Acta Agraria Kaposváriensis (2010) Vol 14 No 2, 111-116
Kaposvári Egyetem, Állattudományi Kar, Kaposvár
Kaposvár University, Faculty of Animal Science, Kaposvár

Concentration of noxious gases in dairy, beef and veal calves farms in Northern Italy

M. Brscic[1], P. Prevedello[1], G. Cozzi[1], P. Paparella[2], F. Gottardo[1]
[1]Department of Animal Science, University of Padova, 35020 Legnaro (PD), Agripolis - viale dell'Università 16., Italy
[2]Associazione Provinciale Allevatori di Padova, Italy

ABSTRACT

Aim of this paper was investigating carbon dioxide and ammonia concentrations through a cross-sectional study applied during winter 2007 in 35 dairy cattle, 21 beef cattle and 30 veal calves farms located in North-eastern Italy. Repeated instrumental gas measurements were carried out in the feeding alley and in the resting area. Regardless of the measure point, gases concentrations in the three categories of cattle did not give reason for concern since average values were below the threshold limit set for animals. Significant difference ($P<0.05$) were observed among cattle categories with the worse air quality detected in veal calves farms. Twenty percent of these farms had at least one ammonia measure exceeding the recommended level of 10 ppm. Carbon dioxide was higher ($P<0.001$) in closed barns compared to open barns for both, dairy and beef cattle indicating a worse ventilation efficiency. Within closed barns tethered compared to loosed housed cows showed higher carbon dioxide concentrations. Similar results were found for beef cattle on fully slatted floors compared to bulls on deep litter. These results should drive attention towards specific management practices and facilities but, in order to obtain a full picture on the levels of gases concentration in cattle farms, further research should consider their emissions in different seasons as well as cattle age, breed, and productive level.
(Keywords: dairy cows, beef cattle, veal calves, greenhouse gases, ammonia)

INTRODUCTION

In the last decades, several studies demonstrated the importance of the farm microclimatic conditions for animal welfare. Continuous intake and oxygen/carbon dioxide exchange between the animal organism and the environment makes the respiratory system constantly exposed to the farm micro-climatic conditions. Particular attention was therefore given to the presence of noxious gases concentrations that are considered harmful for health of both, farmers and animals. The recent *EFSA* (2009) on the effects of farming systems on dairy cow welfare and disease, indeed, reports ammonia, methane and carbon dioxide as some of the most relevant gases.

Ammonia is an irritant gas that originates from chemical/biological breakdown of livestock urine and faeces (*Groot Koerkamp et al*., 1998). High concentrations of ammonia cause inflammation of the respiratory and ocular mucosa and could be noxious for integumental and neuronal systems. In regards to the respiratory system, prolonged exposure to ammonia, decreases the number of ciliated epithelial cells, and consequently acts as a predisposing factor for the development or for enhancing severity of respiratory disorders (*Marschang*, 1973; *Wathes*, 1994; *Hartung*, 1994). In some extreme cases ammonia may even be fatal.

Carbon dioxide is a trace gas currently composing about 0.038% of the global atmosphere equivalent to about 380 ppm by volume (*IPCC,* 2007). It is a greenhouse gas and its concentration varies seasonally and on a regional basis since in urban areas concentrations are generally higher. Indoors carbon dioxide concentration can reach levels up to ten times higher than environmental once. This confirms that carbon dioxide is a very useful indicator for the assessment of air quality and of ventilation intensity in the case of farms micro-climate conditions (*EFSA,* 2006).

Since intensive rearing conditions could be considered borderline between physiological and pathological, fingers are often pointed out on this farming system from the welfare point of view. Several actions have been done in order to set or recommend acceptable levels that guarantee animal health and welfare in Europe. According to the *EFSA* (2009) report, the threshold limit for carbon dioxide in animal house atmosphere is 3000 ppm, while for ammonia it is set to 20 ppm. However, according to the Scientific Committee on Animal Health and Animal Welfare (*SCAHAW,* 2001) and the Swedish animal welfare legislation (*Lundborg et al.,* 2005) ammonia should not exceed 10 ppm for cattle.

