Rožnovský, J., Litschmann, T., (eds): Mendel a bioklimatologie. Brno, 3. – 5. 9. 2014,
ISBN 978-80-210-6983-1

# Effect of age of horses on gas concentration in the stable

**Jan Kalíšek [1,2], Miloslav Šoch[1], Pavel Ondr[1], Ivana Knížková[2], Jiří Ciml[1]**

[1] *University of South Bohemia in České Budějovice*
[2] *Institute of Animal science in Praha – Uhříněves*

**Abstract**

One of the problems currently livestock may be higher densities per unit area. At the same time the animals are increasing demands on their performance. It is therefore necessary to know the demands of animals to their actual needs and is not maintained by subjective human imagination. It is necessary to monitor the effects of individual factors, but also their complex effect on livestock. Animal performance and thus the breeding success of the whole depends on many factors - the nutrition of farm animals for rearing, hygiene environment, veterinary care, livestock breeds and their physiological capabilities and, last but not least, the micro-climatic conditions in the stable.

Measurement of stable gas for its technical difficulty took place at the National Stud Farm in Kladruby 1x per month and the 24-h cycle, from April 2011 to March 2012. The aim of this study was to investigate the concentrations of stable gases - carbon dioxide, methane, hydrogen sulfide and ammonia in the barn with mares and foals in the stable, where the only adult mares. Of interest were also variations in the concentration of these gases over the year.

**Key word:** Microclimate stables, stable gases, carbon dioxide, methane, hydrogen sulfide, ammonia, horse breeding, animal welfare.

## Introduction

Before man domesticated the horse and began to use it for their various needs, so the horse naturally occurred in the vast steppes, mostly in Asia. This way of life suited them, they were used to it. But as the man began to treat the horses in the stables, so they significantly changed their living conditions (Dobroruka and Kholová 1992).

Year after year in the Czech Republic increased number of breeding horses (see tab. 1). According Sodeho (1992), but due to poor housing, inadequate or improper care of the horses, poor nutrition and possibly neglected health care leads to many complications

veterinarian. These include hoof rot, an infection in the respiratory tract, allergies or digestive problems (Ende 2000).

Tab 1. The number of breeding horses in the Czech Republic

| Year | Number of horses |
|---|---|
| 2009 | 28030 |
| 2010 | 29887 |
| 2011 | 31068 |
| 2012 | 33175 |
| 2013 | 34281 |

From: Český statistický úřad

Stable environment has a major impact on the animals. This is due to the fact that in the stables staying most of the day. Kryptoklima is quite significantly influenced by the environment stable. Affect him but also physiological processes of livestock, number, type and age of animals, type of technology used in the stable and respecting common Breeding-hygiene practices. In their midst, the frequency of removal of manure, irrigation as a means to prevent excessive dust and last but not least, ventilation (Kic 1996).

A properly functioning ventilation system continuously removes stale and stable gases richer air out of the stable area. This technique also diverts and increased humidity (Kic and Brož 2000). It increased relative humidity and stable gases can also be a trigger corrosion of buildings (Hujňák 1997). On the other hand, it must also take into account the air temperature and relative humidity outside team-building. By improper ventilation, can cause great loss of energy as heat (Franěk et al., 1965).

Stable environment can be a limiting factor for the energy metabolism of animals and thus the productivity of livestock (Šoch 2005).

**Chemical composition of stable air**

In the bodies of animals housed underway metabolic processes that are manifested, inter alia, the production of liquid, solid and gaseous products. Liquid and solid component is then further degraded by microorganisms into simpler substances. Even with these transformations occur other gases that may accumulate in the stables (Doležal et al., 2004).

Carbon dioxide – $CO_2$

A colorless, flammable gas that is toxic in small concentrations. The air reaches 0.3 percent by volume. Its amount in the atmosphere is still increasing, because it is discharged as a product of combustion of substances containing carbon and at many manufacturing processes.

This gas is primarily a product of stable breathing. Partly but also arises in fermentations in the digestive system and in the litter. Its potential increased concentration is a sign of impaired ventilation.

