



## Case Study

## SIGNIFICANCE OF FEEDING AND MILKING BEHAVIOUR ON DAIRY CATTLE MANAGEMENT

Amit Shakya, B. Roy, J. S. Yadav\* and Kumar Govil

Department of Livestock Production &amp; Management, College of Veterinary Science and Animal Husbandry, Jabalpur (M.P.)- 482001

\*corresponding author e-mail: appuyadavrvet@gmail.com

## ABSTRACT

Animal behaviour is defined as the pattern of action observed in animals that occurs either voluntarily or involuntarily (Taylor and Field, 1998). The behaviour pattern can be defined as the organized segment of behaviour having a special function. Its nature is chiefly determined by hereditary but it can also be modified by learning and training (Scott, 1962). Lorenz is regarded as the father of modern ethology. Lorenz and Tinbergen developed the ethogram. Animal behaviour studies are called 'ethology'. The behaviour of cattle can be separated into six different categories; nutritional, resting, locomotion, social, reproductive and maternal behavior (Phillips, 1993). Under intensive condition and with a restricted food allowances, animals take feed whenever food is offered. With an *ad libitum* supply, circadian patterns develop and little or no feeding takes place at night. In free ranging cattle grazing is largely diurnal. Major grazing periods begins near dawn and recurs in late afternoon, ending close to sunset. Breuer *et al.* (2000) suggest positive human-cattle interaction to increase the productivity of the cow, for example brushing prior to milking by a familiar person showed varying effects on the animal production. When the cow was brushed before milking, there was significantly less elimination of faeces and vocalization, which are clear behavioral indicators of stress in dairy cattle. Animal suffering/ problems can easily be identified by observing their behavior. Controlling social dominance in animals will help in better management of a dairy farm. Behaviour of cow can be utilized for better management of dairy cattle to improve overall productivity.

**KEYWORDS:** Animal Behaviour and Animal Management

## INTRODUCTION

Animal behaviour studies are called 'ethology'. The term derived from the Greek root 'ethos' meaning 'nature' or 'disposition'. Animal behaviour is defined as the pattern of action observed in animals that occurs either voluntarily or involuntarily (Taylor and Field, 1998). The study of behaviour involves not only what an animal does, but also when, how, why and where the behaviour occurred (Lehner, 1979). The behaviour pattern can be defined as the organized segment of behaviour having a special function. Its nature is chiefly determined by hereditary but it can also be modified by learning and training (Scott, 1956, 1962).

Scott has suggested the following categories for an animal's behaviour;

1. Contactual (social) behaviour
2. Ingestive behaviour
3. Eliminative (excretory) behaviour
4. Sexual behaviour
5. Epimeletic (care giving) behaviour
6. Et-epimeletic (care soliciting) behaviour
7. Agonistic behaviour
8. Allelomimetic behaviour (doing something at same time behaviour)
9. Investigative (exploratory) behaviour (Scott, 1962)

Important behavioural traits of dairy cattle are as follows;

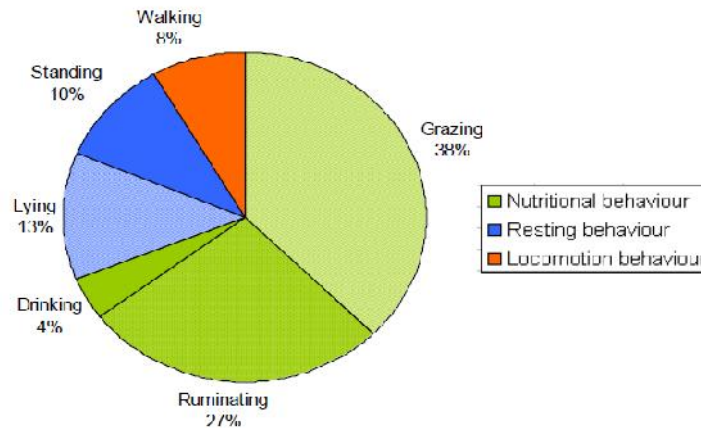
1. Feeding behaviour
2. Grazing behaviour

3. Reproductive behaviour
4. Parturition behaviour
5. Agonistic behaviour
6. Milking behaviour
7. Stress behaviour
8. Sickness behaviour
9. Allelomimetic behaviour
10. Investigative (Exploratory)

