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Prevalence and potential influencing factors of non-nutritive oral behaviors of veal calves on commercial farms

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ABSTRACT

Veal calves raised under intensive conditions may express non-nutritive oral behaviors. When expressed in an abnormal way, these behaviors can be a sign of mental suffering and reduced welfare due to a mismatch between environmental or management features and the animal's needs. The aims of this study were to estimate the prevalence of non-nutritive oral behaviors in a large sample of veal farms in Europe and to determine the potential influencing factors present at farm level. Data were collected on 157 commercial veal farms in the 3 main veal-producing countries in Europe (the Netherlands, France, and Italy). Observations of 3 non-nutritive oral behaviors (manipulating substrates, tongue rolling, and manipulating a penmate) were performed when calves were aged 14 wk, and the prevalence of these behaviors was calculated. Information on management practices and characteristics of the building and equipment were collected on all farms to assess potential influencing factors for each of the 3 behaviors. Odds ratios and 95% confidence intervals were calculated to evaluate the effect of each individual factor within a generalized linear model. The mean percentage of calves per farm performing manipulating substrates was 11.0 ± 0.46%, performing tongue rolling 2.8 ± 0.18%, and manipulating a penmate 2.7 ± 0.09%, with a high range between farms. Allowing more space for calves than the legal minimum requirement of 1.8 m^2/ calf and housing them in groups of >10 calves/pen reduced the incidences of manipulating substrates and tongue rolling. Incidence of manipulating substrates was lower for calves fed maize silage compared with calves fed cereal grain, pellets, or muesli. A higher risk of tongue rolling was found when baby-boxes (i.e., single housing during the first 5 to 8 wk) were not used. Risk of calves manipulating a penmate was higher for calves of milk- or meat-type breeds compared with dual-purpose breeds and for calves fed with 280 to 380 kg compared with those fed >380 kg of milk powder in total for the fattening period. The study allowed assessment of multiple factors across farms that showed variety in terms of conditions and level of non-nutritive oral behaviors. Identification of the factors influencing non-nutritive oral behavior is helpful to define potential actions that could be taken on farms to improve the welfare of calves and reduce the prevalence of these behaviors.

Key words: animal welfare, non-nutritive oral behavior, risk factor, veal calf

INTRODUCTION

Veal calves raised in intensive husbandry systems may experience environmental and management conditions that do not entirely fulfill their behavioral and physiological needs. Veal calves, for example, are separated from their dams at an early age and, therefore cannot ingest their dams' milk in a natural way. Instead, same-aged calves of different farms are brought together in fattening units, where they are commonly fed twice a day with milk replacer from a bucket, trough, or automatic milk delivery device (**AMD**) and a limited amount of solid feed. This condition of unnatural feeding of calves (no dam, imposed time) may result in increased levels of non-nutritive oral behaviors and lead to the expression of abnormal oral behaviors compared with calves with free access to suckle their dams (Fröberg and Lidfors, 2009).

Veal calves express different types of non-nutritive oral behaviors, of which the most frequent are manipulating (licking, nibbling, or biting) substrates of their homepen (Le Neindre, 1993; Veissier et al., 1998), cross sucking (Jensen, 2003), and tongue rolling (Le Neindre, 1993). Non-nutritive oral behaviors were first studied in individual housing where calves, for example,

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spent 10 to 20% of the observed time on manipulating substrates of their homepen (Le Neindre, 1993; Veissier et al., 1998). In group housing, non-nutritive oral behaviors represented between 15 and 35% of the activity of calves, with 15 to 20% of the observed time spent on manipulating substrates (Bokkers and Koene, 2001; Webb et al., 2012). These behaviors are mostly performed around feeding (Veissier et al., 1998) and are thought to be stimulated by milk drinking itself (de Passillé et al., 1992). Nibbling and biting of substrates probably derive from the normal ontogeny of grazing in (pre-)ruminants (Veissier et al., 1998) and from an intrinsic need for exploring (Sato and Wood-Gush, 1988). These behaviors, therefore, indicate that without the opportunity to graze, the absence of an appropriate amount of roughage, or with a poorly stimulating living environment, calves redirect their grazing, ruminating, and exploring behaviors toward inappropriate objects. Licking and sucking of objects might be more related to suckling behavior (de Passillé et al., 1992). Calves have a strong motivation for suckling. In the absence of their dam or a teat, they may redirect this behavior toward elements in their environment. In group housing, suckling can also be directed toward conspecifics, resulting in calves performing cross-sucking (Jensen, 2003). A third category of non-nutritive oral behavior observed in calves is tongue rolling. Tongue rolling is described as a repeated movement of the tongue that can be performed inside and outside the mouth. Tongue rolling represented 1.5 to 5% of the activity of calves in individual (Le Neindre, 1993; Veissier et al., 1998) or group housing (Veissier et al., 1998; Bokkers and Koene, 2001; Webb et al., 2012, 2013).