Tab 2.

| Gas | Air | | |
|---|---|---|---|
| | atmospheric | exhaled | in the stable |
| N | 78,09 | 78,09 | 78,09 |
| O | 20,95 | 16,4 | 19,6 – 20,7 |
| $CO_2$ | 0,04 | 4,24 | 0,2 – 0,4 |

From: Franěk a kol. 1965

Ammonia – $NH_3$

It is a colorless, eyes irritating gas. It is used for example in the production of fertilizers and nitric acid.

The stables are released during decomposition of metabolites digestion. The concentration of this gas depends on the number of animals (live weight), feed composition and flow rate of air in the barn. If there is this greater amount of gas, it may cause a restriction horses resistance against infections. Sufficient air exchange ventilation rapidly changing content of stable gases in general and therefore ammonia in favor of better environmental cleanliness.

Hydrogen sulfide – $H_2S$

This gas is colorless, poisonous, foul-smelling, flammable. In the stables created by anaerobic decomposition of organic substances, mainly proteins with sulfur amino acids. Dangerous primarily in those technologies where the scrub areas accumulate liquid exudates. When their removal may lead to sudden release of hydrogen sulfide and exceeding permitted levels.

It has a greater density than the other components of air, and therefore is held in a thin

layer near the ground. Slightly higher than normal in a stable condition may be caused by the handling of manure.

Methane – $CH_4$

It is the simplest organic compound is not toxic. In combination with oxygen to form an explosive mixture. Located in the natural gas and coal gas. Creates the absence of air in the fetid swamps fermentation (Holinka 2003).

Is mainly produced in the digestive processes in cattle. If the concentration is increased, may begin threatening physiological processes in animals.

Navrátil (2007) in their publication lists the recommended maximum concentrations of stable gases for horse breeding as follows: $CO_2$ = 2500 ppm, 25 ppm = $NH_3$ and $H_2S$ = 10 ppm. But Kic and Brož (1995) recommend the following maximum concentration: $CO_2$ = 3000 ppm, $NH_3$ = 25 ppm and $H_2S$ = 7 ppm. Czech Technical Standard 73 0543-2 specifies the maximum $CO_2$ concentration of 3500 ppm.

Other gases, such as $N_2O$ or $O_3$ may result from the use of specific compound feed. They do not set their limit. In agricultural buildings to meet with a characteristic odor. Its agents are the animals themselves and then also decomposing products of digestion. In the premises there is adequate ventilation oblivious to the stables, can occur in the summer months to excessive odor intensity, which then annoys the animals and keepers. The concentrations of stable gases can be well eliminated. It is a hygiene environment, regular ventilation, use of air ionization and adding additives to animal manure. Their effectiveness is however low, ranging between 3-10%. It is more efficient but the addition of certain substances directly into the ration. This we can achieve efficiencies of up to 30-40%. This way, but we can eliminate only ammonia (Doležal et al. 2004).

**Description of selected stable**

Measuring the concentrations of stable gases was carried out in the stables VIII and IX of the National Stud Farm in Kladruby nad Labem. In the stable No. VIII were housed only mare in the stable and No. IX were mares with foals. Both stables are exactly the same, just inverted mirror image of yourself.

Stables are rectangular footprint measuring 9.4 meters and 46.3 meters. Height Stables is 4.0 meters. Horses but do not have access to the entire stable area, because on the one hand, the stable is a space for temporary storage of hay. Horse, then use area 9.4 meters to 38 meters.

From the stable door leading to the courtyard and the passage to other neighboring

stables. The door to the courtyard are 2.9 meters wide and 3.2 meters high. The passage has a width of 2.6 meters and height of 2.9 meters. It is closed during most of the lower half of the door, the door to the courtyard when the weather is opened (the horses in the courtyard to prevent the escape of a double barrier).

The barn is a total of 14 identical windows. On the long side of the barn opposite the gate to the courtyard of the nine windows on the short wall opposite the passage is 1 window and on the other long side of the barn are three windows to the right of the door and one window to the left of the door. The window width is 1.3 meters and height of 1.5 meters. The entire area of the window is divided into two independently doors and shutters. You are December to February is fully closed. For most of the two shutters open at about 30% in the summer to open up completely, but always in a way that did not originate in a stable draft. The windows are about the height of a horse's head.