The field of ethology was firmly established in the late 1930s with the publication of the first journals relating to animal behaviour in Germany. Alcock (1993) concludes that ethology, as a scientific field, began seriously in the 1950s with the work of three zoologists awarded the Nobel Prize in the physiology and medicine in 1973: Konrad Lorenz, Van Frisch of Austria and Niko Tinbergen of the Netherlands. Lorenz is regarded as the father of modern ethology. Lorenz and Tinbergen developed the ethogram. An ethogram is a complete listing of all the behaviors that an animal performs in its natural environment. Darwin (1859) through his book "Origin of Species" raised serious doubts about the mechanistic view of animal behaviour. He postulated that the animals share many physical characteristic and was one of the first to discuss variation within species, both in their behavior and in their physical appearance. Darwin believed that artificial selection and natural selection were intimately associated. He gave the theory of evolution without any knowledge of genetics. In this book "The Descent of Man" Darwin concluded that

temperament traits in domestic animals are inherited. He also believed that animals have subjective sensations and could think. Darwin wrote, "The different in mind between man and the higher animals, great as it is, is certainly one of degree and not of kind". During the middle of 20<sup>th</sup> century, scientific thought again reverted to mechanistic view. Watson (1930) stated, "Differences in environment can explain all differences in behaviour". He did not believe that genetics had any effect on behaviour. Skinner (1958) wrote in his book "The behaviour of organisms" that all behaviour could be explained by the

principle of stimulus- response and operant conditioning. Operant conditioning uses food rewards and punishments to train animals and shape their behaviour. Eibl-Eibesfeldt and Kramer (1958) defined ethology as the study of animal behaviour in natural environments. They observed that the primary concern of ethologists is instinctive or innate behaviour. The behaviour of cattle can be separated into six different categories; nutritional, resting, locomotion, social, reproductive and maternal behaviour. The most common behaviours in these categories are shown in Fig.1.



(Phillips, 1993)

**FIGURE 1:** The distribution of behaviours performed during 24 h for a high-yielding dairy cow.

### Feeding behaviour

Adequate food intake over the short term for survival and over the long term for reproduction and the successful rearing of young is the driving force in all animals. Feeding behaviour is divided into 2 conditions:

1. Stall fed condition
2. Free Range condition

Under intensively housed conditions man controls following factors influencing ingestive behaviour are,

- i. Amount of food
- ii. Type of feeding available
- iii. Social context of its consumption

Cow's diets consist of voluminous, high-fiber food, in large quantities (Sjaastad *et al.*, 2003). They consume coarse grass that are relatively low in digestibility, and therefore, demand great amounts of mastication before they can be fully digested. They consume grass with relatively low selectivity as quickly as possible, and thereafter masticate it for a longer period, in somewhat safety (Phillips, 2002).

### The Circadian patterns of feeding behaviour

The daily routine of maintenance behaviour is determined by the timing of feeding, with other activities accommodated to it. Under intensive condition, and with a restricted food allowances, animals will feed whenever food is offered. With an *ad libitum* supply circadian patterns develop. These, in livestock mean that little or no feeding take place at night. In free ranging cattle grazing is largely diurnal. Major grazing periods begins near dawn and recurs in late afternoon, ending close to sunset, when day length varies little over the year. An increase in

competition at the feed bunk is not only seen after changes in group composition, but can also result from managerial decisions about barn design and stocking density. Many studies have shown that decreasing available space at the feed bunk decreases time spent on feeding and increases competitive behaviour (Olofsson and Wiktorsson, 2001; DeVries *et al.*, 2004; Huzzey *et al.*, 2006).

The greatest increase in competitive behaviour occurs during the peak in feeding activity seen after delivery of fresh feed (DeVries *et al.*, 2004). Dominant animals often have greater access to fresh feed and subordinate animals are forced to eat later (DeVries *et al.*, 2004). When physical protection against displacement is provided at the feed bunk, subordinate animals show the largest increase in feeding activity (DeVries *et al.*, 2003), likely due to being displaced less often (DeVries *et al.*, 2006; Huzzey *et al.*, 2006). If feed is provided more often or more feeding space is available per cow, displacement of subordinates from the feed bunk decreases and feeding time increase (DeVries *et al.*, 2005; Huzzey *et al.*, 2006).

