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Phenotyping intake rate in dairy goats, a repeatable trait which can be measured automatically

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Abstract. In intensive systems, high producing animals are at risk of acidosis due to the high proportion of concentrates in their diet. There is considerable variability between individuals in occurrence and severity of acidosis which is likely related to feeding behaviour. Phenotyping this behaviour could explain some of the variation in digestive efficiency, and therefore in feed efficiency. Feeding behaviour was assessed at three periods (1st and 2nd lactations, 2nd gestation) on thirty-five contemporary goats. The evolution of feed intake during 15 hours after the afternoon allowance was measured individually every 2 min for 3 days. Two phenotypes were calculated: Q90 (quantity of diet consumed during the first 90 minutes post-feeding), P90 (Q90/quantity consumed during 15 hours). Intra-period individual repeatability was very high. The value for one period was highly correlated with that of a preceding one for P90, but poorly for Q90. Given this repeatability, it would be possible to characterise the feeding behaviour of all the goats during their first lactation and, in the following lactations, to restrict feed allowance of those with the highest P90 or Q90 in order to decrease the occurrence of acidosis in the herd, and thereby increase efficiency. These results on the variability of intake rate show that simple criteria to phenotype goats on intake rate can be applied in precision livestock farming systems.

Keywords. Precision livestock farming – Phenotyping – Intake rate – Dairy goats.

Phénotypage de la vitesse d'ingestion des chèvres laitières, une caractéristique utile et répétable qui peut être mesurée automatiquement

***Résumé**. Dans les systèmes intensifs, les animaux hauts producteurs reçoivent une ration riche en aliments concentrés, mais peuvent souffrir d'acidose avec une occurrence et une intensité variables d'un animal à l'autre qui seraient liées au comportement alimentaire. Le phénotypage de ce comportement expliquerait une partie des variations de l'efficacité de la digestion, et donc de l'efficacité alimentaire. Ce comportement a été mesuré à trois périodes (1ère et 2nde lactations, 2nde gestation) sur trente-cinq chèvres contemporaines. L'évolution de l'ingestion pendant les 15 heures suivant la distribution de l'après-midi a été mesurée individuellement toutes les 2 min pendant 3 jours. Deux phénotypes ont été calculés : Q90 (quantité d'aliment ingérée pendant les 90 minutes suivant la distribution), P90 (Q90/quantité ingérée en 15 h).La répétabilité individuelle était très élevée intra-période. La valeur à une période donnée était fortement corrélée à celle de la période précédente pour P90, mais faiblement pour Q90. Ainsi, il serait possible de caractériser le comportement alimentaire de toutes les chèvres pendant leur première lactation et, pour les lactations suivantes, de restreindre la quantité d'aliment distribuée pour celles présentant les plus hauts P90 ou Q90 afin de diminuer l'apparition de l'acidose dans le troupeau, et donc d'augmenter son efficacité. Ces résultats sur la variabilité de la vitesse d'ingestion montrent que des critères simples peuvent être proposés pour phénotyper les chèvres dans le cadre de l'élevage de précision.*

***Mots-clés.** Elevage de précision – Phénotypage – Vitesse d'ingestion – Chèvres laitières.*

I – Introduction

In intensive systems, high producing animals are fed with a high proportion of concentrates in the diet to meet their requirements. With such acidogenic diets, animals often suffer from acidosis with an occurrence and an intensity differing from one animal to another (Brown *et al.*, 2000; Gao and

Oba, 2014). In previous studies, we showed that feeding behaviour is a key factor to explain the inter-individual variation in the evolution of rumen pH, and therefore in the occurrence of acidosis (Desnoyers *et al.*, 2011). The aim of this study was to develop repeatable, pertinent, and easy to measure criteria to evaluate this trait in dairy goats.

II – Material and methods

1. Animals, Design, Diets and Feeding

The present study was carried out according to French legislation on animal experimentation in line with the European Convention for the Protection of Vertebrates used for Experimental and other Scientific Purposes (European Directive 86/609). Protocols were approved by the ethical committee.

Feeding behaviour was assessed at three different periods during their adult life on thirty-five dairy goats born in early 2011:

- Middle of first lactation (spring 2012)
- End of first lactation and middle of second gestation (autumn 2012)
- Middle of second lactation (spring 2013)

Thirteen goats were from Alpine breed and twenty-two from Saanen breed. At each period of measurement they were housed for 12 days, including 9 days of adaptation, in individual pens with automatic measurement of the quantity of feed eaten every two minutes with free access to feed and water (Giger-Reverdin *et al.*, 2012).

