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Characteristics of organic dairy major farm types in seven European countries

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Abstract This study aimed to identify organic dairy major farm types (MFTs) in seven European countries, describe these MFTs in an open research database and assess central characteristics of the MFTs. This was conducted in a three-step procedure including (1) Identification of organic MFTs in seven European countries: Austria, Switzerland, Germany, Denmark, Lithuania, Poland and Sweden, based on existing data from dairy databases and consultations with experts within the respective fields of knowledge; (2) Collection of data on farm characteristics, management procedures, production level and herd health from at least 10 farms per MFT and country and (3) Creating an open research database on MFT characteristics, description of essential characteristics of MFTs and assessment of similarities and differences between farms within and across MFTs. The results indicate variations in herd characteristics such as production level, herd size, farm size, housing system, milking system and cow health status between organic dairy farms in these seven European countries. It also indicates variations in management strategies such as feeding, animal health management and recruitment strategies across the organic dairy sector in Europe. These variations seem to be associated with

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differences between regions and countries in the conditions for organic dairy production, such as topography, land availability and regulations.

Keywords Organic dairy production · Farm size · Housing · Production level · Health · Feeding · Breeding

Introduction

Consumer demand for organic products is increasing (European Commission 2014; Eurostat 2016) and this, together with the premium price for organic products, has prompted an increase in organic production (Rosati and Aumaitre 2004; Escribano et al. 2015). Moreover, organic production contributes public goods such as biodiversity and human and animal health and welfare (Jespersen et al. 2017). In Europe, the organic dairy sector has seen a steady increase, reaching a market share of between 2 and 11% in 2016 depending on country, with the main markets being in Western Europe (Sørensen et al. 2006). Consequently, organic dairy production in the EU has almost doubled since 2007, and by 2016 constituted more than 2.8% (4.1 million metric tons) of total EU milk production (Willer and Lernoud 2018). Organic dairy production is characterised by high-roughage diets based on home-grown feedstuffs, outdoor access on pasture and restrictive use of antibiotics (EC 2007). In organic dairy production, animal health and welfare is promoted by preventative actions such as using suitable breeds, feed, management and housing system. Accordingly, compared with conventional farms, organic dairy cattle farms have a higher amount of pasture-based feeding systems and a lower amount of concentrate feeding (Kristensen and Kristensen 1998; Valle et al. 2007; Thomassen et al. 2008) and on average a lower use of medicines (Richert et al. 2013; Van Wagenberg et al. 2016). Some of the major challenges within European organic dairy production are preventative handling of mastitis and metabolic diseases (Bennedsgaard et al. 2010; Ivemeyer et al. 2012), improvement of production efficiency based on local feed resources and development of suitable breeding strategies (Röös et al. 2018).

The organic dairy cattle sector must adapt to differences in topography, infrastructure, national and regional organic regulations, traditions and typical management procedures. Consequently, organic dairy farm types vary across Europe. These differences arise within individual countries (e.g. Ivemeyer et al. 2017), but can be expected to be of even greater magnitude between European countries. Thus, there is not one, but many, organic dairy production systems in Europe. However, no systematic mapping of organic dairy production environments in Europe is available at present. Thus, an essential step in the development process in order to enhance knowledge exchange within the European organic dairy sector, and also to provide evidence-based information for advisors, policymakers and regulation developers, is to identify and map major organic dairy farm types in Europe.

Aim

The aim of this study was to identify organic dairy major farm types (MFTs) in seven European countries, describe these MFTs in an open research database and assess central characteristics of the MFTs.

Material and methods

This study was conducted in a three-step procedure:

(1) Identification of organic MFTs in seven European countries: Austria (AT), Switzerland (CH), Germany (DE), Denmark (DK), Lithuania (LT), Poland (PL) and Sweden (SE), based on existing data from dairy databases and consultations with experts (production advisors (including veterinarians) and researchers) within the respective fields of knowledge.
(2) Collection of data on farm characteristics (herd size and structure, housing and milking system), management procedures (related to feed, health and breeding), production level and herd health from at least 10 farms per MFT (Table 2).
(3) Creation of an open research database on MFT characteristics, description of essential characteristics of MFTs and assessment of similarities and differences between farms within and across MFTs.

This three-step procedure was chosen in order to identify and describe some major variations and patterns in the European organic dairy sector, and was not intended to give a representative quantification of characteristics of European organic dairy farms.

Identification of MFTs in seven European countries

The MFTs in each country were identified according to a standardised protocol that covered four criteria: geographical location, herd size, housing type and production level. The protocol was completed using data from different national data sources and expert panel interviews, although methods for MFT identification varied to some extent between countries (Table 1). The relevance of the criteria considered also varied between countries, e.g. there is greater variation in geographical location and milk production level in Switzerland and Austria than in Denmark. Thus, the main criteria included in MFT identification also varied between countries (Table 1).

Collecting data on farm characteristics for each MFT

The characteristics of each farm type were investigated in an in-depth farm survey that included detailed questions on approximately 90 items, such as farm location, housing and milking system, herd size and structure, production level, herd health status and preventive health management, feeding including ratio formulation, pasture management, fodder production and breeding strategies, including breeds kept on the farm and reproduction techniques used. For details of the survey, see OrganicDairyHealth database (2018). The survey protocol was developed jointly by all partners, translated into native languages and used in all countries. Data collection according to the survey protocol was performed as interviews, questionnaires, data collection from databases or a combination of these methods. Methods for identification of farms for inclusion in data collection and methods for data collection varied between countries (Table 2). Protocol information was

Table 1 Information source, identification method and main criteria included in identification of major farm types (MFTs) of organic dairy farms in the seven countries included in the analysis