The whole area of the barn, the horses used is about 15-20 cm tall bedding of straw. On it is a means stables conducted about one meter wide strip of hay. In this way, all horses (mares or mares with foals) ensuring equal access to food. Skybal and wet straw was cleaned every day. Approximately 1x per month cleaning out all the bedding and carried out disinfection.

**Materials and methods**

To evaluate the concentrations of stable gases were selected stables VIII and IX of the National Stud Farm in Kladruby nad Labem. In the stable VIII No. 10 mares were housed Kladruby horses. This is a free type of housing. In the stable No. IX was housed 9 Kladruby horse mares with their foals. The births occurred from late January to about mid-March. It is again a free type of housing.

The monitored stables conducted continuous measurements of air temperature and relative humidity. In this measuring device was used Cometr. It was fixed in the stable on the wall in a place where it did not have access horses around at 2 meters above the ground. Was selected recording interval of 15 minutes. The measured values are periodically withdrawn to the laptop to Microsoft Excel, which is then processed. From June to March 1 conducted monthly measurements of stable gases. At this measurement was used ASEKO station. Measurements always took 24 hours. The station itself is placed into the preparation and the sensor is in the middle of the barn hung on a hook from the ceiling in such a way as not to prevent equine handling techniques. The sensors were connected to the station cables, which resulted in the grooves on the ceiling next to electrical lighting. Records of this measurement was set to 10 minute interval.

In parallel with the experienced and airflow inside the barn, the door is open and the courtyard. Unfortunately, this measurement could not be performed continuously. Starokladrubský horse was declared a national monument. It is a typically Czech breed massive character with a strong klabonosa. Behaves in white at the National Stud Farm in Kladruby nad Labem as a black horse in Slatiňany. Its origin comes from old-spain and old-italy horses. These horses were originally designed for the needs of the imperial court in Vienna in harness. White horse used nobles, black horse again church leaders. Currently mainly used in Driving, for ceremonial purposes in some royal courts as a heavy riding horse. For easy handling it uses cavalry municipal police. Kladruby horse population is not very large, numbering about 1,300 horses. A big reduction in the number marked the first World War. Line Starokladrubské horses with white horses are Generale, Generalissimo, Favor, Rudolfo and Sacramoso; u black horses then Sacramoso (1922 and Napoleone), Solo, Siglavi Pakra and Romke (Navrátil 2007).

**Results and discussion**

First the concentration of the individual gases at the age of stable horses in the stable

1.1 Ammonia

For this gas was found less significant dependence of concentration between the two stables. As the concentration of this gas in the stable depends on bodyweight and thus the amount excluded metabolites digestion, it is clear that for most of the live weight of mares with foals less than a live weight of mares in the second barn.

1.2 Methane

For methane found a very close relationship between the concentration in the stable of mares with foals and mares in the barn. It is therefore evident that the concentration of this gas depends primarily on body weight stabled horses. This gas is relatively well ventilated and even winter in compliance with animal hygiene conditions is not a problem.

1.3 Hydrogen Sulfide

A similar situation is also hydrogen sulphide. The degree of dependence between the concentration of this gas in the barn mares with foals with mares in the stable concentration is very tight.

1.4 Carbon dioxide

Correlation of the concentration of this gas in the barn mares with foals with mares in the

stable concentration approaches the value first So there is a very strong addiction.

Tab 3. The concentration of stable gas

| Month | Stable with foals | | | | Stable with mares | | | |
|---|---|---|---|---|---|---|---|---|
| | $NH_3$ | $CH_4$ | $H_2S$ | $CO_2$ | $NH_3$ | $CH_4$ | $H_2S$ | $CO_2$ |
| Year 2011 | | | | | | | | |
| June | 5,7 | 14,8 | 0,8 | 735,6 | 5,6 | 14,6 | 0,9 | 648,8 |
| July | 5,8 | 13,3 | 0,8 | 742,8 | 5,7 | 13,0 | 0,9 | 653,7 |
| August | 5,7 | 15,2 | 0,8 | 748,9 | 5,6 | 14,8 | 0,9 | 655,3 |
| September | 5,5 | 14,9 | 0,8 | 743,9 | 5,3 | 14,3 | 0,9 | 622,6 |
| October | 5,6 | 14,3 | 0,8 | 734,9 | 5,1 | 13,0 | 0,9 | 612,2 |
| November | 5,7 | 15,2 | 0,8 | 827,3 | 5,7 | 15,3 | 0,9 | 828,1 |
| December | 5,6 | 15,3 | 0,8 | 749,3 | 5,6 | 15,3 | 0,9 | 750,8 |
| Year 2012 | | | | | | | | |
| January | 5,6 | 18,3 | 0,8 | 704,2 | 5,6 | 18,4 | 0,9 | 703,5 |
| February | 5,6 | 15,9 | 0,8 | 686,2 | 5,6 | 15,9 | 0,9 | 684,1 |
| March | 5,6 | 15,4 | 0,8 | 829,9 | 5,6 | 15,4 | 0,9 | 828,2 |