### Grazing behaviour

Grazing has advantages for the cows as well as for the dairy farmers. Grazed grass, which is the very central part of the cow's diet in summer time, is the most inexpensive feed available to the producers (O'Kiely, 1994). Cow's anatomy has evolved and adapted to the available types of plants and is well suited for grazing (Sjaastad *et al.*, 2003; Shipley, 2007). The lips are uncleft and not very mobile while the tongue is long and flexible. Lips, teeth as well as tongue are all used to grab and transport the forage into the mouth. The tongue is wired around the grass, which is transferred into the mouth, where it is compressed between

the incisors in the lower jaw and the upper palate. The grass is ripped off the sward by jaw movements and by shaking the head upwards (Phillips, 2002; Sjaastad *et al.*, 2003). As the cows are grazing they move their head from side to side, in a characteristic sweeping action. Once in the mouth, the herbage is cut by the incisors and grinded by the molars, through up- and inward movements of the lower jaw (Phillips, 2002). The joint in the lower jaw allows great sideways movements, which enhances the grinding effect. Since the upper jaw is wider than the lower jaw, mastication can only be performed on one side at a time. The mastication side is changed about every 50<sup>th</sup> chewing motion (Sjaastad *et al.*, 2003). Through intense chewing, with an additional contribution of saliva, a bolus is created and later on swallowed. After swallowing, the grazing cycle starts over again. During mastication the head is held horizontally, or in a somewhat lowered position (Phillips, 2002). Cows have a walking speed of 1.33 to 1.47 m/s (4.8 km/h, respective 5.3 km/h) (Chapinal *et al.*, 2009). The walking speed during grazing is between 0.25 km/h and 0.6 km/h, which are much slower than the estimated normal walking speed (Shinoda *et al.*, 2009).

In average, dairy cattle spend about 9 h per day grazing and this can be divided into normally five bouts. Each of these bouts lasts for approximately 110 minutes, but the variation can be high. The first bout is occurring shortly after dawn, followed by two to three bouts between the milkings and the last one in the evening around dusk (Phillips, 1993). Cows are crepuscular, meaning that they are mainly active at sunrise and sunset, indicating that these two bouts are the longest and most intense (Albright and Arave, 1997; Gibb *et al.*, 1998).

Generally, cattle prefer to graze dense and dark-green pastures which indicate a greater bite weight and high nitrogen content. When the temperature or humidity is high, easily digestible feed is to prefer over more fibrous feed since fibre produces more heat increment of digestion. During evening, the bite rate is maximal and the chewing rate minimal, indicating that the cow maximize their intake at that time (Phillips, 1993). This might be because of the lower air temperature (Taweel *et al.*, 2005). Cows do not eat close to faecal deposits, and in the end of

the pasture season about 2-4 % of the herbage is contaminated (Phillips, 1993).

A change in grazing times depends on the quality of the pasture, climatic factors like sun, rain, wind, and the competition of the herd mates. Nutritional requirements and the access of supplementary feed are also of great importance. It was shown that when cows were offered supplementary feed, their grazing time was reduced from 7.7 h/day to 6.4 h/day (Phillips, 1993). The grazing time varies between days, but the between-cow variation is higher than the between-day variation. However, during the evening and at night the between-day variation can be very high (Phillips and Denne, 1988). The grazing times are also increased when the pasture quality declines (Albright and Avare, 1997).

#### Feeding space

Feed and access to feed is one of the most valued resources in the environment. Additionally when one cow feeds, other are motivated to eat as well (Grant and Albright, 2001), meaning that cows tend to feed as a herd. This is particularly true in TMR fed herds when the provision of fresh feed encourages all animals to eat at the same time. As a result, animals will compete for access which often results in negative social interactions and bullying if feed space is inadequate. To minimize this and to maximize dry matter intakes, particularly in lower ranking cows, it has been suggested that animals should be provided with at least 0.6m/cow of ad lib access through space and preferably 0.8m/cow (Blowey, 2005). Although by combing the results of a number of different studies, Grant and Albright (2001) report that there is unlikely to be a measurable reduction in DMI providing a minimum of 0.51cm of bunk space is provided. Whilst some evidence suggests that increasing bunk space above 0.5m may not have significant effects on DMI, doubling the amount of feeding space per cow from 0.5m to 1.0m resulted in a 57% reduction in aggressive interactions and allowed cows to increase their feeding activity during the period following the provision of fresh food (DeVries *et al.*, 2004). This was particularly true for subordinate animals.