Behaviors can be considered abnormal for several reasons: when they differ from the norm because they are directed toward inappropriate objects, when they differ from the animal's specific range of behavior in its nature or frequency, or when they have no function or are harmful to the individual (Mason, 1991; Garner, 2005). Abnormal behaviors are mostly performed by animals living in inappropriate captive environments (Mason, 1991) and are increased by social deprivation (Veissier et al., 1998). They can be a serious sign of mental suffering and reduced welfare (Broom and Fraser, 2007). Manipulating substrates is generally not considered an abnormal behavior in calves because it is part of their normal exploratory behavior. However, when this behavior is performed for a significant amount of time and especially around meals it can be a redirected behavior, which is an indication of frustration related to the feeding strategy and therefore a sign of reduced welfare. Manipulating a penmate (cross sucking) is an abnormal behavior because it is a redirection from milk suckling behavior toward the ear, tail, navel, prepuce, or udder of other calves. It can affect the health and welfare of calves because it leads to hair loss and inflammation of the navel or scrotum of the exposed calf (Wiepkema et al., 1983; Jensen, 2003) or to urine drinking, leading to intoxication. Tongue rolling (and to a lesser extent, biting of objects) is often expressed in a stereotypical way. Stereotypies were defined by Mason (1991) as repetitive, invariant behaviors without obvious goal or function. They can indicate frustration or lack of stimulation experienced by the animal (Mason, 1991; Mason and Latham, 2004) and are an attempt by the animal to cope with its environment (Mason and Rushen, 2008). These behaviors are stress-related and, because of the potential calming effect on the animal performing them, they can be a way for the animal to adapt to its environment (Mason, 1991). A high level of tongue rolling behaviors on a farm could therefore be a sign that the animals invest a lot of effort in adapting to their living conditions and that their level of welfare is affected (Broom, 1986). In addition, recent findings indicate that not all animals under similar housing and management conditions show stereotypies, which might mean that those animals not showing the behavior suffer more (Mason and Latham, 2004; Mason and Rushen, 2008). This abnormal behavior indicates problems in the rearing conditions of calves and could be a sign of reduced welfare for both the animal performing it and the animal not performing it. Thus, non-nutritive behaviors can be signs of reduced welfare and their prevalence should be assessed on farms.

In the European Union, all calves from 8 wk of age must be housed in groups and provided daily with a minimum amount of fibrous feed of 50 to 250 g from 8 to 20 wk of age (European Union, 1997, 2008; Council Directives 97/2/EC and 2008/119/EC). Studies carried out on a small number of farms and under experimental conditions, however, showed that even group-housed veal calves provided with some solid feed perform abnormal oral behaviors (Bokkers and Koene, 2001; Webb et al., 2012, 2013). The prevalence of abnormal oral behaviors increases with inappropriate feed or environment and lack of stimuli. It also increases when calves gain age (de Passillé et al., 1992; Bokkers and Koene, 2001; Webb et al., 2012). Although the prevalence of abnormal oral behaviors in veal calves is documented rather extensively, no studies have been conducted to analyze the potential influencing factors on commercial farms.

The objectives of this study therefore were to estimate the prevalence of non-nutritive oral behaviors in veal calves housed in groups on a large number of commercial farms and to determine the potential influencing factors present at the farm level. The results may facilitate the implementation of remedial measures

on housing conditions and management of veal calves to reduce abnormal oral behaviors on commercial veal farms.

