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ABSTRACT

The objectives of this study were to investigate the behaviour of hutch-housed dairy calves, develop an ethogram of general behaviour, and determine whether housing calves in different hutches, day, gender and time of day influenced the behaviour of dairy calves using the developed ethogram. Thirty-one apparently healthy Holstein Friesian calves (6 ± 1 week old) were recruited for this study. The ethogram was developed by directly observing the behaviour of ten female dairy calves housed in two group hutches for five days. Based on these observations, behaviour was then organized into three categories. The first category (I) comprised of postures, attentiveness and social interactive behaviour; the second category (II) comprised of event behaviour which were recorded each time they occurred while the last category (III) comprised of movement and activity behaviour whose duration were recorded. The ethogram was used to record the

behaviour of 16 calves (4 males; 12 females) housed in groups of four using direct and video observations for two consecutive days to ascertain if there are behavioural differences between dairy calves housed in different hutches; between days and gender. Furthermore, the ethogram was used to record the behaviour of an additional five dairy calves housed in a group hutch to determine the time of day effect. The behaviour of these five dairy calves were recorded hourly between the hours of 10:00 and 17:00 for two days using a combination of direct and video observations. Data were expressed as median frequency, duration or mean rank and significance was accepted at $P \leq 0.05$. There were no significant differences in the behaviour of dairy calves housed in different hutches. Significant variations ($P < 0.05$) were observed in the response to observer, ear and mouth postures and ear flicking behaviour between the two days. Tongue position, ear flicking, tail wagging and walking behaviour were significantly higher ($P < 0.05$) in females than in males while body shaking and sniffing other calves were found to be significantly higher ($P < 0.05$) in males than in females. Time of day significantly ($P < 0.05$) influenced the location in the hutch, head, tail and standing posture; and the duration of standing, walking, and lying behaviour. While confirmation is needed, findings suggest the behaviour of dairy calves may be influenced by day, gender, and time of day and this should be considered when undertaking behavioural studies.

Keywords: Dairy calves; Day; Ethogram; Hutch; Gender; Time

1. Introduction

The rearing of dairy calves remains an integral component of dairy production. The dairy calf, unlike its beef counterpart, is usually separated from the dam within the first few hours of birth and reared individually or in pairs for the first one or two weeks. Depending on the farm management practice, they can remain in pairs or be housed in groups until weaning, after which they are reared as herds. It is well known that housing impacts the welfare of calves and invariably, their behavior, which can be used as a welfare assessment tool (Stull and Reynolds, 2008; Pempek et al., 2016). Hutch-housing is a type of housing system currently in use for dairy calves in many parts of Europe and America. The predominant hutch type is the commercial plastic outdoor calf-hutch (made of fiberglass or polythene) which originated in North America and has been in use for over forty years on this continent (Hoshiba, 1986; Otterby and Linn, 1981). These plastic hutches are normally enclosed in an outdoor pen which is considered an enrichment mechanism and helps calves maintain visual and auditory contact, and possibly tactile contact (depending on proximity) with calves in other hutches. The outdoor pen may also serve as a play arena since the inner hutch provides minimal space for play.

Even though the hutches have existed for several years, studies describing the general behaviour of hutch-housed dairy calves have not been documented. Behavioural studies which have been performed on

dairy calves in hutches commonly focus on a specific area including feeding and performance (Schingoethe et al., 1986; McKnight, 1978; Razzaque et al., 2009; oral behaviour (Ertugrul et al., 2000); feed intake and oral behaviour (Hepola et al., 2006); oral, movement, play and grooming behaviour (Pempek et al., 2016); locomotor play, sucking and interactive behaviour (Pempek et al., 2017); feeding, social and lying behaviour (Wormsbecher et al., 2017); lying down frequency as a discomfort index in heat-stressed Holstein bull calves (Kovács et al., 2018). This paucity of research detailing the general behaviour of hutch-housed dairy calves invariably implies that the assessor/farmer maybe unaware of the behavioural changes occurring in these calves, especially following routine procedures performed in dairy calves. For example, the dairy calf undergoes a number of routine procedures such as ear tagging, disbudding, vaccination, and medical treatments at an early age of life, all of which are known to be potential stressors with the capacity to influence their behaviour. Without proper knowledge of how these calves behave in their hutches, the assessor/farmer may have difficulty recognising behavioural changes associated with husbandry practices or assessing the efficacy of intervention strategies like analgesic regimens. Hence, the need to address this knowledge gap.