**TABLE 1.** Measures of feeding behaviour<sup>1</sup> with 0.5 and 1.0 m of allocated feed alley space per cow

Measures	Feed alley space per cow		SE	P
	0.5 m	1.0 m		
Daily feeding activity <sup>2</sup>	1334.5	1520.9	24.51	<0.001
Total daily mealtime <sup>3</sup>	279.0	307.6	4026	<0.001
Feeding intensity <sup>4</sup>	4.9	5.0	0.09	0.46

<sup>1</sup>Data were averaged for the 7 d per treatment for 4 groups of cows (6 cows per group), fed 2x day.

<sup>2</sup>The total number of hits that the feed alley monitoring system recorded per day.

<sup>3</sup>Sum total length of time (minutes) included in the meals per day.

<sup>4</sup>The number of hits per day divided by the total daily mealtime (DeVries *et al.*, 2004)

There is also evidence that feed bunk design can influence aggressive behaviour; for example, cows were displaced more frequently from a post and rail feed barrier, compared to a barrier composed of headlocks (Huzzey *et al.*, 2006). Lastly the frequency of feeding may influence behaviour. Whilst the number of aggressive encounters at the feed bunk did not decrease as the frequency of feed delivery increased, subordinate cows were displaced less

frequently when the herd was fed more often (DeVries *et al.*, 2005).

#### Rumination

When ruminating, cows are relaxed and quiet, having their heads down and the eyelids lowered. The cow is ruminating for approximately six to seven hours per day, divided into about 15-20 bouts. The duration of the rumination can differ to a great extent; between a few minutes to one hour (Fraser, 1983). Usually, the

rumination is performed in connection with the grazing times and with the most intense period several hours after dusk. The rumination time depends on the feeds fibre content. The more fibrous feed, the longer rumination time (Phillips, 1993). When cows lay down during rumination, they prefer to lie on their left side. The rumen is positioned on the left side and therefore the rumination will be the most effective (Grant *et al.*, 1990).

When the ambient temperature is rising, the rumination is decreased. In a study by Tapki *et al.* (2006), it was stated that the rumination decreased from 18.1 % in the morning to 14.6 % in the middle of the day. However, protection from sun may prevent this, when the temperature was around 35-40°C. Blackshaw and Blackshaw (1994) also stated that the rumination is increased if the cows have access to shade. It is also clear that a high producing cow ruminate less than a low producing when the ambient temperature is high. One explanation for this is that the cows produce a lower rate of metabolic heat if they ruminate less (Kadzere *et al.*, 2002).

A scoring system was used to distinguish between active chewing during rumination periods and meals. Active

periods were assigned a score indicating the likelihood that the chewing was part of a rumination period. Scores were based on the duration of chewing activity, the number and standard deviation of chews per second, and the duration of the preceding and succeeding pauses. Four consecutive periods of active chewing with high rumination scores constituted a rumination period. Each rumination period was then extended to include all boli, with slightly lower rumination scores that occurred before and after these four, until a period of no rumination was encountered. Once included in a rumination period, each active period was denoted as a rumination bolus.

All other chewing occurred during meals. Eating periods and eating pauses were combined to form meals. Eating periods, separated by at least 4 min of inactivity, were considered to be two different meals. Meals of less than 2 min, or less than 4 min, if the chewing rate was slower than 1 chew/s, were considered to be idle periods. Chewing that followed eating by less than 30s was denoted as eating. Table 2 provides a listing of minutes attributed to each chewing activity by hour and day.