Country	Information source	MFT identification method	Main criteria included in MFT identification
Austria	National cattle database and data from an on-farm research project	Expert opinion (researchers and representatives of breeding organisations) based on collected information	Herd size, housing type, location/level of intensity of farming
Switzerland	National cattle database and expert panel interview	Expert opinion (researchers and advisors) based on collected information	Location, production level
Germany	National agricultural statistical database, data from on-farm research projects and expert panel interview	Cluster analysis, expert opinion based on results from cluster analysis (Ivemeyer et al. 2017)	Herd size, housing type, location, production level
Denmark	National cattle database and expert panel interview	Expert opinion (researchers and advisors) based on collected information	Housing type, production level
Lithuania	Data from the organic certification organisation Ekoagros	Expert opinion (researchers) based on collected information	Herd size, housing type
Poland	National cattle database and data from Agricultural and Food Quality Main Inspection	Principal components analysis[1]	Housing type, location
Sweden	National cattle database (Växa 2014) and data from organic certification organisation KRAV	Expert opinion (researchers and production advisors from Växa) based on collected information	Herd size, production level (nested within milking equipment type)

[1] Poland: MFTs were defined using data from 463 organic dairy farms obtained through the national cattle database. Using PROC FACTOR method = prin in SAS 9.4® software (SAS Institute Inc. 2017), principal component analysis (PCA) was used to identify variables that explained the largest degree of variance. Input variables were the continuous variables 'herd size' and 'milk yield', and the binominal variables 'location mountain', 'location lowland', 'loose housing' and 'tie-stall'. Number of components to be retained was decided using Kaiser's criterion. On the basis of the PCA, location mountain, location lowland, loose housing and tie-stall were chosen as defining variables for MFTs. However, this created a farm type with too few observations (location mountain, loose housing; $n = 6$). The two mountain farm types were therefore merged into one, and three final MFTs were defined (lowland, loose housing; lowland, tie-stall; mountain, loose housing and tie-stall)

collected from at least 10 farms per farm type. A survey was considered complete when critical information on housing and milking system, herd size and structure, production level and herd health status was recorded. In total, 715 completed surveys were obtained. All data collected referred to production year 2014, except for Denmark, for which information for production year 2015 was recorded.

Building a database on organic dairy farm characteristics

Data obtained in the data collection process were compiled into a common database with information on farm level to be used as input to other work packages in the OrganicDairyHealth project (OrganicDairyHealth database 2018). Database information summarised on MFT level is publicly available and can be accessed at http://projects.au.dk/coreorganicplus/research-projects/organicdairyhealth/database-summary/. It is intended for use in future research projects. The database is extensive and includes more than 250 variables describing detailed characteristics of the 715 farms surveyed. In this paper, we do not aim to provide a complete description of all recorded characteristics, but focus on describing critical farm, herd and management characteristics.

Data processing

All data were edited in Microsoft Excel 2013 (Microsoft Inc., 2013) and SAS® 9.4 (SAS Institute Inc., 2013). Descriptive statistics on variations within and between MFTs were calculated using SAS® 9.4 (SAS Institute Inc., 2013). Graphical illustrations were created in RStudio ver1.0.143 (RStudio Team, 2016). The final dataset analysed comprised 22 variables and 715 farm observations from the seven countries included in the study.

Table 2 Methods used for data collection and for farm identification and number of farms with a completed survey in each of the seven countries included in the analysis

Country	Methods for data collection	Methods for identification of farms	Number of farms with complete surveys
Austria	Interviews by phone (57 farms), in combination with data from the national cattle database Rinderdatenverbund (RDV) and another research project[1] (27 farms)	Farms included in another research project and farms identified by performance testing and organic organisations that best fitted the major farm type (MFT) criteria	60
Switzerland	Interviews by main or phone in combination with data from the national cattle database	Organic dairy farms with completed records for 2014 were selected from a FiBL database. Of 142 farms fulfilling MFT criteria, 10 farms per MFT were randomly selected within geographical regions	20
Germany	Interviews on farms (13 farms) and interviews by phone (28 farms), in combination with data collected in other research projects	Farms included in other research projects and farms in the research database that best fitted the MFT criteria	41
Denmark	Interviews on farms in combination with data from the national cattle database	Farms included in other research studies. All fitting the DK MFT-profiles, thus including farms with robot milking	10
Lithuania	Interviews on farms (9 farms), interviews by phone (12 farms), paper questionnaire (19 farms) and data from the organic certification organisation Ekoagros	Farms that best fitted the MFT criteria and then randomly selected within geographical regions	40
Poland	National cattle database and data from Agricultural and Food Quality Main Inspection	All farms with sufficient data in the Polish databases and fulfilling the MFT criteria	463
Sweden	Internet-based questionnaire	The questionnaire was e-mailed to 400 randomly selected KRAV-certified organic dairy farms in Sweden. Of these, 108 entered and 81 completed the survey	81

[1] Records collected within the project 'Analysis and optimization of production efficiency and environmental impact within the Austrian cattle production' (Efficient Cow), Project No. 100861, were used

Results

Identified MFTs

The number of MFTs identified varied between countries. Definitions of the MFTs identified in each partner country are presented in Table 3.

Farm size and structure

Farm size, in terms of number of cows and area of arable land, varied between MFTs (median 11 to 143 lactating cows per herd, median 28 to 385 ha per farm). Size showed skewed distributions within MFTs, as indicated by the interquartile ranges (IQRs) and the relationships between medians and IQRs (Table 4). The availability of arable land for pasture and access to semi-natural pasture varied between regions, and thus between MFTs (Table 4). The age distribution of the cows in the herd varied between a MFT median of 16.7 and 35.8% for first-parity cows in the herd. Age distribution also varied between countries, with a higher proportion of first- and second-parity cows in MFTs in Austria, Denmark and Sweden and a larger proportion of cows in parity 3 or older in MFTs in Germany, Lithuania and Switzerland (Table 4). Variation was also observed in average age at

Table 3 Definition and name of the major farm types identified in the survey in each of the seven countries included in the analysis