Additionally, even though many calf-specific ethograms exist in the literature, a comprehensive ethogram which considers postures, social interaction, movement, and activity patterns in dairy calves is lacking. Examples of dairy calf-ethograms which are frequently used by

97 researchers undertaking behavioural studies in dairy calves include
98 ethograms of play behaviour (Jensen et al., 1998; Jensen and Kyhn,
99 2000; Mintline et al., 2013); ethograms of postural (lying and upright),
100 suckling and social behaviour in Danish Holstein Friesian dairy calves
101 (Jensen, 2011); ethograms of feeding, social and lying behaviour in dairy
102 calves (Wormsbecher et al., 2017); ethograms of oral, movement, play
103 and grooming behaviour in Jersey dairy calves (Pempek et al., 2016);
104 ethograms of feeding, oral and lying behaviour (Todd et al., 2018);
105 ethograms of lying, active (standing, attempt to stand, walk, play and
106 groom) and secondary behaviour including investigatory, social and
107 drinking in Holstein dairy calves (Gladden et al., 2019). However, none
108 of the above cited ethograms described all behaviour exhibited by dairy
109 calves but rather focused on aspects of behaviour depending on the
110 objectives of each study. Thus, the development of an inclusive
111 ethogram for dairy calves would be a useful tool for comprehensive
112 studies of calf behaviour.

113 This study was thus designed to investigate the behaviour of
114 hutch-housed dairy calves, develop a comprehensive ethogram as a
115 means of recording calf behaviour, and determine factors influencing
116 the behaviour of dairy calves in hutches using the developed ethogram.

117 **2. Materials and methods**

118 The study was carried out on the University of Bristol Veterinary
119 School dairy farm (Lower Langford, Bristol, United Kingdom), following

ethical approval from the University's Animal Welfare and Ethical Review Body (UOB/19/00). The dairy farm has a herd of 317 Holstein Friesian cattle including followers. It serves both teaching and research purposes for Bristol Veterinary School and runs as a commercial dairy unit. On the farm, calves are housed in twin or group hutches. Male calves born on the farm are reared with females for the first few weeks of life and are sold at about 10-12 weeks of age.

2.1 Calves

Thirty-one apparently healthy Holstein Friesian calves aged 6±1 week were recruited for this study. Calves were separated from their dams within 36 hours of birth and kept in individual pens for 5-7 days. Thereafter, they were housed in groups of four or five per hutch (Agri-plastics, The Calf Housing Specialist®, Canada). Each group hutch had an inside and outside dimension of 229cm L x 269cm W x 200 cm H and 296cm L x 254cm W x 191cm H respectively. These group hutches were enclosed within a four-part galvanized fence (488cm L x 274cm W). The floor of the hutches was bedded with dry wheat straw while the outdoor pen was made of rough concrete. The hutches were set on the ground and not anchored to the concrete floor. The calves were fed twice daily (early morning and mid-afternoon period) with 50% Calf milk powder (150g/l; Farm Direct®, Devon), wheat straw and Start 'n' Wean nuts (Wynnstay®, Powys) and had access to clean drinking water (replaced twice daily irrespective of consumption) *ad libitum*. The

number of dairy calves as used in each study phase are presented in Table 1 below.

2.2 Calf selection and habituation

The group hutches selected for the study were based on the absence of illness of all the calves residing in them; hence only hutches with apparently healthy calves were studied. To habituate the calves, an observer (with or without a video camera) stood in front of each hutch watching the calves until the calves showed minimal interest in the observer. This habituation period lasted for three days.