It was aim of the current study, therefore, to investigate on-field concentrations of the potentially noxious gases in dairy and beef cattle and veal calves farms at the existing farming conditions.

MATERIALS AND METHODS

The cross-sectional study was carried out during winter 2007 on a sample of 86 commercial farms located in the Veneto region (North-East Italy). All farms were specialized units: 35 rearing dairy cows, 21 rearing beef cattle and 30 rearing veal calves. Every farm was visited ones by a trained assessor who gathered information regarding the housing system and measured gases concentrations.

Instrumental gas measurements were carried out adopting the Dräger X-am 7000 device (Dräger Safety Italia S.p.A., Milano, Italy) that detects methane, carbon dioxide, ammonia, hydrogen sulphide and sulphur dioxide and is provided with a telescopic probe. This allowed the assessor to remain in the feeding alley avoiding also excessive animals movements. Considering that spatial distribution of gases concentrations differ inside a single animal barn three repeated measurements were taken at a standardized distance from the animals both, in the feeding alley and in the resting area.

At the time of the gases concentration measurements, micro- and macro-climate temperature was also assessed using a termohygrometer (Delta OHM S.r.l., Padova, Italy).

Data were submitted to statistical analysis with the SAS package (*SAS,* 2003). Farm distribution and frequency were studied using the PROC FREQ procedure. Analysis of variance was carried out adopting a mixed model approach with the PROC MIXED statement considering the main effect as fixed and the farm and repeated measurement effects as random. Main effects studied were at first the category of cattle (dairy, beef and veal calves), the analysis was later on restricted to open versus closed barns in dairy and beef cattle farms and to the type of housing system or floor where present such distinction. Results were considered statistically significant for $P<0.05$.

RESULTS AND DISCUSSION

Farm sample distribution according to the housing conditions showed that, among the 35 dairy farms, 23 reared cows in a loose housing system with the adoption of cubicles

either in open or closed barns while the remaining farms reared cows tethered in close barns. Beef cattle were fattened on fully slatted floors in 11 farms and on deep litter in 10 farms. All veal calves were reared indoors on fully slatted floors either of concrete (12 farms) or wooden (18 farms).

The present study focused mainly on the concentrations of carbon dioxide and ammonia while methane, hydrogen sulphide and sulphur dioxide were omitted from results. Methane was not detected in any farm and the remaining 2 gases were detected only in veal calves farms in negligible concentrations. Descriptive statistics regarding environmental temperature showed that on average it remained within seasonal ranges and, considering that the study was carried out during winter, temperature was not further on included in the analysis.

As shown in *Table 1* regardless of the measure point, carbon dioxide and ammonia concentrations were below the threshold limit set for animals (*EFSA*, 2009) in all the three categories of cattle. However, the significant differences among cattle category underlined that veal calves farms had the highest gases concentrations (*Table 1*). In regards to carbon dioxide it is interesting to notice that the minimum recorded concentrations are similar to the values reported for the composition of the global atmosphere (*IPCC*, 2007), indicating likely good air exchange in these farms.

Positive results were also found looking at the concentrations of ammonia since they never reached 4 ppm (*Table 1*). Values detected in this study confirm results reported by *Groot Koerkamp et al.* (1998) for the three considered categories of cattle. Similarly to carbon dioxide, the highest ammonia concentrations were recorded in veal calves barns where the maximum value reached 15 ppm, comparable to the level recorded in group housed calves on slats in the Netherlands (*Groot Koerkamp et al.*, 1998). A detailed picture of the farm distribution according to the threshold ammonia level of 10 ppm recommended for cattle by the Scientific Committee on Animal Health and Animal Welfare (*SCAHAW*, 2001) and accepted by the Swedish animal welfare legislation (*Lundborg et al.*, 2005) showed, indeed, that 20% of the veal calves farms had at least one ammonia measure above such value. Poor air quality detected in this study for veal calves is in accordance with the main characteristics of the standardized veal calves production system that is based on indoor housing in closed barns on fully slatted floors (*Cozzi et al.*, 2009).