This table shows the mean values of stable gases. Typically each month held one measurement length of about 24 hours.

Tab 4. Interpolation weights foals (kg) in the barn No. IX

| Foal / Month | I. | II. | III. | IV. | V. | VI. | VII. | VIII. | IX. | X. | XI. | XII. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 0 | 63 | 100 | 145 | 180 | 220 | 260 | 290 | 310 | 335 | 0 | 0 |
| 2. | 0 | 69 | 95 | 140 | 175 | 210 | 250 | 280 | 305 | 320 | 0 | 0 |
| 3. | 68 | 85 | 105 | 145 | 180 | 205 | 245 | 285 | 325 | 370 | 0 | 0 |
| 4. | 0 | 65 | 105 | 140 | 175 | 210 | 245 | 270 | 300 | 325 | 0 | 0 |
| 5. | 0 | 70 | 115 | 150 | 185 | 220 | 255 | 295 | 310 | 335 | 0 | 0 |
| 6. | 0 | 60 | 100 | 140 | 180 | 225 | 265 | 310 | 330 | 350 | 0 | 0 |
| 7. | 0 | 0 | 65 | 105 | 150 | 195 | 240 | 285 | 310 | 330 | 0 | 0 |
| 8. | 0 | 0 | 74 | 110 | 150 | 195 | 240 | 285 | 315 | 335 | 0 | 0 |
| 9. | 0 | 0 | 68 | 105 | 145 | 185 | 225 | 265 | 290 | 315 | 0 | 0 |
| 9 mares á 700 kg | 6300 | 6300 | 6300 | 6300 | 6300 | 6300 | 6300 | 6300 | 6300 | 6300 | 6300 | 6300 |
| In sum | 6368 | 6712 | 7127 | 7480 | 7820 | 8165 | 8525 | 8865 | 9095 | 9315 | 6300 | 6300 |

Note: red = actual weight of the foal; Yellow = interpolation weights foal

Average monthly growth: 38,857 kg

The average weight of mares during the year varies very little. The production of stable

gas these minor variations do not affect. Therefore, the weight of adult mares considered as constant.

Second the concentration of stable gas on the season

2.1 Ammonia

Ammonia gas is easily ventilated, so if compliance with the basic rules for horse breeding, such as regular removal skybals a maximum number of animals in the barn for which it was designed stable and not exceeded the standard concentration. In the stable to accumulate even in the winter months when conditions deteriorated for ventilation air. At this time, namely, in addition to removal of stale air out and supplying fresh air inside take into account the loss of heat.

2.2 Methane

Methane is also among well-ventilated gases. In horse breeding, causing its increased concentration problems even in the winter months when it is necessary to take into account the economic losses in the form of heat escaping from the stable of excessive ventilation.

2.3 Hydrogen sulfide

Hydrogen sulfide is a gas that is in horse breeding does not occur in higher concentrations. It is far more common in cattle or pigs. From a technical point of view it is not possible to record slight variations in the concentration, the more so as regards its threshold concentration. Changes in the concentration of this gas in both the stable mares with foals and mares in the barn alone was in the order of hundredths and thousandths of a ppm. Therefore, the two lines is constant.

2.4 Carbon dioxide

Carbon dioxide is mainly breathing. Its concentration in the enclosure is thus dependent partly on the number and weight of the horses (the livestock units), their physical activity and then the intensity of the ventilation of stables. Live weight of the animals in the barn mares almost unchanged. However, the live weight of mares with foals grow over time. From the graph it is but obvious that the influence of the concentration of carbon dioxide is a natural activity of animals. And that was generally higher in the stable of mares with foals. Therefore, the concentration of carbon dioxide in the barn mares with foals higher.