MATERIALS AND METHODS

Farm Sample

Data were collected between summer 2007 and spring 2009 on 157 veal farms in the Netherlands (98 farms), France (45 farms), and Italy (14 farms). Farms were selected so that they represented a cross-section of farms producing veal in Europe involving the 3 main veal-producing countries and the prevailing rearing systems in terms of housing and feeding strategies (Brscic et al., 2011). Calves were housed either in small (4 to 6 calves per pen) or intermediate-size groups (7 to 15 calves per pen) and milk-fed by bucket (39 farms) or trough (98 farms), or in large groups of 25 to 80 calves per pen and milk-fed with an AMD (20 farms). All farms complied with the EU Council Directives 97/2/EC and 2008/119/EC (European Union, 1997, 2008). The sample within each country consisted of farms located in the main regions where veal calves are raised and was selected from farms belonging to integrators or owners willing to participate in the study. A single batch of calves (i.e., a group of same-aged calves) was selected for each farm, and the tested batches were evenly distributed across all 4 seasons. Calves arrived at the fattening units at approximately 15 d of age and were slaughtered at 17 to 30 wk of age. Farms showed variation in type and origin of calves, size of the farm, diet (amount and composition of milk replacer and amount and type of solid feed), climate control, daylight intensity, and general management.

Behavioral Observations

Behavioral observations were performed on all farms when the calves were aged 14.9 ± 1.6 (SD) wk by one observer per farm (10 observers in total). Observers (men and women) wore similar dark-colored clothing on all farms. Although the observers were experienced in behavioral research, they completed training with videos and photos of calf behavior and practiced together at a farm beforehand (for methodology, see Bokkers et al., 2009). Observers were considered sufficiently trained when they reached 80% agreement with the gold standard.

On all farms, observations were performed in 3 sessions corresponding to the same time points in the daily routine procedures of the day in each farm. The morning session took place approximately 1 h after the start of the morning meal. The noon session took place around 1200 h. The afternoon session took place at least 1 h before the start of the afternoon meal. During the day of observation, lights were on in the building(s). In each session (morning, noon, afternoon), 3 observation bouts of 10 min were performed on different pens. Observation pens and the order of observation were randomly selected beforehand. In farms with groups of fewer than 15 calves per pen, 4 pens were observed simultaneously for each observation bout (different pens used for each observation bout), and 36 pens in total (3 sessions × 3 observation bouts × 4 pens) were observed. In farms with groups of more than 15 calves per pen, 1 pen was observed for each observation bout, and 9 pens in total (3 sessions × 3 bouts × 1 pen) were observed. All pens were observed if there were fewer than 9 pens, with observations repeated for some pens to obtain 9 observations at each farm.

For each observation bout, the observer waited 5 min before starting the observation, so that calves could become accustomed to the observer's presence. Thereafter, the observer recorded, every 2 min, the posture (lying/standing) and the behavior of all calves in each pen using instantaneous scan sampling (Altmann, 1974). A complete ethogram was used during observation (see Leruste et al., 2013). For this study, only non-nutritive oral behaviors were analyzed. The following behaviors were recorded: oral manipulation of substrates (the calf licks, nibbles, sucks, or bites an object such as wall, fence, bucket, trough, floor, or any other object accessible in the pen, except for feed), tongue rolling (calf performs a repeated movement of the tongue inside or outside the mouth), and manipulating a penmate (calf takes into its mouth and sucks or bites a part of the body of a penmate, including sucking the prepuce and drinking urine from the prepuce).

Farm Data

On all farms, information was collected, by means of a questionnaire, on the characteristics of the building and equipment such as the type of milk distribution system, number of calves, space allowance, prevalent breed, and so on (Table 1). The stockpersons were interviewed on another day (before the behavioral observations were made) about management practices, such as number of years of experience with calves, daily time spent in the building, frequency of the visit by the technical adviser, and so on. These data were used to determine a list of potential influencing factors for the prevalence of non-nutritive oral behavior.

Statistical Analysis

Data were analyzed by using GenStat software (GenStat Committee, 2000) with farm as statistical unit.

