2.4	2.9	3.3	3.8	4.4
	POUT	29	2.7	3.0	3.2	3.7	7.0
	OUT	10	2.8	2.9	4.9	6.5	7.5
ME MJ/kg	IN	23	12.0	12.5	12.7	13.0	14.8
	POUT	29	12.0	12.8	12.9	13.0	13.4
	OUT	10	9.5	9.5	13.0	13.5	14.7
CP [g/kg]	IN	23	118	154	159	170	190
	POUT	29	130	144	168	177	202
	OUT	10	112	114	151	170	186
total P [g/kg]	IN	23	3.3	4.40	5.0	5.5	6.4
	POUT	29	3.4	3.7	4.9	5.5	6.4
	OUT	10	0.8	2.4	3.2	3.7	6.4

Table 1: Percentages of floor type for lactating and pregnant sows, weaners and fattening pigs kept in the systems indoor (IN) and partly outdoor (POUT).

Animal category	System	n ²	Floor type ¹						Out-door (all-year)	Partly out-doors
			CB	DL	CB, DL	DL, PS	CB, PS	CB, DL, PS		
Lactating sows	IN	22	59%	---	5%	---	32%	5%	---	---
	POUT	29	7%	---	---	---	7%	---	83%	4%
Pregnant sows	IN	22	55%	---	14%	---	32%	---	---	---
	POUT	29	14%	---	---	---	4%	---	45%	38%
Weaner	IN	22	50%	---	5%	---	41%	5%	---	---
	POUT	29	---	4%	21%	---	14%	10%	28%	24%
Fattener	IN	22	55%	---	5%	---	32%	9%	---	---
	POUT	29	24%	14%	---	---	10%	28%	14%	10%

¹ CB=Concrete with bedding; DL=Deep litter; PS=Partly slatted floor; ² Excluding three PCs with missing data.

Table S7: Type and frequency of manure treatment by system.

Manure type	System	n	Frequency of different slurry treatments			
			None	Composting	Aerobic	Anaerobic
Slurry	IN	24	20	---	4	---
	POUT	30	21	2	5	2
			Frequency of composting of solid manure			
			None	Composting		
Solid	IN	24	19	5		
	POUT	30	26	4		

Table S8: Cluster characteristics regarding number of sows on PC at farm visit, average number of slaughtered fattening pigs/year and number of livestock units (LSU).

Parameter	Cluster impact category [cluster number]	n ¹	Min.	Q25%	Mean	Median	Q75%	Max.
n sows	low [2]	19	12	50	158	80	180	650
[present at visit]	intermediate [1/4]	21	8	35	203	110	222	1300
	high [3]	14	15	20	77	28	160	249
LSU [n present at visit]	low [2]	19	14	44	167	118	138	795
	intermediate [1/4]	21	11	43	187	121	192	1158
	high [3]	14	13	18	57	38	106	184
slaughtered fatteners [n/1yr]	low [2]	18	65	417	1936	659	1827	11016
	intermediate [1/4]	20	15	317	2633	859	3199	16000
	high [3]	14	14	261	598	324	687	3100

¹Number of observations differs from number of production chains/systems, as not each parameter was available for all production chains.