**TABLE 2.** Time spent eating, ruminating, and idling summarized hourly and daily

Hours	Idle (%)	Eating (%)	Ruminating (%)	Total (%)
12:00	6.0	94.0	0	100.0
13:00	30.8	69.2	0	100.0
14:00	41.1	12.6	46.3	100.0
15:00	62.8	29.4	7.8	100.0
16:00	71.2	0	28.8	100.0
17:00	75.2	0	24.8	100.0
18:00	74.2	0	25.8	100.0
19:00	37.0	0	63.0	100.0
20:00	53.1	0	46.9	100.0
21:00	53.4	0	46.6	100.0
22:00	100.0	0	0	100.0
23:00	50.1	0	49.9	100.0
00:00	72.6	0	27.4	100.0
01:00	62.7	0	37.3	100.0
02:00	65.6	0	34.4	100.0
03:00	52.9	0	47.1	100.0
04:00	61.4	0	38.6	100.0
05:00	66.3	33.7	0	100.0
06:00	71.8	28.2	0	100.0
07:00	10.0	30.0	0	100.0
08:00	40.7	31.9	27.4	100.0
09:00	52.1	0	47.9	100.0
10:00	51.5	0	48.5	100.0
11:00	94.7	0	5.3	100.0
12:00	30.4	0	69.6	100.0
Day	59.7	11.0	29.2	100.0

(Beauchemin *et al.*, 1989)

A great part of the foraging time is spent in chewing. While chewing they cannot graze efficiently, but they can start looking for the next food item. If they find the next bite while still chewing the former bite, the remaining mastication time could be spent in vigilance for predators (Phillips, 2002).

#### Drinking behaviour

Cattle drink about two to five times a day, corresponding to about one hour. They synchronize drinking with the feeding bouts, and this is most obvious in early morning. There is also a peak in drinking behaviour when being returned to the pasture after milking (Phillips, 1993).

Cardot *et al.* (2008) showed that the three-fourths of the water intake occur between 6 am and 7 pm. It is important that feed and water is available under the shade, otherwise the cow must choose between staying under shade or eating and drinking. This might lead to a lower water and feed intake and to a decreased milk production (Bucklin *et al.*, 1991). Choose between staying under shade or eating and drinking. This might lead to a lower water and feed intake and to a decrease milk production (Bucklin *et al.*, 1991).

The water intake is affected by several factors;

- Average ambient temperature

- Milk production
- Dry matter intake (DMI)
- Dry matter content of ration
- Body weight
- Lactating number
- Day in lactating

Na intake and K intake all shows a positive correlation to water intake. However, the most obvious factors affecting water intake is the dry matter content of the ration, DMI, milk production and the ambient temperature (Meyer *et al.*, 2004).

Predicting the water consumption has been shown to be rather difficult. Cardot *et al.* (2008) state that three times their milk yield is more correct and a study by Meyer *et al.* (2004) showed a need for 1.3 liters of water per produced kg milk. According to Cardot *et al.* (2008) free water intake (FWI) (l/d) can be calculated as follows:  $1.53 \times \text{dry matter intake (kg/d)} + 1.33 \times \text{milk yield (kg/d)} + 0.89 \times \text{dry matter content (\%)} + 0.57 \times \text{minimum temperature (}^{\circ}\text{C)} - 0.30 \times \text{rainfall (mm/d)} - 25.65$ . When cows are suffering from heat stress it may also have a direct impact on the cows comfort when drinking water. This is because of its direct cooling of the reticulum. Finally, the thermal load will also be decreased.

#### Milking behaviour

Dairy cows being fearful do often kick during milking procedures and has higher residual milk. Fear can be measured in different ways. Welp *et al.* (2003) for instance, investigated vigilance as a measure of fear in dairy cows. 20 cows were tested indoor with an unfamiliar, aversive or a gentle person. The study showed that the vigilance increased in the presence of an aversive person compared to during the presence of both the gentle and the unfamiliar person. The conclusion of the study was that the vigilance is altered by the cows depending on their degree of fear towards humans, and an estimation of

the animal's fearfulness can hence be provided. Many studies have used the same method as to measure fear in dairy cows, i.e., the cow's distance to handlers. Results of the study indicate that cows stayed closer to gentle handlers than to aversive handlers. This is interpreted as fearfulness of aversive handlers. A similar method to investigate fear in dairy cows is to observe the approach behavior towards handlers, which has been done by, among others Breuer *et al.* (2000) and Waiblinger *et al.* (2003). All studies mentioned show that cows seem to be fearful of aversive handlers.