Table 1. Parameters recorded on veal farms through the questionnaire

Item	Level
Parameters related to production and housing system	
Farm size (total number of calves)	≤300 | 300 < x ≤600 | 600 < x ≤1,200 | > 1,200
Space allowance	= 1.8 | >1.8 m^2/calf
Type of floor	Slatted wooden floor | slatted concrete floor | slatted rubber floor or straw
Estimated luminosity of the barn	Light | half-light | dark
Environmental enrichment	No | Yes
Renovation of the barn	≤4 | 4 < x ≤8 | >8 yr
Parameters related to batch characteristics	
Quality of the batch at arrival[1]	Good | average | bad
Season at arrival at the farm	Spring | summer | autumn | winter
Calves' origin	National | one foreign country | several countries
Prevalent breed	Holstein or other milk breed | dual-purpose breed | crossbred or meat breed
Percentage of females	0 | 0 < x ≤5 | >5%
Average hemoglobin level at the age of observation	≤5.7 | 5.7 < x ≤6.2 | >6.2 mmol/L
Average number of calves/pen	≤6 | 7 ≤ x ≤9 | ≥10
Age of calves at observation	Less | More than 15 wk
Duration of fattening cycle	<24 | 24 ≤ x ≤30 | >30 wk
Parameters related to management and farmer experience	
Prophylaxis treatment	No | Yes
Use of individual baby-boxes	No | Yes
Duration of baby-box use	0 | 0 < x ≤4 | 4 < x ≤6 | >6 wk
Sorting/regrouping practice	No | Yes
Frequency of visits by technician	Weekly | every 2 wk | More than 2 wk between visits
Frequency of visits by veterinarian/fattening cycle	<3 | ≥3
Frequency of visits by farmer/day	≤2 | >2
Farmer's experience	≤5 | 5 < x ≤15 | 15 < x ≤25 | >25 yr
Years of adoption of the existing rearing system	≤2 | 2 < x ≤10 | >10 yr
Number of stockpeople	1 | 2 | 3 or more
Urine drinkers are separated	No | Yes
Parameters related to feeding system	
Type of milk delivery system	Bucket | trough | automatic milk delivery device
Total amount of milk-replacer powder	≤280 | 280 < x ≤330 | 330 < x ≤380 | >380 kg/calf per fattening cycle
Calves always receive ≥14 liquid meals/wk	No | Yes
Prevalent type of solid feed	Maize silage | pellets or muesli | cereal grain[2] | treated maize[3]
Total amount of solid feed	≤50 | 50 < x ≤100 | 100 < x ≤150 | 150 < x ≤300 | >300 kg of DM/calf per fattening cycle
Type of roughage distribution	On floor | trough or bucket | separated trough or bucket | automatic distribution | start period in trough, fattening period on floor | trough and separated trough | trough and automatic distribution
Water provision	Ad libitum | limited | no water
Water origin	Tap | well
Drinker type	Bucket | trough | nipple | bowl | other

[1]Estimation by the farmer.

[2]Barley or maize.

[3]Rolled or flaked maize or both.

For each farm, data from the 3 observation sessions (morning, noon, afternoon) were summed. Data were expressed as average percentages with standard error (SE) of calves performing a specific behavior by unit of time. Risk factor analyses were performed for each of the following response variables: percentage of calves manipulating substrates, percentage of calves performing tongue rolling, and percentage of calves manipulating a penmate.

The explanatory variables used for the construction of the models were obtained from the questionnaire and are listed in Table 1. Levels of factors were defined according to the frequency of farms per level and, according to Brscic et al. (2011), all covariables were transformed into class variables with a maximum of 5 classes. Potential influencing factors were at first inspected individually by generalized linear model (GLM) univariate analyses, and those factors significantly associated with the dependent response variable ($P < 0.10$) were further included in the multivariate analysis. Final multivariate models were built using both stepwise backward and forward selection. On the union of the final models of both selection procedures, best subset selection was performed and significance tests for the effects of the selected influencing factors were evaluated. Consistent with the statistical approach of Brscic et al. (2012), only main effects were considered, precluding interactions and avoiding multicollinearity

problems. The model selection procedure was based on an increase in R^2 and retaining factors that were significant ($P < 0.05$), where R^2 is the square of the multiple regression coefficient and represents the explained portion of the variance in the dependent variable. The final model was fitted to the data, and for each risk factor retained in the final model, an odds ratio and a corresponding 95% confidence interval was obtained. All generalized linear models were logistic regression models, comprising a multiplicative overdispersion factor with respect to the binomial variance function. Occasionally, some farms were missing in the odds ratio analyses (n < 157) because information on particular parameters was missing on those farms.

RESULTS

General Results

The mean percentage of calves per farm manipulating substrates was 11.0 ± 0.46% (range 2.2–38.6; Figure 1), tongue rolling 2.8 ± 0.18% (range 0.2–14.8), and manipulating a penmate 2.7 ± 0.09% (range 0.5–8.1).