Country and code structure	Definitions of major farm types (MFT)	Name MFT
Austria AT_Barn type_Area	Loose housing, herd size small-medium to large; extensive/higher/alpine regions	AT_Loose_Alpine
	Loose housing, herd size small-medium to large; intensive/favourable production area	AT_Loose_Favourable
	Loose housing, herd size small-medium to large; medium production area	AT_Loose_Medium
	Tie-stall, herd size small to medium; higher/alpine regions	AT_Tie_Alpine
	Tie-stall, herd size small to medium; favourable or medium production area	AT_Tie_Fav_Medium
Switzerland CH_Yield	Lowland (valley), high input (≥ 6500 kg milk yield) Mountain region, high input (≥ 6000 kg milk yield)	CH_High
	Lowland (valley), low input (< 6500 kg milk yield) Mountain region, low input (< 6000 kg milk yield)	CH_Low
Germany DE_Scale_Yield[1]	Large-scale herds, high milk yield, typically cubicles, typically northern Germany	DE_Large_High
	Medium-scale herds, low-medium milk yield, typically eastern Germany	DE_Medium_Low/Medium
	Medium-scale herds in southern Germany, medium milk yield	DE_Medium_Medium_South
	Small-scale herds, low milk yield, typically straw yards, typically western Germany	DE_Small_Low
Denmark DK_Barn type_Yield	Danish organic, loose-housed, high production	DK_Loose_High
Lithuania LT_Barn type_Herdsize	Loose housing, small (< 80 cows), milking parlour	LT_Loose_Small
	Loose housing, large (≥ 80 cows), milking parlour	LT_Loose_Large
	Tie-stall, large (≥ 50 cows), mobile single milking machine connected to milkline/bucket	LT_Tie_Large[2]
	Tie-stall, small (< 50 cows), mobile single milking machine connected to milkline/bucket	LT_Tie_Small
Poland PL_Location_Barn type	Mountain regions, tie-stall and loose housing	PL_Mountain_Loosetie
	Lowland regions, loose housing	PL_Lowland_Loose
	Lowland regions, tie-stall	PL_Lowland_Tie
Sweden SE_MilkingEquip	Tie-stall, mobile single milking machine connected to milkline	SE_Machine_Milkline
	Loose housing, milking parlour	SE_Parlour
	Loose housing, milking robot	SE_Robot

[1] All German MFT had loose housing systems. For more details of German MFT definitions, see Ivemeyer et al. (2017) MFT names: DE_Medium_Low/Medium = MFT A, DE_Small_Low = MFT B, DE_Large_High = MFT C; DE_Medium_Medium_South = MFT D)

[2] As this MFT had only three observations, it was combined with LT_Loose_Large for statistical analysis

Table 4 Farm size and structure, housing and milking system, feeding, production level, herd health and use of breeds for the major farm types (MFTs) in different countries. For MFT definitions, see Table 3. IQR, interquartile range

MFT[1]	AT_Loose_ Alpine	AT_Loose_ Favourable	AT_Loose_ Medium	AT_Tie_Alpine	AT_Tie_Fav_ Medium	CH_High	CH_Low	DE_Large_High	DE_Medium_ Low_Medium	DE_Medium_ Medium_South
Farm size and structure										
Number of lactating cows										
N	11	9	16	9	12	10	9	11	10	10
Median	21	19	26	13	14	28	19	78	40	40
IQR	10.9	8.1	12.4	6.8	3.7	27.7	7.5	56.7	15.1	11.8
Parity distribution of cows (%)										
N	11	9	16	9	12	9	10	11	10	10
1st parity	35.7	29.6	25.5	32.2	28.2	24.6	23.5	27.7	22.6	22.8
2nd parity	26.5	23.4	23.0	21.7	22.7	21.8	17.7	17.2	18.4	19.5
3rd or higher parity	37.8	47.0	51.5	46.1	49.1	53.6	58.8	55.1	59.0	57.7
Total land (ha)										
N	6	5	13	6	8	10	9	11	10	10
Median	44	55	47	38	28	36	30	170	176	56
IQR	33	42.5	35	20.5	10.7	19.2	13.8	230	76	18
Total pasture land (ha)										
N	6	5	13	6	8	10	9	11	10	10
Median	37	20	34	25	20	26	28	66	71	45
IQR	42.0	24.0	14.5	27.5	17.8	13.0	8.0	55.0	37.7	19.0
Area of semi-natural pasture (ha)										
N	11	7	16	7	10	10	10	11	10	10
Median	36	40	24	14	–	24	26	62	65	45
IQR	20.9	42.0	21.5	15.7	–	7.2	4.2	53	25.7	22.0
Housing and milking system (%)										
N	11	10	17	10	12	7	9	11	10	10
Loose-housed	100	100	100	0	0	85.7	55.6	100	100	100
Tie	0	0	0	100	100	14.3	44.4	0	0	0
Lying area in loose housing (%)										
N	11	10	17	0	0	9	6	11	10	10
Straw yard or sloped floors	0	0	0	–	–	0	0	0	50	0
Cubicles	100	100	100	–	–	100	100	100	50	100
N	11	10	17	10	12	10	10	11	10	10
Straw material in lying area (% of farms answering yes)	100	80	88.2	0	0	90	60	81.8	50	100
N	11	10	17	10	12	10	10	11	10	10
Rubber mattress in lying area (% of farms answering yes)	9.09	40	0	0	0	10	0	18.2	0	10
N	11	10	17	10	12	10	10	11	10	10
Concrete floor in lying area (% of farms answering yes)	0	0	17.6	0	0	60	60	9.09	0	10
Milking system (%)										
N	11	10	17	10	12	10	9	11	10	10

Table 4 (continued)