To increase the productivity of the cow Breuer *et al.* (2000) suggests an improved positive human-cattle interaction. This could for example be brushing prior to milking. Performed by a familiar person this has showed varying effects on the animal, when the cow was brushed before milking, there was significantly less elimination of faeces and vocalization, which are clear behavioral indicators of stress in cattle. The reduction of these factors is the strongest indicators that the presence of humans can reduce fear responses in cattle. The conclusion of the study by Rushen *et al.* (2001) is, at times where humans are present, some behavioral stress indicators create less stress response in the animals. Furthermore, the results indicate that, in the presence of an aversive handler the acute stress is more distinct. The importance of the handlers' behavior and that it affects the behavior of the cow is also shown in a study by Waiblinger *et al.* (2002). The study also observes that cows approach the handlers which are using calm interactions more frequent, and the writers underline the importance of the handler's behavior in order to avoid fear of humans in cattle. Stepping behaviour is associated with fear of novelty, increased heart rate and increased milk cortisol concentrations, whereas kicking behaviour rather than initiated by nervousness or anxiousness seems to be expressed by not fearful cows (Wenzel *et al.*, 2003).

**TABLE 3.** Observed behaviours of dairy cows when milked in milking parlour

Behaviour			Description
Stepping	behaviour	during milking	Every individual weight shifting from one hind foot to the other with the foot less than 10 cm off the ground
Kicking	behaviour	during milking	Every individual occasion of lifting the hind foot at least 10 cm off the ground and moving it quickly forward

(Rushen *et al.*, 2001)

To investigate the frequency of stepping and kicking behaviour during milking in the milking parlour, the behaviour of cows during mid day milking (14:30-16:00) was recorded by using between two and four video cameras. Behaviors (Table 3) were recorded from when first teat cup was attached to a cow's teat until the last teat cup was automatically removed.

Behaviour during udder preparation and after-treatment was not recorded, and if the milking machine was kicked off by the cow or automatically went off before milking was finished, time and observation stopped until all teat

cups were attached again. Time and observation were also stopped if hind legs and/or udder of the cow were out of sight. Hence, the total milking time during which behaviours were recorded (typically 3-6 minutes) is not identical to actual time spent in milking parlour (typically 10-20 minutes). Behaviors were recorded as rates, calculated by dividing frequencies of behaviors over time observed, in seconds. Each animal was recorded during two milkings per test-batch and the value used in the analysis is the individuals mean value of those two recordings.

**TABLE 4.** Milking Temperament Score

Score	Definition	Description of behaviour
1	Docile	Animal stand quietly, rarely moves, except raise or lower head, Never give any trouble either during milking or during preparation of milking.
2	Slight restless	Animal stand quietly in the stall, Do not bother by preparation of milking or milking itself, They may move frequently shifting weight from side to side, Occasionally flick the tail,
3	Restless	Animal moves almost continuous, Flicking of tail frequently, frequently snots, May lift the leg, but does not kick
4	Nervous	It is very restless during preparation moves around a lot, may lift the leg, occasionally during preparation of milking does not kicks, flicks the tail frequently etc.
5	Aggressive	The animal is very restless during the preparation of milking, Struggles violently, Kick at milker, attacks observer by butting, Moves from side to side, Very difficult to handled, Bellows and froths at the mouth.

A milking temperament score was used in a study as one parameter to determine social dominance among large groups of the 5-point scale ranged from a score of 1, a very quiet cow that was extremely docile during milking and the “ideal” milker; to 5, a cow that was restless during milking, appeared agitated, kicked at handler, and flinched when a hand was placed on her. In a study conducted by Lanier *et al.* (2000) revealed that highly temperamental cows were more sensitive to sounds, touch and motion. Isolation from the herd was shown to increase defecation, urination, vocalization, and stepping during milking. Eighteen cows were milked under each of three experimental settings: 1) milked in the usual setting; 2) milked alone in an unusual room; and 3) milked in unfamiliar room with human contact. Incidence of stepping was significantly higher in the isolated group. During the study, only one cow was seen defecating or urinating during milking in the control group, while 13 cows were observed defecating in isolation; human contact curbed this behavior to numbers similar to the control group. Total milk yields for the three groups were not significantly different, but this is due to a higher initial milk yield and lower residual milk yield in the control group compared to the isolation and human contact groups. Although a standardized behaviour scale was not utilized for this study, it is clear that the findings correspond to those that did use a milking temperament score.