Risk Factor Analyses

Manipulating Substrates. Prevalent breed of calves, farmer's experience, prevalent type of solid feed, space allowance per calf, average number of calves per pen, and season when the batch entered the farm were found to influence ($P < 0.05$) the percentage of calves manipulating substrates (Table 2). These variables accounted for 41.6% of the variance. Crossbreed or meat-breed calves were associated with a higher risk of manipulating substrates compared with dual-purpose breeds. Compared with a farmer's experience of 5 to 15 yr, the other experience classes showed increased risk for the development of manipulating substrates in calves. Calves fed maize silage showed a lower level of manipulating substrates compared with calves fed pellets, muesli, or cereal grain. A space allowance above the legal requirement (1.8 m^2) was associated with a lower risk of calves manipulating substrates. Farms with calves housed in pens of fewer than 10 calves were associated with a higher incidence of calves manipulating substrates compared with farms with calves housed in pens of more than 10 calves. The incidence of manipulating substrates was greater when the batch arrived at the farm during summer (i.e., behavioral observations performed during autumn) compared with winter.

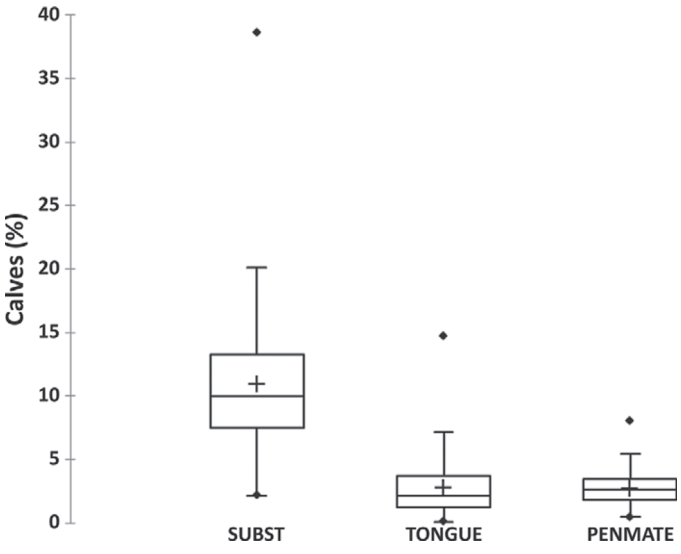

Figure 1. Prevalence of calves manipulating substrates (SUBST), tongue rolling (TONGUE), and manipulating a penmate (PENMATE) among the 157 farms. Dots represent minimum-maximum values of the sample, and line and cross in the box represent median and average values, respectively, of the variable.

Tongue Rolling. Number of calves per pen, space allowance per calf, and use of baby-boxes (i.e., single housing during the first 5 to 8 wk) were found to influence ($P < 0.05$) the percentage of calves performing tongue rolling (Table 3). These variables accounted for 20.9% of the variance. A higher risk of calves performing tongue rolling was found in calves housed in pens of fewer than 10 calves compared with those housed in pens of more than 10 calves. Allowing more space for calves than the legal requirement (1.8 m^2) reduced the risk of calves performing tongue rolling. Calves showed an increased level of tongue rolling when no baby-boxes were used, compared with farms were baby-boxes were used.

Manipulating a Penmate. Breed of calf and amount of milk powder were found to influence ($P < 0.05$) the percentage of calves manipulating a penmate (Table 4). The variables accounted for 12.2% of the variance. Compared with dual-purpose breed, Holstein or milk breed and crossbreed or meat breed calves showed a higher risk of manipulating a penmate. Compared with calves fed more than 380 kg of milk powder in total for the fattening period, calves fed between 280 and 380 kg of milk powder were associated with an increased risk of manipulating a penmate.

DISCUSSION

The objectives of this study were to estimate the prevalence of non-nutritive oral behaviors of group-housed veal calves in a large sample of commercial farms and to identify potential influencing factors at the farm level.

Risk factor analysis was performed considering the relevant variability observed within the farm sample of

Table 2. Multivariate regression model for the percentage of calves performing manipulating substrates (n = 153)[1]