MFT[1]	AT_Loose_ Alpine	AT_Loose_ Favourable	AT_Loose_ Medium	AT_Tie_Alpine	AT_Tie_Fav_ Medium	CH_High	CH_Low	DE_Large_High	DE_Medium_ Low_Medium	DE_Medium_ Medium_South
Robot	9.09	0	0	0	0	0	0	36.36	0	0
Parlour	90.91	100	100	0	0	80	66.67	63.64	100	100
Single milking machine	0	0	0	100	100	20	33.33	0	0	0
Bucket	0	0	0	0	0	0	0	0	0	0
Feeding										
Roughage in winter ratio (%)										
N	10	9	13	7	10	4	7	7	7	5
Median	75	77	75	79	87	94	95	82	90	76
IQR	12.7	13.4	13.7	5.82	10.1	7.43	10.5	4.09	24.4	24.5
Concentrates [kg/cow&yr] Median	1071	1003	1200	600	915	440	0	1600	860	908
IQR	395	619	1082	698	490	250	75	600	400	540
N	10	9	15	10	10	10	10	11	10	10
Only hay as roughage in winter (% of farms)	10	11.1	0	20	20	30	20	0	40	30
Production level										
Milk (ECM)										
N	11	9	16	9	12	10	10	11	10	10
Median	6707	6435	7643	6073	6489	6834	5370	7732	6058	6301
IQR	2339	1846	1736	1281	1627	625	869	1305	1530	861
Protein %										
N	11	9	16	9	12	10	10	11	10	10
Median	3.28	3.24	3.35	3.27	3.34	3.38	3.29	3.24	3.45	3.4
IQR	0.19	0.14	0.11	0.08	0.13	0.15	0.13	0.16	0.18	0.18
Fat %										
N	11	9	16	9	12	10	10	11	10	10
Median	4.10	4.00	4.12	3.97	4.09	4.08	3.97	4.13	4.30	3.95
IQR	0.24	0.22	0.26	0.17	0.14	0.23	0.21	0.30	0.53	0.24
Average age at first calving (month)										
N	11	10	16	10	11	10	10	11	10	10
Median	29.6	27.5	29.0	29.6	27.4	28.5	32.0	27.0	30.2	28.8
IQR	6.32	4.91	2.52	3.61	25.9	7.00	3.00	2.37	7.61	6.48
Breeds (% of herds)										
N	11	10	17	10	11	10	10	11	10	10
One major breed	45.4	30.0	64.7	70.0	36.4	60.0	20.0	45.5	50.0	70.0
Two major breeds	27.3	40.0	24.9	20.0	36.4	20.0	70.0	18.2	20.0	30.0
More than two major breeds	27.2	30.0	5.9	10.0	27.2	20.0	10.0	36.3	30.0	0.0
N	10	9	13	7	10	10	10	11	10	10
Cross bred (dairy breeds) cows in the herd (yes/no)	80.0	55.6	61.5	42.9	80.0	20.0	10.0	27.3	30.0	40.0
Herd health										
Treated for mastitis (all treatments)										

Table 4 (continued)

MFT[1]	AT_Loose_ Alpine	AT_Loose_ Favourable	AT_Loose_ Medium	AT_Tie_Alpine	AT_Tie_Fav_ Medium	CH_High	CH_Low	DE_Large_High	DE_Medium_ Low_Medium	DE_Medium_ Medium_South
N	7	14	8	5	8	10	9	0	0	0
Average per 100 cows and yr	11.4	19.6	18.2	16.3	40.2	16.2	10.9	–	–	–
Treated for metabolic diseases										
N	7	14	8	5	8	10	9	0	0	0
Average per 100 cows and yr	0.64	0.18	5.50	0.00	0.00	5.53	0.00	–	–	–
Culling rate										
N	11	9	16	9	11	10	9	9	6	10
Average culled cows (%, per yr)	19.8	24.3	17.1	20.5	23.4	19.3	17.9	25.0	19.3	24.4
SCC × 10^3 average/yr										
N	11	10	16	10	11	10	10	11	10	10
Median	171	175	184	138	135	185	176	249	302	152
IQR	153	113	129	164	76	66	53	105	195	41

MFT[1]	DE_Small_Low	DK_Loose_High	LT_Loose_ Small_Large	LT_Loosetie	LT_Tie_Small	PL_Mount_ Loosetie	PL_Lowland_ Loose	PL_Lowland_Tie	SE_Machine_ Milkline	SE_Parlour	SE_Robot
Farm size and structure											
Number of lactating cows											
N	10	10	10	10	18	143	48	270	17	16	30
Median	24	143	58	106	28	11	33	12	30	70	70
IQR	10.1	67	22	17	10	6	23	7	20	90	55
Parity distribution of cows (%)											
N	10	10	9	9	16	0	0	0	16	13	26
1st parity	17.6	35.8	26.3	16.7	17.7	–	–	–	27.2	30.8	32.2
2nd parity	17.9	21.7	21.3	24.5	17.0	–	–	–	26.4	24.5	27.6
3rd or higher parity	64.5	42.5	52.4	58.8	65.3	–	–	–	46.4	44.7	40.2
Total land (ha)											
N	10	9	11	11	18	143	48	269	12	12	18
Median	77	201	223	385	71	38	216	37	148	214	239
IQR	38	79	141	335	23	96.9	389	69.3	194	246	168
Total pasture land (ha)											
N	10	9	11	11	18	143	48	269	12	12	18
Median	40	60	135	185	54	20	68	18	21	50	36
IQR	27.0	68.0	43.1	100.0	19.0	63.0	217.0	43.8	33.2	76.0	43.5
Area of semi-natural pasture (ha)											
N	10	9	0	0	0	143	48	269	12	12	19

Table 4 (continued)