Table 1

Concentration of carbon dioxide and ammonia detected in the feeding alley and in the resting area in dairy, beef and veal calves farms

Item	Dairy cattle farms (n=35)		Beef cattle farms (n=21)		Veal calves farms (n=30)		RMSE
	Lsmean	Min-Max	Lsmean	Min-Max	Lsmean	Min-Max	
Carbon dioxide (ppm)							
feeding alley	703[b]	300–2000	609[c]	300–1100	861[a]	300–2200	260.3
resting area	781[b]	300–1600	770[b]	400–1200	977[a]	400–2200	257.5
Ammonia (ppm)							
feeding alley	0.3[b]	0–6	0.0[b]	0–0	2.9[a]	0–15	2.16
resting area	0.9[b]	0–11	0.4[b]	0–8	3.7[a]	0–15	2.75

Different superscript letters within row mean significantly different for P<0.001

Unlikely from the standardized veal calves production, dairy and beef cattle could be reared adopting different housing systems. A first distinction between open and closed barns allowed us to assess differences in gases concentrations for dairy and beef cattle reared in the two types of barns (*Table 2*). As expected, open barns showed lower carbon dioxide concentrations in both categories of cattle either when detected in feeding alley or in the resting area. Ammonia concentration was significantly lower in the feeding alley of open dairy farms while it showed no difference in the other cases.

Table 2

Carbon dioxide and ammonia concentrations detected in open versus closed barns in dairy and beef cattle farms

Item	Dairy cattle farms				Beef cattle farms			
	Open barn (n=18)	Closed barn (n=17)	SE	P	Open barn (n=5)	Closed barn (n=16)	SE	P
Carbon dioxide (ppm)								
feeding alley	519	898	43.4	***	467	654	39.7	***
resting area	593	980	39.4	***	640	810	44.2	***
Ammonia (ppm)								
feeding alley	0.0	0.59	0.20	**	0.0	0.0	-	-
resting area	0.63	1.14	0.41	ns	0.0	0.5	0.36	ns

ns: not significantly different; ** significantly different for $P<0.01$; *** significantly different for $P<0.001$ within cattle category

Since carbon dioxide was higher in closed barns, a second step was the investigation, within cattle category, of the housing system that has detrimental effects on air quality. Looking at results in *Table 3*, it is noteworthy that carbon dioxide was more concentrated in tie dairy farms regardless of the place of measurement. Ammonia concentrations were not significantly different, but the lower level recorded in the resting area for tethered cows is in accordance with the trend reported by *Amon et al.* (2001) who assumed a likely higher ammonia emission in loose housing systems due to their different design.

Table 3

Carbon dioxide and ammonia concentrations detected in closed barns according to the housing system in dairy cattle farms and to the type of floor in beef cattle farms

Item	Dairy cattle farms				Beef cattle farms			
	Loose housing (n=5)	Tie stall (n=12)	SE	P	Slatted floor (n=9)	Deep litter (n=7)	SE	P
Carbon dioxide (ppm)								
feeding alley	687	986	80.6	***	707	586	37.6	**
resting area	793	1058	62.7	***	863	743	43.5	**
Ammonia (ppm)								
feeding alley	0.0	0.8	0.45	ns	0.0	0.0	-	-
resting area	1.5	1.0	0.57	ns	0.6	0.4	0.41	ns

See *Table 2.*

In beef cattle farms, slatted floors seem worsening air quality since both higher carbon dioxide and ammonia concentrations were detected even though ammonia levels were not significantly different (*Table 3*). The same trend was recorded by *Groot Koerkamp et al.* (1998) who studied ammonia concentrations and emissions in different livestock categories. It is likely that different manure handling affects gas emission in the farms, and in particular when liquid manure is kept underneath fully slatted pens (*Cozzi et al.*, 2009).