Ventilation rate was stable in both approximately equal. This also corresponds to an increase in the concentration of carbon dioxide in the winter months when there is not enough ventilation.

The actual measured $CO_2$ values ranged from 600 to 950 ppm, net issuance is obtained by subtracting a constant 380 ppm. The ammonia concentration ranged between 5.6 and 6.0 ppm. Hydrogen sulfide during a measurement interval 0.7 to 0.8 ppm. The above implies that the concentration of stable gases in the stables of the National Stud Farm in Kladruby nad Labem are entirely within the required limits.

Tab 5. Overview of ambulatory measurement values

| Date, time | Air flow in the stable in m/s | | Air flow in the courtyard in m/s | |
|---|---|---|---|---|
| | interval | median | interval | median |
| 1.4.2011, 11:05 | 0,06 - 0,81 | 0,27 | 0,31 - 2,38 | 0,74 |
| 29.4.2011, 11:30 | 0,07 - 0,41 | 0,15 | 0,23 - 2,89 | 1,43 |
| 27.5.2011, 11:00 | 0,04 - 0,17 | 0,08 | 0,10 - 0,19 | 0,15 |
| 9.6.2011, 11:00 | 0,35 - 1,16 | 0,80 | 0,43 - 3,62 | 2,85 |
| 10.6.2011, 10:00 | 0,08 - 0,42 | 0,12 | 1,86 - 2,47 | 0,43 |
| 7.7.2011, 11:00 | 0,05 - 0,12 | 0,09 | 0,15 - 0,71 | 0,43 |
| 8.7.2011, 10:45 | 0,00 - 0,32 | 0,03 | 0,00 - 1,21 | 0,76 |
| 9.8.2011, 9:30 | 0,00 - 0,82 | 0,16 | 0,04 - 1,63 | 0,86 |
| 10.8.2011, 13:00 | 0,00 - 0,76 | 0,23 | 0,00 - 1,96 | 0,83 |
| 11.8.2011, 10:00 | 0,00 - 0,00 | 0,00 | 0,00 - 0,36 | 0,08 |
| 8.9.2011, 10:00 | 0,01 - 0,46 | 0,20 | 0,07 - 0,51 | 0,25 |
| 9.9.2011, 10:00 | 0,00 - 0,47 | 0,02 | 0,00 - 0,61 | 0,12 |
| 6.10.2011, 10:30 | 0,00 - 0,30 | 0,17 | 0,06 - 1,15 | 0,75 |
| 7.10.2011, 10:30 | 0,00 - 0,00 | 0,00 | 0,00 - 0,29 | 0,03 |
| 3.11.2011, 10:15 | 0,00 - 0,00 | 0,00 | 0,00 - 0,10 | 0,04 |
| 4.11.2011, 10:00 | 0,06 - 0,10 | 0,07 | 0,02 - 0,49 | 0,15 |
| 8.12.2011, 10:00 | 0,07 - 0,54 | 0,29 | 1,93 - 3,19 | 2,65 |
| 9.12.2011, 10:00 | 0,02 - 0,16 | 0,09 | 0,05 - 0,79 | 0,39 |
| 5.1.2012, 10:00 | 0,05 - 1,48 | 0,30 | 0,19 - 4,74 | 2,00 |
| 6.1.2012, 9:30 | 0,08 - 1,83 | 0,54 | 0,15 - 3,90 | 1,78 |
| 16.2.2012, 13:30 | 0,02 - 0,40 | 0,16 | 0,08 - 4,93 | 1,97 |
| 17.2.2012, 14:00 | 0,05 - 0,17 | 0,08 | 0,36 - 2,52 | 1,11 |
| 29.3.2012, 10:00 | 0,19 - 2,64 | 0,45 | 0,17 - 3,86 | 0,96 |
| 30.3.2012, 9:45 | 0,02 - 0,32 | 0,08 | 0,05 - 1,29 | 0,66 |

## Conclusion

The concentration of stable gas depends on the number and age of the horses in the stable, their physical activity and ventilation. A close relationship was observed with concentrations of carbon dioxide, hydrogen sulfide and methane when comparing their concentrations in mares with foals barn with stables themselves mares. In ammonia was demonstrated moderate level of dependence. This was probably due to the low concentration of this gas and the fact that it is released continuously from the litter.