MFT[1]	DE_Small_Low	DK_Loose_High	LT_Loose_Small_Large	LT_Loosetie	LT_Tie_Small	PL_Mount_Loosetie	PL_Lowland_Loose	PL_Lowland_Tie	SE_Machine_Milkline	SE_Parlour	SE_Robot
Median	37	7	–	–	–	18	52	16	5	23	15
IQR	27.0	21.0	–	–	–	56.7	167.0	36.0	9.5	33.5	38.0
Housing and milking system (%)											
N	10	10	11	11	18	143	48	270	20	20	40
Loose-housed	100	100	100	72.7	5.56	4.2	100	0	15	100	100
Tie	0	0	0	27.3	94.4	95.8	0	100	85	0	0
Lying area in loose housing (%)											
N	10	10	10	8	1	6	48	0	12	19	40
Straw yard or sloped floors	70	0	0	0	0	0	6.25	–	8.33	21	2.5
Cubicles	30	100	100	100	100	100	93.8	–	91.7	78.9	97.5
N	10	10	11	11	18	7	48	2	20	21	40
Straw material in lying area (% of farms answering yes)	40	50	45.5	18.2	5.56	85.7	87.5	0	20	9.52	17.5
N	10	7	11	11	18	–	–	–	20	21	39
Rubber mattress in lying area (% of farms answering yes)	0	100	45.5	54.5	0	–	–	–	25	71.4	97.4
N	10	7	–	–	–	–	–	–	20	21	39
Concrete floor in lying area (% of farms answering yes)	10	0	–	–	–	–	–	–	5	4.76	2.56
Milking system (%)											
N	10	10	11	11	18	143	48	270	19	20	40
Robot	0	60	0	0	0	0	0	0	0	0	95
Parlour	100	40	100	72.73	0	0.7	29.17	0	0	100	5
Single milking machine	0	0	0	27.27	33.33	4.2	70.83	0.74	100	0	0
Bucket	0	0	0	0	66.67	95.1	0	99.26	0	0	0
Feeding											
Roughage in winter ratio (%)											
N	8	8	4	6	7	–	–	–	10	6	14
Median	74	69	75	84	77	–	–	–	66	56	64
IQR	23.8	11.6	13	6.28	15.7	–	–	–	18.2	20.6	15.6

Table 4 (continued)

MFT[1]	DE_Small_Low	DK_Loose_High	LT_Loose_Small_Large	LT_Loosetie	LT_Tie_Small	PL_Mount_Loosetie	PL_Lowland_Loose	PL_Lowland_Tie	SE_Machine_Milkline	SE_Parlour	SE_Robot
Concentrates [kg/cow&yr] Median	750	–	–	–	–	–	–	–	2100	1500	2250
IQR	745	–	–	–	–	–	–	–	1460	889	608
N	9	9	10	11	17	–	–	–	10	8	19
Only hay as roughage in winter (% of farms)	22.2	0	0	0	5.88	–	–	–	0	0	5.26
Production level											
Milk (ECM)											
N	10	10	9	10	9	143	48	270	16	14	26
Median	5370	9505	6073	6150	5800	3000	3493	3000	9443	8250	9200
IQR	710	1496	1052	650	400	1596	1996	1578	1552	3045	1300
Protein %											
N	10	10	9	9	12	143	48	270	16	12	26
Median	3.42	3.46	3.3	3.3	3.25	3.24	3.19	3.24	3.40	3.50	3.40
IQR	0.37	0.71	0.09	0.1	0.34	0.19	0.2	0.17	0.1	0.23	0.2
Fat %											
N	10	10	9	9	12	143	48	270	16	12	26
Median	4.10	4.21	4.28	4.23	4.25	4.04	3.96	4.07	4.28	4.25	4.18
IQR	0.26	1.59	0.22	0.20	0.48	0.41	0.46	0.32	0.30	0.35	0.30
Average age at first calving (month)											
N	10	9	8	11	10	143	48	270	9	13	13
Median	31.2	25.5	24.0	24.0	24.5	20.0.	20.0	20.0	24.4	26.0	25.0.
IQR	1.52	2.10	3.00	1.00	2.00	0.00	2.00	2.00	2.68	2.00	3.00
Breeds (% of herds)											
N	10	10	10	11	14	–	–	–	12	13	15
One major breed	50.0	50.0	30.0	54.5	57.1	–	–	–	16.7	23.1	13.3
Two major breeds	30.0	50.0	60.0	27.3	28.6	–	–	–	50.0	30.8	60.0
More than two major breeds	20.0	0.0	10.0	18.2	14.3	–	–	–	33.3	46.1	26.7
N	10	10	10	11	16	–	–	–	10	14	17
Cross bred (dairy breeds) cows in the herd (yes/no)	30.0	50.0	0.0	9.09	18.8	–	–	–	20.0	42.9	29.4
Herd health											

Table 4 (continued)

MFT[1]	DE_Small_Low	DK_Loose_High	LT_Loose_ Small_Large	LT_Loosetie	LT_Tie_Small	PL_Mount_ Loosetie	PL_Lowland_ Loose	PL_Lowland_Tie	SE_Machine_ Milkline	SE_Parlour	SE_Robot
Treated for mastitis (all treatments)											
N	0	10	4	9	6	0	0	0	14	13	15
Average per 100 cows and yr	–	13.0	22.1	10.4	8.4	–	–	–	12.0	6.8	9.8
Treated for metabolic diseases											
N	0	10	4	9	6	0	0	0	14	14	17
Average per 100 cows and yr	–	0.35	2.42	2.67	2.82	–	–	–	2.68	2.81	1.76
Culling rate											
N	7	0	9	10	15	0	0	0	13	12	15
Average culled cows (%, per yr)	14.7	–	13.0	8.0	14.7	–	–	–	33.5	27.3	28.8
SCC × 10^3 average/yr											
N	10	10	8	9	12	143	48	270	11	14	20
Median	230	213	265	215	250	847	722	858	180	200	205
IQR	100	65	115	50	84	553	469	512	152	55	51

[1] Code structure for MFT names for each country is given in Table 3

first calving, which was higher and showed greater variation in MFTs in Austria, Switzerland and Germany compared with MFTs in Denmark, Lithuania and Sweden (Table 4).

Housing and milking system

Milking and housing systems were interrelated. A milking parlour was the most common milking system in loose housing systems and a mobile single milking machine was the most common in tie-stall housing systems (Table 4). The majority of all farms had cubicles with straw in the lying area (Table 4). Farms with straw yards or sloped floors were identified as relevant housing systems within MFTs only in Germany, Sweden and Poland.

Feeding strategy

The proportion of roughage in the winter ration varied between a median of 56 and 85% on dry matter (DM) basis for the MFTs surveyed. A feeding strategy including only hay as roughage was most common among German, Swiss and Austrian MFTs (Table 4).