2.3 Development of ethogram

Ten female dairy calves housed in two group hutches were directly observed for five days. The observer stood just outside the outdoor pen and documented their postures, activities, and movements for twenty minutes three times daily (morning, afternoon, and evening) to establish a list of behaviour exhibited by these calves in their environment. The ethogram was first organized into activities (chewing, drinking, defaecating, eating, grooming/licking, playing, scratching, sniffing and urinating); attentiveness, movements (stand, walk, lie, run, jump and buck), position in the hutch, postures, social interactive behaviour and vocalization. However, when this ethogram was used to record calves by direct observation, it was impossible to score behaviour simultaneously at the one-minute interval which it was designed for, and it required looking at each calf more than once.

Hence, modification of the ethogram was carried out several times and the final version chosen based on practicality and efficiency of use. This version was organized into three categories. The first category (I) comprised postures (location within hutch, anatomical components of posture), attentiveness and social interaction; the second category (II) comprised point or event behaviour which were recorded each time they occurred during the study period while the last category (III) comprised movement and activity behaviour whose duration of occurrence were of interest. This last category was termed 'state behaviour'. While defining the behaviour contained in the ethogram, several consultations were made to the literature. Definitions of behaviour were modified from ethograms of Jensen et al. (1998); Jensen and Khyn (2000); Mintline et al. (2013); Caray et al. (2015) in dairy calves and Love (2009) in horses.

2.4 Determination of factors influencing behaviour

The ethogram developed above required pilot use in the hutch environment to ensure it contained behaviour which are most robust for measuring in the field. Hence, data collection was carried out using the ethogram to identify factors which can potentially influence behaviour. The study ascertained if there are behavioural differences between dairy calves housed in different hutches due to the limited number of calves which each group hutch can contain. Additionally, it also determined whether the behaviour of hutch-housed dairy calves varies across days, gender, and time of day. Thus, the behaviour of 16

dairy calves (4 males and 12 females) housed in four group hutches (n=2 males, 2 females in hutch A; n=4 females in hutch B; n=1 male, 3 females s in hutch C; n=1 male, 3 females in hutch D) were recorded using the developed ethogram for two consecutive days. On each day, observations began at 10:00 and lasted approximately 80 minutes. Each calf was focally sampled using direct and concurrent video observations for five minutes. During each five-minute period, the postural, attentiveness and social interactive behaviour were recorded at sampling intervals of 60 seconds by direct observation while the frequency of the event behaviour, and the duration of movement and activity behaviour were determined using the video recordings for each calf. For the direct observation, the observer stood just outside the fence of the hutch facing the calves. Video recording was obtained using a Canon camera (Legria HF R606), positioned on a tripod just outside the fence at the height of 1.2m and angle of 60 degrees (and manoeuvered by hand when necessary).

Variation in the behaviour of dairy calves housed in different hutches was determined by statistical comparison between the four groups of calves housed in the four group hutches.

To determine whether the behaviour of hutch-housed dairy calves varies across days, the behaviour of these dairy calves recorded above was compared between the two days.

Due to the presence of male dairy calves in three out of the four group hutches as described above, the behaviour of the male dairy calves were compared against the female calves.

To determine the influence of time of day on the behaviour of calves residing in the same hutch, a new group hutch containing five calves (4 females; 1 male) was selected. This group hutch was selected because it contained more calves. Calves were recorded at hourly interval between the hours of 10:00 and 17.00 for two consecutive days. Using the same protocol outlined above, each calf was focally sampled for 10 minutes every hour by direct and concurrent video observations. The behaviour of these calves was then compared across hourly intervals to ascertain the time of day effect.