CONCLUSIONS

Actual levels of carbon dioxide and ammonia were quantified through a cross-sectional study carried out on a sample of dairy, beef and veal calves farms in North-eastern Italy during winter. In comparison to other livestock categories such as poultry and pigs, results obtained for cattle showed that there is no reason for concern since the gases concentrations were always below the threshold limits. However, poor air quality recorded in some farms rearing veal calves in particular should drive attention towards specific management practices and facilities in order to improve it. Implementation of suitable barn design, appropriate ventilation and apt manure storage could be some practical examples.

In order to obtain a full picture on the levels of gases concentration in cattle farms, further research should, however, consider gases emissions in different seasons as well as cattle age, breed, and productive level.

REFERENCES

Amon, B., Amon, Th., Boxberger, J., Alt, Ch. (2001). Emissions of NH_3, N_2O and CH_4 from dairy cows housed in a farmyard manure tying stall (housing, manure storage, manure spreading). Nutr. Cycl. Agroecosys. 60. 103-113.

Cozzi, G., Brscic, M., Gottardo, F. (2009). Main critical factors affecting the welfare of beef cattle and veal calves raised under intensive rearing systems in Italy: a review. It. J. Anim. Sci., 8. 1. 67-80.

EFSA (2006). Scientific Report on the risks of poor welfare in intensive calf farming systems. An update of the Scientific Veterinary Committee Report on the Welfare of Calves. The EFSA Journal. 366. 1-36.

EFSA (2009). Scientific report on the effects of farming systems on dairy cow welfare and disease. Report of the Panel on Animal Health and Welfare. The EFSA Journal. 1143. 1-38.

Groot Koerkamp, P.W.G., Metz, J.H.M., Uenk, G.H., Phillips, V.R., Holden, M.R., Sneath, R.W., Short, J.L., White, R.P., Hartung, J., Seedorf, J., Schröder, M., Linkert, K.H., Pedersen, S., Takai, H., Johnsen, J.O., Wathes, C.M. (1998). Concentrations and emissions of ammonia in livestock buildings in Northern Europe. J. Ag. Engr. Res., 70. 1. 79-95.

Hartung, E., Büscher, W., Jungbluth, T. (1994). Basic research on the ammonia release in livestock production using liquid manure. Ag. Eng. Report. 94-C-007. 8.

IPCC (2007). In: Solomon S., Qin D., Manning M., Chen Z., Marquis M., Averyt K.B., Tignor M., Miller H.L. (Eds.), Climate Change: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

Lundborg, G.K., Svensson, E.C., Oltenacu, P.A. (2005). Herd-level risk factors for infectious diseases in Swedish dairy calves aged 0–90 days. Prev. Vet. Med., 68. 123-143.

Marschang, F. (1973). Ammonia, losses and performance in large cattle sheds. Deut. Tierärztl. Woch., 80. 4. 5. 88.

SAS (2003). Statistical Analysis System User's Guide, version 9.1.3. SAS Institute, Cary, USA.

SCAHAW - Scientific Committee on Animal Health and Animal Welfare (2001). The Welfare of Cattle kept for Beef Production. 25 April 2001. SANCO.C.2/AH/R22/2000, http://europa.eu.int/comm/food/fs/sc/scah/outcome_en.html.

Wathes, C.M. (1994). Air and surface hygiene. In: Livestock Housing. Wathes CM, Charles DR (eds.) CAB International, Wallingford, 123-148.

Corresponding authors:

Marta Brscic
Dipartimento di Scienze Animali, Università degli Studi di Padova
I-35020 Legnaro (PD), Agripolis - viale dell'Università, 16., Italy
Tel.: +39 049 8272620; fax: +39 049 8272669
e-mail: marta.brscic@unipd.it