Production level and breeds

Median production level varied from 3000 to 9505 kg energy-corrected milk (ECM) per year, with the lowest production levels on Polish MFTs and the highest on MFTs in Denmark and Sweden. Milk protein and fat content varied between MFTs, but with no clear patterns. A majority of all farms had one major breed in the herd, but crossbreeds in the herd were common. The proportion of farms with only one breed was lower in MFTs in Sweden, compared with the other countries (Table 4).

Herd health and treatment routines

Average herd somatic cell count (SCC) over the year varied between a median of 135 and 858 × 10^3 cells/mL, with lower levels in some Austrian and Swiss MFTs and higher levels in Polish MFTs (Table 4). Most MFTs had an average mastitis prevalence of between 10 and 20% of lactating cows. Average culling rate varied between 8 and 34% of lactating cows (Table 4).

A majority of farmers on all MFTs except one (a German MFT) used antibiotics routinely for treatment of clinical mastitis. Use of the practice of drying off teat quarters and use of homoeopathic treatments varied more between MFTs, both between and within countries. A higher proportion of farmers in Lithuania and Sweden used drying off quarters as a mastitis treatment and a higher proportion of Lithuanian and Swiss farms used homoeopathic treatment (Fig. 1).

Most farms used veterinary treatments to treat metabolic disease. Homoeopathic treatment was more commonly used by farmers in Lithuania and Switzerland and small German farms (Fig. 2).

Discussion

The objectives of this study were to identify major farm types (MFT) in seven European countries, describe these MFTs and assess their critical characteristics. We identified 22 MFTs in the countries studied and entered descriptions of these MFTs into a public research database (http://projects.au.dk/coreorganicplus/research-projects/organicdairyhealth/database-summary/), where the variation in farm characteristics is illustrated. The data collected is not, and was not intended to be, a representative sample of the organic herds in each country, as we did not intend to quantify organic dairy production characteristics. This study, and the methodology used, aimed to capture some major variations and patterns in European MFTs and the characteristics of these. The same basic protocol for data collection was used in all seven countries, but the method of data collection varied between countries, from internet-based questionnaires and compiling data from databases to telephone or in-person interviews. Differences in data collection methods, in combination with differences in management and interpretation of questions between countries and farms, may have influenced the accuracy of the answers, which must be taken into account when interpreting the results.

The results from the survey indicated that the highest milk production level and largest herd sizes are found in northern regions of Europe, i.e. Denmark, Sweden and northern Germany. The smallest herd sizes and lowest milk producution levels occur on Polish, Austrian and Swiss organic dairy MFTs, especially in mountain regions, which also displayed relatively larger variation in these characteristics. Moreover, the Lithuanian data on herd size showed great reported variation, varying from relatively small to the largest of all countries included in the survey. These results are in line with Sørensen et al. (2006), who described dairy cattle production in the

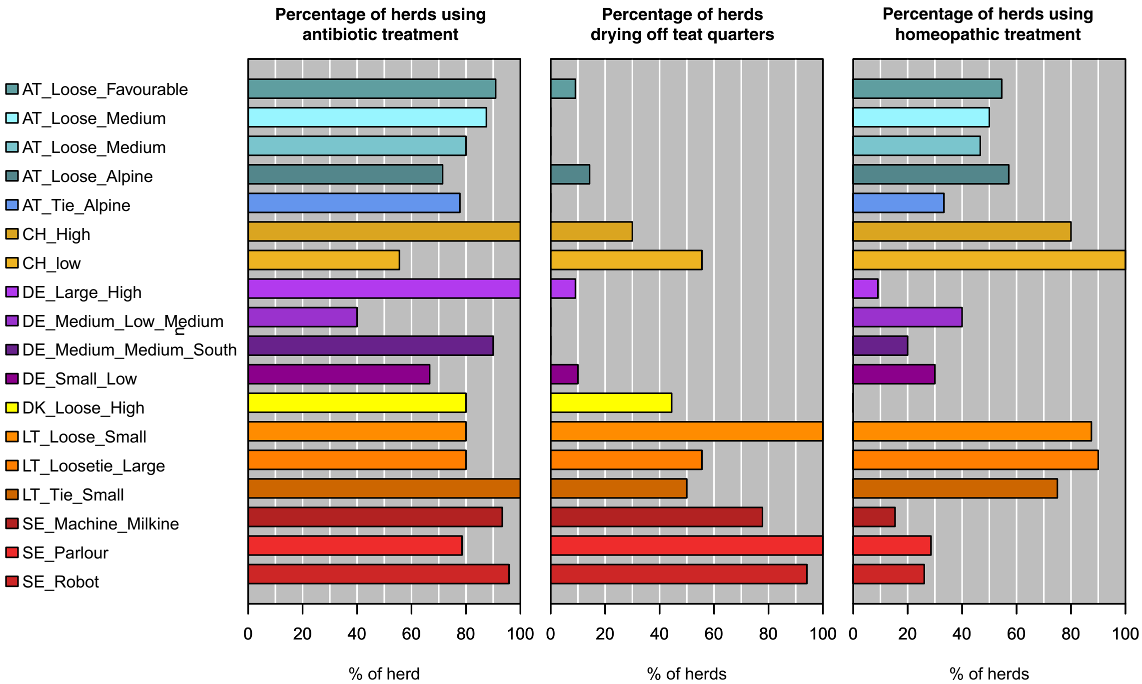

Fig. 1 Proportion of herds in different major farm types (MFTs) with routine treatment using antibiotics ($N = 191$), drying off teat quarters ($N = 181$) and homoeopathic treatment for mastitis ($N = 183$). Polish MFTs are not included, as no data were available