2.5 Statistical analysis

Postural and event behaviour were calculated as frequency while movement and activity behaviour were determined as duration. To determine the frequency of events, and duration of movement and activity behaviour, the ethogram was coded into behavioural observation research interactive software (BORIS® version 7.4.15) (Friard and Gamba, 2016) by assigning a code to each of the behaviors contained in the ethogram. Behaviour was then logged as each video clip played on BORIS. Prior to coding and logging of behaviour into BORIS, the video clips were shown to two behavioural experts and the various aspects of behavior identified and discussed. A time budget

analysis was then performed on all behaviour logged onto BORIS to generate the frequency of event behaviour and the duration of movement and activity behaviour. Statistical analysis was performed with SPSS software (IBM SPSS® version 25.0.0). All the behavioural data generated were tested for normality and homogeneity using Kolmogorov-Smirnov and Levene's test, and due to the significant variations observed; non-parametric tests were chosen for the analysis. To test for behavioural differences between dairy calves housed in different hutches, data from the four group hutches were compared using Kruskal Wallis test. To test for behavioural differences across days, data from day one was compared with day two (blocked for different hutch-housing effect) using Wilcoxon Signed Rank test. Additionally, the influence of gender was determined using Mann Whitney U test (blocked for different hutch-housing and day effect). The Friedman test was used to investigate the influence of time of day on the behaviour of hutch-housed dairy calves. Data were expressed as median frequency, median duration, or mean rank. Significance was accepted at $P < 0.05$ unless otherwise stated.

3. Results

3.1. Ethogram development

The full description of the ethogram of hutch-housed dairy calves is attached as a supplemental material. When subjected to pilot use, the developed ethogram was found to be comprehensive for

hutch-housed dairy calves in this environment and did not need modifying for the subsequent studies.

3.2. Influence of housing calves in different group hutches

There were no significant differences in the behaviour of dairy calves housed in different hutches.

3.3. Influence of day

The frequency of calves 'looking towards' the observer was significantly higher (Z = -2.04; P < 0.041) on day 1 (18.25) than on day 2 (11.97) while 'looking away' from observer was significantly higher (Z = -0.32; P < 0.041) on day 2 (18.03) than on day 1 (11.75). The frequency of 'forward' posture of the ear was significantly higher (Z = -2.18; P < 0.033) on day 1 (18.46) than on day 2 (11.77) while the reverse was the case with 'side' ear posture (Z = -2.90; P < 0.004) with frequencies of 10.43 and 19.27 on days 1 and 2 respectively. 'Open mouth' posture was significantly higher (Z = -2.18; P < 0.029) on day 2 (17.90) than on day 1 (11.80) while 'closed mouth' posture was significantly higher (Z = -2.18; P < 0.029) on day 1 (18.11) than on day 2 (12.10). Ear flicking on day 1 (15.42) was significantly higher (Z = -2.07; P < 0.039) than on day 2 (9.23).

3.4. Influence of gender

The results of the influence of gender on the behaviour of dairy calves showed that the frequency of 'tongue inside mouth' posture (Z =

-2.27; $P < 0.023$), ear flicking ($Z = -2.69$; $P < 0.007$), tail wagging ($Z = -2.04$; $P < 0.042$) and duration of walking ($Z = -2.02$; $P < 0.044$) were significantly higher in females (16.70, 17.37, 16.16 and 17.68) than in males (11.22, 8.44, 11.00 and 11.15), while body shaking ($Z = -2.09$; $P < 0.036$) and sniffing other calves ($Z = -2.01$; $P<0.045$) were found to be significantly higher in males (13.50 and 13.33) than in females (16.61 and 18.72).

3.5. Influence of time of day

The results of the influence of time of day on behaviour showed that postural behaviour (such as location in the hutch, head, tail and standing posture) and movement behaviour (including standing, walking and lying duration) were affected by time of day as shown in Tables 2 and 3 below respectively. A significant increase in frequency of standing and relaxed-tail postures together with calves staying in front of the hutch were observed at the hours of 10:00, 13:00 and 15:00 when the calves spent most time standing and walking while higher frequency of low-head and tucked-tail postures coincided with an increased lying period at 12:00. Day 2 data from the time of day component of the study were lost due to hardware storage failures.