Factor	Level	Predicted prevalence	Odds ratio	95% CI	*t*	*P*-value
Breed	Holstein or milk breed	10.42[ab]	1.24	0.99–1.55	0.066	0.024
	Dual-purpose breed	8.62[b]	—	—	—	
	Crossbred or meat breed	11.80[a]	1.43	1.10–1.84	0.007	
Farmer experience	≤5 yr	11.32[a]	1.43	1.15–1.80	0.002	<0.001
	5 < x ≤15 yr	8.21[b]	—	—	—	
	15 < x ≤25 yr	10.20[a]	1.27	1.04–1.56	0.021	
	>25 yr	11.40[a]	1.45	1.21–1.72	<0.001	
Prevalent type of solid feed	Maize silage	8.24[b]	—	—	—	<0.001
	Pellets or muesli	10.79[a]	1.35	1.14–1.61	0.001	
	Cereal grain	12.15[a]	1.55	1.26–1.91	<0.001	
	Treated maize	9.93[ab]	1.23	0.89–1.70	0.207	
Space allowance	1.8 m^2/calf	11.78[a]	1.39	1.17–1.66	<0.001	<0.001
	>1.8 m^2/calf	8.58[b]	—	—	—	
No. of calves/pen	≤6	11.13[a]	1.60	1.25–2.05	<0.001	0.001
	7–9	12.42[a]	1.82	1.34–2.46	<0.001	
	≥10	7.29[b]	—	—	—	
Season of arrival at the farm	Spring	9.49[b]	1.05	0.81–1.35	0.735	<0.001
	Summer	12.90[a]	1.48	1.20–1.83	<0.001	
	Autumn	9.62[b]	1.06	0.85–1.32	0.598	
	Winter	9.12[b]	—	—	—	

[a,b]Values within the same column with different superscripts per level differ significantly ($P < 0.05$).
[1]Adjusted $R^2 = 41.6$.

non-nutritive oral behaviors despite moderate standard errors. On the studied farms, calves exhibited very low or high levels of non-nutritive oral behaviors and manipulating substrates in particular. In the present study, the average prevalence of the observed behaviors was comparable to values found in previous studies in group-housed calves observed around 3 to 4 mo of age (Bokkers and Koene, 2001; Webb et al., 2012, 2013), with tongue rolling and manipulating a penmate representing around 3% of the time-budget of calves and manipulating substrates representing about 10%.

The final risk factor model for manipulating substrates explained more than 40% of the variance with factors related to calves, farmer, feed, housing, and season. The final risk factor model for tongue rolling explained 20% of the variability, with risk factors only related to housing (group size, space allowance, and use of baby-boxes). The lower proportion of variability explained could be due to the lower prevalence of the measure. These results suggest that housing can be an important factor for the development of tongue rolling, as previously observed in individually housed calves by Le Neindre (1993) and in group-housed calves by Bokkers and Koene (2001). The final risk factor model for manipulating a penmate explained 12% of the variability, with factors related to both calves and feed. Again, this measure had a low prevalence, which made the model unstable, with a low proportion of the variability explained.

Differences between calves of different types of breed were found. Crossbred or meat-type calves showed a higher risk of manipulating substrates compared with calves of dual-purpose breeds, and both Holstein or milk breed calves and crossbred or meat breed calves

Table 3. Multivariate regression model for the percentage of calves performing tongue rolling (n = 143)[1]

Factor	Level	Predicted prevalence	Odds ratio	95% CI	*t*	*P*-value
No. of calves/pen	≤6	3.24[b]	1.85	1.06–3.23	0.032	0.002
	7–9	4.40[a]	2.56	1.46–4.46	0.001	
	≥10	1.78[c]	—	—	—	
Space allowance (m^2/calf)	=1.8	3.79[a]	1.55	1.16–2.07	0.003	0.002
	>1.8	2.49[b]	—	—	—	
Duration of baby-box use (wk)	No baby-box	5.76[a]	2.89	1.83–4.54	<0.001	<0.001
	0–4	2.09[b]	—	—	—	
	4–6	2.31[b]	1.11	0.82–1.49	0.498	
	>6	2.41[b]	1.16	0.78–1.72	0.460	

[a–c]Values within the same column with different superscripts per level differ significantly ($P < 0.05$).
[1]Adjusted $R^2 = 20.9$.

Table 4. Multivariate regression model for the percentage of calves performing manipulating a penmate (n = 111)[1]

Factor	Level	Predicted prevalence	Odds ratio	95% CI	*t*	*P*-value
Breed	Holstein or milk breed	2.90[a]	1.53	1.19–1.97	0.001	0.004
	Dual-purpose breed	1.91[b]	—	—	—	
	Crossbred or meat breed	2.57[a]	1.35	1.01–1.82	0.047	
Amount of milk (kg/calf per fattening cycle)	280–330	2.73[a]	1.36	1.07–1.73	0.014	0.010
	331–380	2.64[a]	1.32	1.09–1.60	0.006	
	>380	2.02[b]	—	—	—	

[a,b]Values within the same column with different superscripts per level differ significantly ($P < 0.05$).
[1]Adjusted $R^2 = 12.2$.

showed a higher risk of manipulating a penmate than did dual-purpose breed calves. Genetic variability in the expression of cross-sucking has been reported in calf and heifer offspring from different sires (Fuerst-Waltl et al., 2010) but no significant effect of breed type has been found for that behavior (Keil et al., 2001). A genetic predisposition exists to express these behaviors at the individual and line levels but also probably at the breed level. However, breed effects need to be further investigated to confirm breed differences in the expression of both manipulation of substrates and manipulation of penmates and to explain related mechanisms (e.g., higher motivation to suckle, to explore).