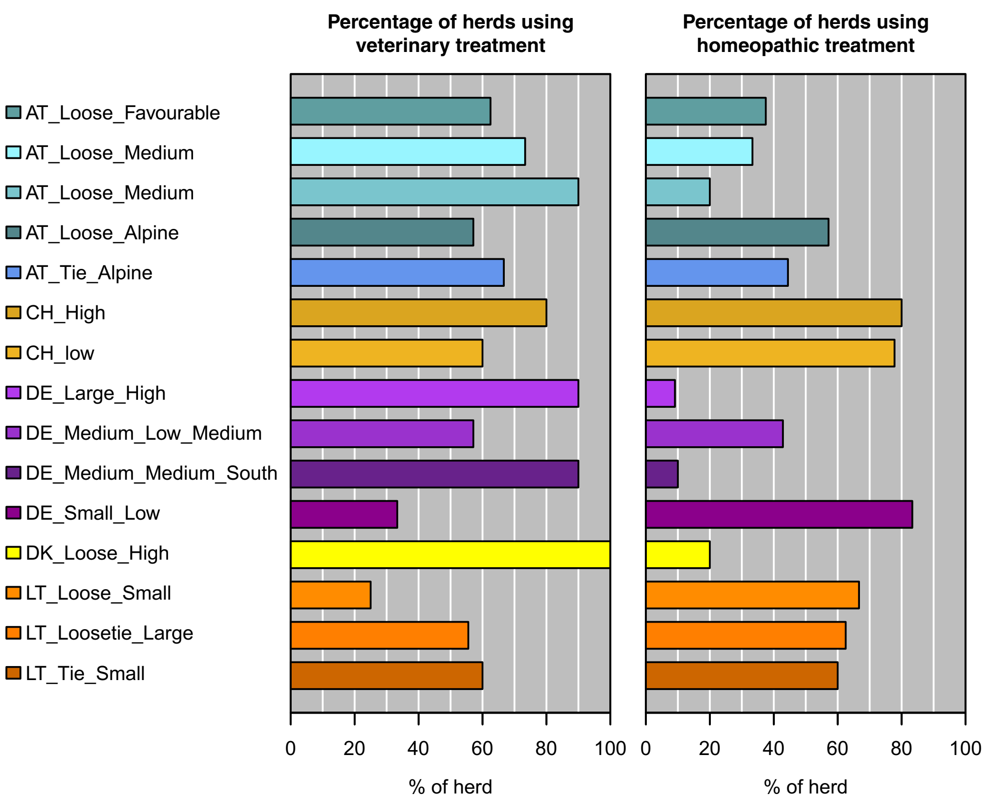

Fig. 2 Proportion of herds in different major farm types (MFTs) using routine veterinary ($N = 131$) and homoeopathic ($N = 126$) treatment for metabolic diseases. Polish and Swedish MFTs are not included, as no data were available

industrialised world as highly specialised and with high milk production levels. However, that study also reported large differences, with dairy farms in the Netherlands, Germany, Denmark and Sweden typically being characterised as highly intensive. In the present study, we found that the countries reporting the largest variation in MFTs were Austria and Germany. These countries are situated in a region of Europe that has both lowland and mountain dairy systems. Nevertheless, in Germany, the most extreme differences between MFTs were constituted not only by topography (lowlands in the north and mountainous in the south), but more regarding production intensity (partly within the same regions; Ivemeyer et al. 2017). According to Stuaro et al. (2009), in recent decades, the number of traditional extensive farming units has decreased in favour of highly mechanised and intensive production practices and this decrease has been particularly dramatic for the traditional extensive livestock farms of the Alpine region.

Apart from herd size, the amount of farm land also varied between MFTs, indicating differences in availability of arable land for fodder production, pasture and access to semi-natural pasture. Thus, conditions for dairy production differ between regions, explaining part of the variation in dairy production systems observed in the countries and regions included in this study.

Among the farms surveyed in this study, the majority of cows were kept in loose housing systems, but there are still some tie-stall housing systems, typically in Alpine regions (Austria and Switzerland), Sweden and central Europe (Poland and Lithuania). This is in line with previous findings (e.g. Krieger et al. 2017), indicating that the farms and MFTs included in this study reflect the situation in the European dairy sector. These differences are partly explained by different conditions due to topography in mountain and lowland regions, partly by cultural, traditional and socio-economic differences and partly by differences in regulations in different countries and regions. Since 2010, EU regulations on organic production demand that cows be loose-housed, with the exception of small farms (EC 2007). However, it is not permitted to build new tie-stalls even for small farms. The threshold for 'small dairy herds' was not defined consistently in the previous version of EUs regulation (before 2018) and is instead defined at national level (Swensson 2008; Barkema et al. 2015). Countries and federal states within countries have defined these cut-offs individually, e.g. 20–35 cows, depending on federal state, in Germany, 35 livestock units in Austria, and 45 cows in Sweden (Swensson 2008). Altogether, this indicates that a considerable proportion of the cows on organic farms in Europe are kept in tie-stalls with access to pasture during the vegetation period and regular exercise during the remainder of the year, but this proportion can be expected to decrease in the future.

Milking and housing system were found to be interrelated. A milking parlour was the most common milking system in loose-house systems and mobile single milking machine was the most common in tie-stall housing systems. Milking robot systems were used in some MFTs and seemed to be more common in regions with higher milk yields, i.e. northern Germany, Denmark and Sweden. This may partly be explained by high investment costs for automated milking systems and the need for high yields for good returns on this investment. However, it may also be attributable to differences in culture and experiences between regions, e.g. regions where automatic milking is common also in conventional dairy production (Svennersten-Sjaunja and Pettersson 2008).