4. Discussion

The objectives of this study were to investigate the behaviour of hutch-housed dairy calves, develop a comprehensive ethogram as a means of recording calf behaviour and determine the factors influencing

303 the behavior of dairy calves with the intention of establishing an all-
304 inclusive ethogram for use in subsequent studies. The arrangement of
305 the ethogram and score sheet used in this study were chosen based on
306 practicality and ease of use. The ethogram incorporated every aspect of
307 dairy calf behaviour seen during the observation period, including
308 postures (location within the hutch and anatomical components of
309 posture), social interaction (interaction with calves and observer),
310 movements (standing, walking and lying behaviour), activities (eating,
311 drinking, playing, chewing, yawning, head rubbing, body rubbing,
312 stretching, urinating and defaecating), exploratory (grooming, licking
313 object) and avoidance behaviour (ear flicking, feet stamping, head
314 shaking, body shaking, scratching, tail wagging), providing an
315 opportunity to evaluate the entire calf. Pilot testing of this ethogram
316 revealed that the developed ethogram was comprehensive for hutch-
317 housed dairy calves.

318 Calves in the four group hutches all maintained homogeneity in
319 behaviour. This suggests that there are no differences in the behaviour
320 of dairy calves housed in different hutches on the same farm. This was
321 not surprising because of the strong social bond which exists between
322 groups of cattle due to their gregarious nature (Philips, 2002).
323 Additionally, the visual and auditory contact offered by the outdoor pen
324 may have contributed to the high level of homogeneity in the behaviour
325 between the calves despite being housed in different hutches.
326 Homogeneity in behaviour has also been reported in adult cows.

Schrader (2002) and Fregonesi et al. (2004) observed consistency in the behavioural activities of dairy cows throughout weeks while Müller and Schrader (2005) reported the behaviour of dairy cows to be consistent between two consecutive lactations.

The results also suggest that postural, social interactive and avoidance behavior may vary across days. However, this is only based on a two-day observation period and further observations would be needed to confirm these results. The behaviour and physiology of cattle is known to be influenced by environmental conditions (Schütz et al., 2010; Hill et al., 2011; Charlton and Rutter, 2017; Kovács et al., 2018) which tend to vary across days. However, during the observation period, environmental conditions were not substantially different between the two days with temperatures of 8.5^{o}C and 9^{o}C; relative humidity of 94% and 83% and Wind of 11 mph WSW and 9 mph S in days 1 and 2 respectively. The variation in behaviour between days may indicate that the calves were not fully habituated to the observer as evidenced in response to observer behaviour, even after the three days habituation period prior to data collection.

The behaviour of hutch-housed dairy calves was also found to be influenced by gender. The increase in frequency of ear flicking and tail wagging in the female calves may suggest that they react more robustly than the males to the presence of irritants and as a coping strategy and spent more time walking to avoid irritation. Tail wagging

350 and ear flicking; known as ‘avoidance behaviour’, occur following
351 irritation or threat in cattle (Philip, 2002). While the literature is scant
352 on gender effects on cattle behaviour, gender was reported to influence
353 play behaviour in calves (Philips, 2002) and grazing behaviour in adult
354 cattle (Hall, 1986). According to Philips (2002), male calves are the
355 initiators of play but subsequently become the receivers more than the
356 female counterparts. While gender did not influence duration of play
357 behaviour in this study, the above cited literature supports the finding
358 of gender-based differences in the behaviour of calves. One reason for
359 the scant literature on the effects of gender is probably due to the
360 absence of the male animals on dairy farms. In commercial dairy farms,
361 retention of dairy females is the usual practice and male calves born in
362 dairy farms are sold off almost immediately depending on the
363 management practices of the farm. While the findings on gender in this
364 study together with the above cited literature suggest that a gender
365 effect be borne in mind while studying behaviour of calves, it is also
366 important to acknowledge that the small, uneven sample size (4 males
367 versus 12 females) and the short observation period may have
368 influenced the results.