## CONCLUSION

- Behaviour is best expressed by animals in range condition.
- More scope of expression in loose housing system than stanchion system.
- Observing cow behavior can be utilized as an important tool for management of dairy farm.
- Animal suffering/ problems can easily be identified by observing their behaviour.
- Controlling social dominance in animals will help in better management of a dairy farm.

## REFERENCES

Albright, J.L. (1987). Dairy Animal Welfare: Current and needed research. *Journal of Dairy Science*, **70**: 2711-2731.

Albright, J.L. and Arave, C.W. (1997). The behaviour of cattle, Commonwealth Agricultural Bureaux International Wallingford, 256 pp.

Alcock, J. (1993). *Animal Behaviour: An Evolutionary Approach*, 5<sup>th</sup> edition, Sinauer Associates, Sunderland, MA. 625 pp.

Blackshaw, J.K. and Blackshaw, A.W. (1994). Heat stress in cattle and the effect of shade on production and behaviour: a review. *Australian Journal of Experimental Agriculture*, **34**(2): 285-295.

Blowey, R.W. (2005). Factors associated with lameness in dairy cattle. *Journal of Dairy Science*, **27**: 154-162.

Breuer, K., Hemsworth, P.H., Barnett, J.L., Matthews, L.R. and Coleman, G.J. (2000). Behavioural response to humans and the productivity of commercial dairy cows. *Applied Animal Behavioural Science*, **66**: 273-288.

Bucklin, R.A., Turner, L.W., Beede, D.K., Bray, D.R. and Hemken, R.W. (1991). Methods to relieve heat stress for dairy cows in hot, humid climates. *Applied Engineering in Agriculture*, no.7(2): 241-247.

Cardot, V., Le Roux, Y. and Jurjanz, S. (2008). Drinking behaviour of lactating dairy cows and prediction of their water intake. *Journal of Dairy Science*, **91**: 2257-2264.

Chapinal, N., de Passille, A.M. Weary, D.M. Von Keyserlingk, M.A.G. and Rushen, J. (2009). Using gait score, walking speed, and lying behaviour to detect hoof lesions in dairy cows. *Journal of Dairy Science*, **92**: 4365-4374.

Darwin, C. (1859). *On the origin of species by means of natural selection or the preservation of favoured races in the struggle for life*. W. Clowes and Sons, Stamford street, and Charing Cross. pp 491.

DeVries, A. (2006). Economic value of pregnancy in dairy cattle. *Journal of Dairy Science*, **89**: 3876-3885.

DeVries, T.J., Von Keyserlingk, M.A.G. and Weary D.M. (2003). Effect of feeding space on the inter-cow distance, aggression and feeding behaviour of free stall housed lactating dairy cows. *Journal of Dairy Science*, **87**: 1432-1438.

DeVries, T.J., Von Keyserlingk, M.A.G. and Beauchemin, K.A. (2004). Diurnal feeding pattern of lactating dairy cows. *Journal of Dairy Science*, **86**: 4079-4082.