According to the EU regulations on organic agriculture, at least 60% (50% at the beginning of lactation) of the dry feed matter has to be roughage (EC 2007). The results of our survey indicate a wide range in feeding intensity on organic dairy farms. The highest values are more than 90% roughage in the dry matter ration on Swiss MFTs and typically between 80 and 90% on MFTs in Austria, Germany and Lithuania. The lowest shares of roughage in the ration (below 70%) are used especially on all MFTs in high-yielding regions, such as in Sweden and Denmark. This variation reflects differences in national and regional regulations. For example, according to 'BioSuisse' standards of organic farming in Switzerland, the proportion of concentrates in the yearly ration for cattle—defined as cereals and grain legumes such as soybeans—may not exceed 10% of dry matter (BioSuisse, 2017). Krieger et al. (2017) observed differences in concentrate feeding levels for organic dairy farms in four European countries, with an average of 616, 1200, 1500 and 2373 kg concentrates per cow and year in France, Germany, Spain and Sweden, respectively. These results support our findings of a wide range between countries and of high average concentrate amounts fed in Sweden of more than 30% in the dry matter ration. Organic dairy farms in the UK are reported to use on average 1800 kg concentrates per year (Langford et al. 2009). Thus, our results support und complement previous findings and reflect typical variations in feeding management within the European organic dairy sector, caused by differences in available resources and differences in regulations between regions.

According to organic principles and standards, disease prevention must be a high priority in organic dairy production (IFOAM 2014). Disease prevention should primarily be ensured by implementing site-adapted breeding, management, nutrition and housing appropriate to the animal species (EC 2007). However, the regulations clearly state that diseased animals should be treated with appropriate methods to prevent animals suffer (e.g. antibiotic treatments in cases of serious infections). Regarding herd health, in the present study, we focused on mastitis and metabolic diseases as two important health impairments in dairy cows in general (reviewed by Martin et al. 2018 and Sundrum 2015) but also in organic dairy cows (Ivemeyer et al. 2012). Udder health was measured as arithmetic mean of somatic cell count (SCC) over 1 year from test day data and, for both udder and metabolic health, treatment incidence was used to assess disease incidence. When interpreting the results, it has to be taken into account that differences in the use of antibiotics in particular, but also other veterinary medicines, may be due not only to infection levels but also to farmers' attitudes to treatment choice (Vaarst et al. 2006; Bennedsgaard et al. 2010).

The results show a wide range of udder health conditions in the European organic sector, with the lowest SCC in Alpine and northern European regions and the highest in central European regions. While the results have to be carefully interpreted regarding absolute SCC, they are in line with other findings of similar patterns between regions. They indicate that SCC in organic herds in several European countries is on such a high level that improvements are necessary (Ivemeyer et al. 2012; Krieger et al. 2017). Mastitis treatment incidences found in the present survey support findings by Ivemeyer et al. (2012) that mastitis incidences range widely and that mastitis is a major reason for antibiotic treatment of organic dairy cows. Moreover, all treatment incidences on MFTs (average ranging from 7 to 40 treatments due to udder problems per 100 cow-years) were within the range reported in other studies (e.g. Fall and Emanuelson 2009; Bennedsgaard et al. 2010). Besides production method, management intensity has been found to have an impact on medicine use. Intensive production systems are reported to be closely associated with frequent veterinary treatment (Richert et al. 2013). However, the results from our survey did not indicate interrelations between production intensity (e.g. milk yield and feeding ratio) and treatment incidence for mastitis or metabolic diseases within organic production systems.

Interestingly, the results of the survey indicated that non-antibiotic (non-allopathic) treatment regimes varied more between regions and countries than between MFTs. While e.g. drying off single mastitic udder quarters during lactation seems to be a well-known measure in Sweden and Lithuania, and is also used by some organic farms in Switzerland and Denmark, it seems to be uncommon in Germany and Austria. The use of homoeopathic treatment also varies, being quite common in countries like Switzerland and Lithuania and less used in Denmark and Sweden. The results related to treatment strategies indicate differences between regions and countries caused by differences in regulations and culture. This emphasises the importance of cross-country and region knowledge transfer on farmer and advisor level.

The age distribution of the cows in the herds varied between MFTs, with higher proportions of first- and second-parity cows on Austrian, Danish and Swedish MFTs and higher proportions of cows in parity 3 or older on German and Lithuanian MFTs. Moreover, there was variation in average age at first calving, which was reported to be higher and to have a larger variation on MFTs in Austria, Switzerland and Germany compared with MFTs in Denmark, Lithuania and Sweden. This might partly be explained by breed differences where dual-purpose breeds, which usually have a higher age at first calving, are more common in Alpine areas. Accordingly, culling rates varied widely between MFTs. MFTs with a long productive lifetime and a low culling rate were found particularly in Lithuania. A higher culling rate than a median of 25% was found on the high-yielding MFTs in Sweden and Germany. Taken together, these results could indicate differences in dairy cow recruitment strategies between regions, but are also clearly linked to production intensity, where a high intensity is connected to reduced longevity and fertility.

More than one-third of the farms surveyed had one major breed in the herd, but also kept some crossbred cows in the herd, indicating that breeding strategies including crossing of dairy breeds are widespread in the European organic dairy sector. The majority of these crosses were between high-producing dairy breeds, but crosses with native dairy breeds also occurred. The IFOAM norms for organic agriculture state that the breeds used in organic production should be adapted to local conditions, and the use of native breeds is promoted (IFOAM 2014). The widespread use of crossbreeds may be an indication that organic dairy farmers across Europe try to take advantage of heterosis and to benefit from both high-producing modern breeds and the functional traits of locally adapted native breeds.

One of the aims of the study was to describe characteristics of the MFTs in an open research database. The primary aim was to provide input to other work packages of the OrganicDairyHealth project, which has been achieved. A secondary aim was to make the information in the database openly available for future research projects interested in farm characteristics of organic dairy farms. Thus, information from the database summarised on MFT level has been made publicly available for anyone interested to use it for research purposes. However, as the project is finalised, there are no plans for further expansion or development of the database.

Conclusions

This survey revealed variations in herd characteristics such as production level, herd size, farm size, housing system, milking system and cow health status between organic dairy farms in seven European countries. There were also variations in management strategies such as feeding, animal health management and recruitment strategies across the organic dairy sector in Europe. These variations seem to be caused by differences between regions and countries in the conditions for organic dairy production, such as topography, land availability and regulations. Future development of organic dairy production in Europe would benefit from exchange of knowledge and experience, on farm and advisory level, across regions and countries.

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