369 The time of day influenced the behavior of hutch-housed dairy
370 calves. While some postural and movement behaviour (categories I and
371 III) were influenced by time of day, the events were unaffected
372 (category II). Calves staying in the front part of the hutch together with
373 increases in postural behaviour such as standing and relaxed tail posture

374 coincided with the active periods of the calves while very low head
375 posture and tucked tail posture were frequently observed during the
376 less active periods. The significant variations observed in the duration of
377 standing, walking, and lying behaviour demonstrate that movement
378 behaviour are influenced by time of day. Findings also revealed that
379 calves spent over two-thirds of the entire study period lying while active
380 movements such as standing, playing, and walking made up the other
381 one-third. In agreement, Weiguo and Philips (1991, cited in Philips,
382 2002) reported that calves spent approximately 13 hours per day lying.
383 Equally, Jensen et al. (1998) observed increased resting time and low
384 level of play in dairy calves kept in pens. There was no consistent
385 pattern in the display of active movements since these were observed
386 both in the morning (10:00) and afternoon periods (13:00 and 15:00). It
387 is thought that the increase in the duration of standing and walking
388 behavior at 15:00 was in preparation of the second round of feeding as
389 these calves were routinely fed between 15:00 and 16:00. In line with
390 the report of Jensen et al. (1998) and Rushen and de Passillé (2014),
391 calves spent little time playing in this study. Play behaviour observed
392 included running, jumping and head to head/frontal push which were all
393 performed in the outside pen as the inside hutch provided very minimal
394 space for play. Other aspects of social and locomotor play reported by
395 Jensen et al. (1998) were not seen during the study period. Under
396 favourable conditions, young animals are expected to play (Holloway
397 and Suter, 2004). During the study, the group hutches were observed to

reverberate (since they were not anchored to the ground) whenever the calves jumped or ran. This resonating effect may have elicited fear in the calves, thereby discouraging play behaviour. Fear was hypothesized as one of the factors which suppresses the manifestation of play behaviour in calves (Wood-Gush and Vestergaard, 1991). In their study, these authors suggested that play behaviour was deterred when fear counterbalances exploration. However, dairy calves are known to play less during the weaning phase (Krachun et al., 2010).

The limitations of this study include the short observation period per calf, small sample sizes, and the lost data from day 2 (time of day component). The small sample sizes were due to the limited number of calves which each group hutch could accommodate. The lack of comparative studies in the literature also limits the ability to draw appropriate conclusion until confirmatory studies are performed. Yet despite these limitations, the findings provide a valuable insight into the behaviour of group-housed calves in hutches.

5. Conclusion

This study is the first to develop a comprehensive ethogram to record the full range of calf behaviour. While confirmatory studies are needed to refine this ethogram, the ethogram will help farmers, veterinarians and researchers better understand the behaviour of hutch-housed dairy calves and to recognize changes in all aspect of the dairy calf behaviour. This study also provides data on the influence of

factors such as housing calves in different hutches, day, gender, and time of day on the behaviour of hutch-housed dairy calves. Veterinarians and other stakeholders also need to be aware that the behaviour of dairy calves could be affected by these factors and control for them in further studies.

Declaration of interest

None.

Acknowledgments

Authors wish to thank all the farm staff at Wyndhurst for their indispensable assistance throughout the study period. This study was supported by a University of Bristol Scholarship and Tertiary Education Trust Fund, Nigeria.

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Table captions

Table 1. Table 1. A table showing the number of dairy calves in each study phase

Table 2. Influence of time of day on postural behavior. Median frequencies in a row with different superscripts differ significantly ($P < 0.05$)

Table 3. Influence of time of day on the duration of standing, walking, and lying behaviour. Median duration a row with different superscripts differ significantly ($P < 0.05$)