Some characteristics of feeds provided on commercial farms affected non-nutritive oral behaviors of calves. The risk of manipulating substrates was lower when the solid feed was based on maize silage compared with cereal grain, pellets, or muesli. Maize silage and treated maize contain more fiber (50 to 60% of raw cellulose) than cereal grain, pellets, or muesli (INRA, 2007). Cereal grain, pellets, and muesli can be considered as concentrated feeds, which are ingested and digested relatively quickly (Morisse et al., 2000). Several recent studies corroborate the positive effect of solid feed with high fiber content on oral behaviors in calves and heifers (Keil et al., 2001; Lidfors and Isberg, 2003; Webb et al., 2013). Compared with an all-milk diet, provision of solid feeds with high fiber content (such as hay or straw) next to milk replacer reduces non-nutritive oral behaviors such as manipulating the trough in veal calves (Webb et al., 2013), whereas more concentrated feeds (such as beet pulp) have a lesser effect on calf behavior (Mattiello et al., 2002). This effect was also shown in dairy heifers by Lidfors and Isberg (2003), who found a higher risk of cross-sucking on farms with a solid feed ratio of concentrate feed:roughage above 30:70, and by Keil et al. (2001), who found that cross-sucking was more important in dairy heifers that do not have access to pasture or that fed large amounts of maize silage. The overall effect of solid feed on calves' oral behavior depends on a combination of type of feed, feed quality, and quantity of feed (Webb et al., 2013). The best combination and quantity of solid feed should permit a long duration of ingestion and rumination in calves while covering their nutritional needs and without greatly affecting the meat color through a controlled supply of iron.

It seems surprising that the quantity of solid feed was not a risk factor in the present study for either manipulating substrates or tongue rolling. One explanation could be that a significant effect of the quantity of solid feed is seen only when a substantial difference exists between low and high levels of solid feed provision. In recent experimental studies of Webb et al. (2012), for example, the amount of solid feed given to calves after milk replacer ranged from 0 to 1.2 kg of DM per calf per day. On commercial farms in the present study, calves received, on average, 0.534 ± 0.018 kg of DM per calf per day of solid feed during the total fattening period, with the average daily intake ranging from 0.040 to 1.360 kg of DM per calf per day. On half of the farms participating in the current study, the average daily intake of solid feed provided to calves after milk replacer ranged between 0.39 and 0.66 kg of DM per calf per day. It is possible that differences between the majority of farms in the present study were too low to result in differences in the behavior of the calves. This suggestion seems to be supported by the recent observation that the voluntary intake of solid feed by calves around 14 wk of age was approximately 2 kg of DM per calf per day (L. E. Webb, Animal Production Systems Group, Wageningen University, Wageningen, the Netherlands, personal communication), which is about 4 times the amount that calves received on farms in the current study. It is also possible that calves received equivalent amounts of solid feed at the age of observations (around 14 wk) even if the total amount of solid feed distributed during the entire fattening period was different. Finally, calves were observed at a relatively young age (14 wk of fattening). In older calves, a higher level of abnormal oral behaviors, especially tongue rolling, can be expected (Mason, 1991; Bokkers and Koene 2001; Webb et al., 2012, 2013).

Calves with the highest quantity of milk powder consumed during the fattening period had a lower incidence

of manipulating a penmate. An effect of daily milk allowance on the development of cross-sucking in (dairy) calves was reported by Lidfors and Isberg, (2003). Cross-sucking is a behavior elicited by the ingestion of milk (Jensen, 2003) and especially by the motivation to suckle after a meal. Hunger and restricted milk feeding can increase this phenomenon (Rushen and de Passillé, 1995). In addition to the quantity of milk powder consumed, the type of milk delivery system (bucket, trough, or AMD) could have an effect on manipulating a penmate, as found in dairy calves (Jensen, 2003). For instance, in AMD systems, calves tend to suckle each other while waiting for the feed station to be available (personal observation), although this effect was not shown with the statistical analyses conducted in the present study. Other factors such as a combination of daily milk allowance, milk powder composition, milk flow rate, use of a separation gate in AMD systems, or use of teats in bucket systems can affect the level of cross sucking, as suggested by Jensen (2003). Milk feeding is an important component in terms of veal calf welfare, as it should meet both their nutritional and behavioral needs.