They were fed *ad libitum* a complete diet adapted to requirements. On a dry matter basis, its composition was: 20% concentrate, 20% meadow hay, 30% dehydrated Lucerne and 30% pressed sugar beet pulp silage. One third of the diet was delivered after the morning milking (around 7 a.m.) and two thirds after the afternoon milking (around 3 p.m.) according to the intervals between milkings.

Animals were weighed at each experimental period before the afternoon milking. Dry matter content of the diet was measured during each period of measurement

2. Recording of dynamic patterns of intake

The evolution of feed intake during 15 hours after the afternoon allowance was automatically measured by weighing devices fitted under individual feed-troughs with a recording frequency of every 2 minutes on three days in each period. Two phenotypes were automatically calculated and analysed:

- Q90: quantity of diet consumed by 90 minutes post afternoon feed distribution expressed on a dry matter basis per kg of body weight.
- P90: ratio between Q90 and total quantity of feed consumed between the afternoon feed distribution and the next morning milking (consumption in fifteen hours). This is an estimation of the rate of intake during the main eating phase after feed distribution.

3. Statistical analysis

The mean values and standard deviation of P90 and Q90 were calculated per goat at each period. Across animals, the average variability was estimated as the average of the standard deviation of this mean value. It was estimated for each period (n = 35 goats), and for the combined three periods (n = 105 observations).

Between-animal variability per period was estimated by the standard deviation of the individual goat mean value. A variance analysis was performed with all the period combinations.

The correlations between periods were calculated using the individual within-period means.

III – Results and discussion

1. Factors of variation of the phenotypes

A. Evolution between periods and between-goat variability

The mean Q90 value varied from 8.90 to 27.4 g DM/kg BW with a mean value of 16.1 and a standard deviation of 3.63 (n = 105). It was similar between the first two periods (P1 = 14.6 ± 3.36 vs P2 = 14.8 ± 2.83) and significantly higher at the third period (18.8 ± 3.03).

The mean P90 value varied from 0.242 to 0.768, with a mean value of 0.499 and a standard deviation of 0.1115 (n = 105). It was significantly lower for the first period (0.416 ± 0.1055) compared to the others (P2 = 0.524 ± 0.0972 vs P3 = 0.556 ± 0.0796). The between-goat variability decreased as goats get older. The mean value of 0.499 showed that goats ate around half of the total intake of the 15 hours during the first 90 minutes after feed allowance.

The increase in P90 as goats get older is also in agreement with the observations on cows as primiparous cows ate more slowly than multiparous (Beauchemin and Rode, 1994; Neave *et al.*, 2017).

The effect of goat was significant for these two variables (Q90 and P90) which shows a significant between animals variability. This agrees with previous data on goats (Daovy *et al.*, 2008) or on cows (Vasilatos and Wangsness, 1980) suggesting that eating behaviour may be characteristic of individuals.

B. Across animals, average repeatability

The mean standard deviation of the Q90 value/goat/period varied from 0.13 to 4.18 with a mean value of 1.56 (± 0.896). It was the highest during the first period (2.05) but not significantly different for the other two periods (P2 = 1.33 and P3 = 1.29).

The mean standard deviation of the P90 value/goat/period varied from 0.0057 to 0.0941 with a mean value of 0.0422 (± 0.02321). It decreased significantly from the first (0.0520) to the third period (0.0343) with a mean value of 0.0406 for the second period which did not differ from each of the other periods.

The period effect was significant for these two variables, but there was no goat effect. These values show that there is a good repeatability for each goat within a period, and that the behaviour is more repeatable as animals get older.

2. Evolution between periods

The quantity eaten during the 90 first minutes of the first period was highly correlated with that eaten at the second period (r = 0.61, n = 35, P = 0.001) and correlated with that of the third period (r = 0.42, n = 35, P = 0.01). However, the correlation between the quantities eaten at the second and third periods was not significant. For the P90, the highest correlation concerned the first with the third period (r = 0.63, n = 35, P = 0.001). The others were also significant: (P1 and P2, r = 0.54, P = 0.001; P2 and P3, r = 0.38, P = 0.03).

These results meant that the rate of intake (P90) is more repeatable than the Q90 and is a characteristic of the feeding behaviour of the goat.

IV – Conclusion and practical implications

It is possible to derive summary measures to characterise the feeding behaviour of all the goats. This suggests that this could be evaluated during their first lactation (corresponding to the first period of this trial) and, in the following lactations, to restrict the feed allowance of those with the highest P90 or Q90 in order to decrease the risk of acidosis in the herd, and then increase efficiency and welfare (Giger-Reverdin *et al.*, 2013).

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