Measured gases has been demonstrated that their concentration in the stable of mares with foals is higher than in the barn where they were housed only mares. This fact can be explained by the fact that the Colts for most of the day are physically active, and secondly, by themselves cause their breathing higher concentrations of carbon dioxide and, secondly, how they move the litter and mechanically cause a higher rate of release of gas from skybals.

The concentration of stable individual gases to the season was observed only carbon dioxide and methane even partially. This is due to limited ventilation in the winter months when it is necessary, on the one hand, to ensure a supply of fresh air in stables and on the other, also take into account the loss of heat.

## References


Dobroruka, J. a Kholová H.: Zkrocený vládce stepi. Panorama, Praha, 1992.

Doležal, O. a kol.: Zásady welfare a nové standardy EU v chovu skotu. VÚŽV, Praha, 2004.

Ende, H.: Die neue Stallapotheke. Müller Rüschlikon Verlags AG, Cham, 2000.

Franěk, B. a kol.: Úprava stájového prostředí. SZN, Praha, 1965.

Holinka, J.: Chemie. Nakladatelství Radek Veselý, Třebíč, 2003.

Hujňák, J.: Přestavby a opravy stájí. ÚZPI, Praha, 1997.

Kic, P. a Brož, V.: Tvorba stájového prostředí. Institut výchovy a vzdělávání Mze ČR, Praha, 1995.

Kic, P. a Brož, V.: Zařízení pro větrání a klimatizaci stájí. Institut výchovy a vzdělávání Mze ČR, Praha, 2000.

Kic, P.: Úprava vzduchu ve stájových objektech. Ústav zemědělských a potravinářských informací, Praha, 1996.

Navrátil, J.: Základy chovu koní. ÚZPI Praha, Praha, 2007.

Sode, M. L.: Kenne ich mein Pferd? Franckh-Kosmos Verlags, Stuttgart, 1992.

Šoch, M.: Vliv prostředí na vybrané ukazatele pohody skotu. Jihočeská univerzita v Českých Budějovicích, České Budějovice, 2005.

Česká technická norma ČSN 73 0543 - 2, Vnitřní prostředí stájových objektů, část 2.: Větrání a vytápění. Český normalizační institut Praha, Praha, 1998.

www.csu.cz

**Acknowledgement**

NAZV QJ1210144, GAJU 020/2013/Z a MZE 0002701404

**Summary**

Jeden z problémů současné živočišné výroby může být vyšší koncentrace zvířat na jednotku plochy. Zároveň se na zvířata zvyšují požadavky na jejich užitkovost. Je tedy nutné znát nároky zvířat na jejich skutečné potřeby a ne je vytvářet podle subjektivních představ člověka. Je potřeba sledovat vlivy jednotlivých faktorů, ale i jejich komplexní působení na hospodářská zvířata. Užitkovost zvířat a tedy i úspěšnost celého chovu závisí na mnoha faktorech – na výživě hospodářských zvířat, na způsobu ustájení, hygieně prostředí, veterinární péči, na plemeni hospodářských zvířat a jeho fyziologických možnostech a v neposlední řadě i na mikroklimatických podmínkách ve stáji.

Měření stájových plynů pro svou technickou náročnost probíhalo v Národním hřebčíně v Kladrubech nad Labem 1x za měsíc a to ve 24 h cyklu, od dubna 2011 do března 2012.

Cílem této práce bylo sledování koncentrací stájových plynů - oxidu uhličitého, metanu, sirovodíku a amoniaku ve stáji klisen s hříbaty a ve stáji, kde byly pouze dospělé klisny. Předmětem zájmu byly rovněž odchylky koncentrací těchto plynů v průběhu roku.

**Contact**

Ing. Jan Kalíšek

Výzkumný ústav živočišné výroby, v. v. i., Praha – Uhříněves, Přátelství 815, 104 00, Praha Uhříněves, Česká republika

Jihočeská univerzita v Českých Budějovicích, Česká republika