Characteristics of calf housing had an effect on tongue rolling behavior. Calves showed more tongue rolling behavior when housed in groups of relatively small size (fewer than 10 calves per pen) than in larger groups, regardless of the type of milk distribution system. A space allowance above the legal requirement (>1.8 m^2/calf) was associated with a reduced risk of tongue rolling. The positive effect of a higher space allowance on oral behaviors has been shown before (Schlichting et al., 1990; cited in Jensen, 2003). Low space allowance is expected to increase the stress response and induce modifications in adrenal response and changes in resting and social behaviors in bovines (Fisher et al., 1997; Grasso et al., 1999). Both can explain an effect of space allowance on tongue rolling behaviors. In the current study, calves had a greater risk of performing tongue rolling when no baby-boxes were used. We might have expected an effect of the use of baby-boxes on manipulating a penmate rather than on tongue rolling behavior. Early group housing allows calves to develop cross-sucking behaviors at a very young age (Jensen, 2003). Housing calves in baby-boxes at the beginning of the fattening period has been shown to reduce cross-sucking in veal calves (de Wilt, 1985), which is one of the reasons why baby-boxes are used and allowed in commercial practice. The absence of baby-boxes during the first weeks of fattening of calves could result in lower surveillance of calves by the farmer, more exposure to diseases, more disturbance by other calves, and therefore an increased level of stress, which could result in a higher expression of tongue rolling later compared with calves housed in baby-boxes until 5 or 8 wk of age. To our knowledge, there is no evidence in the literature to suggest that the use of baby-boxes would interfere with the later development of tongue rolling. The effect of the use of baby-boxes on stress levels and abnormal behaviors in calves should be investigated.

The experience of the farmer (i.e., number of years) affected the percentage of calves manipulating substrates. Farmers having less than 5 yr of experience and, surprisingly, farmers having more than 15 yr of experience were found to increase the risk of calves manipulating substrates compared with farmers having 5 to 15 yr of experience. These results support the idea that stockpersons influence the behavior and welfare of calves (Hemsworth and Coleman, 1998; Lensink et al., 2000a). However, the present findings do not provide a clear explanation as to which components of a farmer's experience would explain the higher risk of a calf manipulating substrates. Although our statistical approach aimed at avoiding multicollinearity problems, other underlying causes cannot be excluded as predisposing factors for this non-nutritive oral behavior. Experienced farmers might, for instance, have experience in raising calves partly based on the former housing and feeding system (individual crates and no solid feed) that was predominant before 2004. They could, therefore, have adapted differently to the present system, for instance, in terms of feed management and distribution. Lensink et al. (2001) showed that the attitude and behavior of the farmer affect the behavior of calves (reactivity and ease of handling). In our study, attitudes of farmers were not analyzed. More information is therefore needed on the farmers' experience, practices, attitude, and behavior to explain their effects on the behavior of calves.

Unexpectedly, calves exhibited more manipulation of substrates when behavioral observations were performed during autumn (calves arrived at the farm in summer). We found no indication that housing conditions or management of calves were different throughout the year. Therefore, we speculate that other underlying factors such as luminosity, humidity, temperature, or daylength at the start of the batch or at the time of observation influenced calves' behavior.

CONCLUSIONS

This study allowed a quantitative examination of associations between prevalence of non-nutritive oral behaviors in veal calves and multiple husbandry factors as observed on commercial veal farms in practice. The recorded prevalence of non-nutritive oral behaviors varied between farms. When assessing non-nutritive oral behaviors in calves, factors such as breed of calves,

season, or farmer's experience should be taken into consideration because they influence recorded levels of behaviors. Providing maize silage rather than pellets or muesli, providing more than 380 kg of milk powder per fattening cycle, allowing more space (>1.8 m^2/calf) for calves, housing them in larger groups, and using baby-boxes had a positive effect on the expression of non-nutritive oral behaviors in calves. These findings will help us define concrete remedial actions that could be taken on commercial farms to improve the welfare of veal calves. These results confirm and partly complement those from experimental studies. Additional studies are necessary to further elucidate underlying causal mechanisms linking the above-mentioned factors and the expression of non-nutritive oral behaviors in veal calves.

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