- DeVries, T.J., Von Keyserlingk, M.A.G., Beauchemin, K.A. (2005). Frequency of feed delivery affects the behaviour of lactating dairy cows. *Journal of Dairy Science*, **88**: 3553-3582.
- Eibl-Eibesfeldt, I. and Kramer, S. (1958). Ethology, the comparative study of animal behaviour. *The Quarterly Review of Biology*, **33**(3): 181-211.
- Gibb, M.J. Huckle, C.A. and Nuthall, R. (1998). Effect of time of day on grazing behaviour by lactating dairy cows. *Grass and Forage Science*, **53**: 41-46.
- Grant, R.J. and Albright, J.L. (2001). Effect of animal grouping on feeding behaviour and intake of dairy cattle. *Journal of Dairy Science*, **84**: 156-163.
- Grant, R.J., Colenbrander, V.F. and Albright, J.L. (1990). Effect of particle size of forage and rumen cannulation upon chewing activity and laterality in dairy cows. *Journal of Dairy Science*, **73**: 3158-3164.
- Hemsworth, P.H. (2003). Human-animal interactions in livestock production. *Applied Animal Behaviour Science*, **81**: 185-198.
- Huzzey, J.M., DeVries, T.J., Valois, P. and Von Keyserlingk, M.A.G. (2006). Stocking density and feed barrier design affect the feeding and social behaviour of dairy cattle. *Journal of Dairy Science*, **89**: 126-133.
- Kadzere, C.T., Murphy, M.R. Silanikove, N. and Maltz, E. (2002). Heat stress in lactating dairy cows: a review. *Livestock Production Science*, **77**: 59-91.
- Lanier, J.L. Grandin, T., Green, R.D., Avery, D. and McGee, K. (2000). The relationship between reaction to sudden intermittent movements and sounds and temperament. *Journal of Animal Science*, **78**: 1467-1474.
- Lehner, P.N. (1979). Handbook of Ethological Methods. Garland STPM Press, New York.
- Meyer, U., Everinghoff, M., Gadeken, D. and Flachowsky, G. (2004). Investigation on the water intake of lactating dairy cows. *Livestock Production Science*, **96**: 117-121.
- O'Kiely, P. (1994). The Cost of feedstuffs for Cattle. R & H Hall Technical Bulletin and R. and H. Hall, Dublin, Ireland.
- Olofsson, J. (2001). Feed availability and its effects on intake, production and behaviour in dairy cows. Swedish University of Agricultural Sciences, Uppsala, Sweden 221pp.
- Phillips, C. (2002). Cattle Behaviour and Welfare, Second edition, Chapter 10 to 12 Blackwell, Science Ltd. Cornwall, United Kingdom.
- Phillips, C.J.C. (1993). Cattle Behaviour 1<sup>st</sup> edition, Farming press books, 212.
- Phillips, C.J.C. and Denne, S.K.P.J. (1988). Variation in the grazing behaviour of dairy cows measured by a vibrarecorder and bite counter monitor. *Applied Animal Behaviour Science*, **21**: 329-335.
- Scott, J.P. (1956). The analysis of social organization in animals. *Livestock Production Science*, **37**: 213.
- Scott, J.P. (1962). Introduction to Animal Behavior. In: *Behaviour of Domestic Animals*. E.S.E. Hafez (Ed.) William and Wilkins.
- Shinoda, M., Sudou, K., Matsumura, T. and Umemuta, K. (2009). Estimation of grazing time of Holstein cows by walking time observed by a hand-held GPS. *Japanese Journal of Grassland Science*, **55**: 34-39.
- Shipley, L.A. (2007). The influence of bite size in foraging at large spatial and temporal scales by mammalian herbivores. *Oikos*, **116**: 1964-1974.
- Sjaastad, Q.V. Hove, K. and Sand, O. (2003). Scandinavian Veterinary Press. Oslo, Norway.
- Skinner, B.F. (1958). The Behaviour of Organisms: *An Experimental Analysis*. Cambridge. Massachusetts: B.F. Skinner Foundation: 457pp.
- Tapki, D. and Sahin, A. (2006). Comparison of the thermoregulatory behaviours of low and high producing dairy cows in a hot environment. *Applied Animal Behaviour Science*, **99**: 1-11.
- Taweel, H.Z. Tax, B.M., Smit, H.J., Tamminga, S. and Elgersma, A. (2005). A note on eating behaviour of dairy cows at different stocking systems-diurnal rhythm and effects of ambient temperature. *Applied Animal Behaviour Science*, **98**: 315-322.
- Taylor, R.E. and Field, T.D. (1998). Scientific Farm Animal Production. Prentice Hall. New Jersey.
- Waibilinger, S., Fesdorf, A. and Spitzer, G. (2002). The role of social licking in cattle for conflict resolution. In: *Proc. 1st European Conference Behavioural Biology*, 1-4 Aug. in Muenster. Germany, 122.
- Waibilinger, S., Menke, C. and Folsch, D.W. (2003). Influences on the avoidance and approach behaviour of dairy cows towards humans on 35 farms. *Applied Animal Behaviour Science*, **84**: 23-39.
- Watson, J. B. (1930). Behaviorism. William Warder Norton & Company, New York.
- Welp, T., Rushen, J., Kramer, D.L., Festa-Bianchet, M. and De Passille, A.M.B. (2003). Vigilance as a measure of fear in dairy cattle. *Applied Animal Behaviour Science*, **87**: 1-13.
- Wenzel, C., Schonreiter-Fischer, S. and Unshelm, J. (2003). Studies on step-kick behaviour and stress of cows during milking in an automatic milking system. *Livestock Production Science*, **83**: 237-246.