‘Cow Signs’ in Assessing the Quality of Nutrition

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Cow signs are behavioral, physiological, and management parameters that can be observed and measured. Cow signs can be used as a field approach to evaluate the composition of the ration, the quality of rumen fermentation, the quality of digestion, and the general herd health of cattle of interest. This research of cow signs associated with nutrition provides farm advisors, consultants, nutritionists, practitioners, and dairy farmers with an additional toolkit that can be used to improve the assessment of the quality of dairy cattle nutrition. ‘Cow signs’ are not to be used alone as a sole tool for assessment of the quality or nutrition of dairy cows. Some of the ‘cow signs’ are incorporated in precision technologies on many dairy farms and are extensively used in the assessment of dairy cow welfare, health, and nutrition.

Keywords: appetite ; demeanor ; fecal digestibility scoring ; fecal scoring ; fecal perineal staining ; obtundancy ; prehension ; rumen fill scoring ; rumination ; thirst

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1. Introduction

Dairy cattle productivity, health, and fertility are significantly affected by the quality and quantity of the nutrition, making dairy cattle nutrition an important profit driver [1]. The biggest issue when feeding dairy cattle is addressing both metabolic compartments, namely, the rumen microbes and the bovine tissues [2][3]. Therefore, the nutrition should aim to keep the rumen functioning optimally whilst providing the appropriate levels of nutrients for health, maintenance, and production [4]. The assessment of the quality and quantity of dairy cattle nutrition is a critical task for dairy herd practitioners, consultants, and dairy farmers/managers. The term practitioners in this entry means a herd-level advisor or consultant, nutritionist, or veterinary practitioner.

A variety of approaches to assess the adequacy of nutrition in dairy cattle have been adopted by veterinarians in practice or consultancy services. The majority of practitioners use a combination of methods, including assessment of the value of production indices and cow sign profiles, utilization of nutritional analysis of the diet, and/or metabolic profiling [5]. The most commonly used method of assessment of the adequacy of nutrition is the feed (nutrition) analysis of a representative sample of the diet/feedstuffs. Significant limitations to this approach are the uncertainty regarding how representative the sample is and the cost.

2. Assessment of the Skin and Hair Coat

The condition of the skin and coat can give an indication of the nutritional status; however, practitioners should be aware that other conditions can also affect this system. The general appearance of the skin and hair coat, including the absence of lick marks (e.g., acidosis), dullness of the hair coat (e.g., undernutrition, several deficiencies in macro- and micronutrients), discoloration (e.g., copper deficiency), and overall clinical impression (e.g., undernutrition, imbalanced nutrition, zinc deficiency, ingestion of photosensitization agents), may be indicative of nutritional mismanagement but are difficult to interpret [6][7].

Fecal Perineal Staining

Many digestive problems of dairy cattle are characterized by lower fecal scores with increased water content. Feces with increased water content are typically visible by fecal staining of the perineal area. A scoring system devised by the first author is presented in **Table 1**. Fecal perineal staining can also be caused by infectious diarrhea (e.g., gastro-intestinal parasitism, Johne’s disease), disorders of other body systems (e.g., congestive heart failure, chronic amyloidosis), or environmental conditions (e.g., sudden weather change) [8]. Fecal perineal staining can be used as an indirect indicator of nutritional problems (e.g., subacute ruminal acidosis) but other etiologies must be considered [9][10][11][12][13][14][15][16][17][18]. It should be noted that dairy cattle grazing lush, high-quality pasture will commonly have lower fecal scores and increased fecal staining of the perineal area (fecal staining score of 3–4 may be ‘normal’).

Table 1. Scoring of the fecal soiling of the perineal area in cattle. The percentage (in the brackets) refers to the proportion of the perineal area that is stained. Perineal area in this table refers to area around the anus, caudal hindlimb and rump, and tail.

Score	Description
1	**No fecal perineal staining**
2	**Mild; Few flecks of perineal staining (2–10%)**
3	**Moderate; Maximum up to 30 of the perineal area stained with feces (11–30%)**
4	**Severe; Large portion of the perineal area stained with feces (31–60%)**
5	**Very severe; Nearly whole perineal area stained with feces (>60%)**

3. Assessment of Feeding

The feeding assessment is very important and may provide useful insights into the feed quality, quantity, and delivery method. Important cow signs related to feeding include appetite, thirst, prehension, and rumination. Aberrant feeding behavior may be present in the whole group of dairy cattle or only in an individual. Nutrition-related aberrant feeding behavior is usually present in the majority or the whole group. Conversely, aberrant feeding behavior in only one or few dairy cattle is more likely to be related to clinical conditions affecting the individual.

3.1. Appetite

Appetite is the desire to eat the offered feedstuffs and is mainly assessed through the feed intake. Feed intake can be affected by a number of factors, including climatic conditions, diet composition, social dynamics, feed availability, delivery systems used, body size, stage and level of production, pregnancy, age of cattle, stress, and exercise [2][10][19][20][21][22][23][24][25][26][27]. The accepted knowledge of the effect of breed and body size on the utilization of feed by dairy cattle has been questioned by newer publications [28][29][30][31]. Previously, it was accepted that dairy cattle of the Jersey breed and individual cattle of larger frame and weight eat more per unit of body weight [31].

The appetite can be normal, decreased (inappetence, hypophagia), increased (polyphagia), abnormal (alotriophagia), or completely absent (anorexia). Aberrant appetite can be temporary or permanent. Medical causes of depressed appetite in dairy cattle include a lack of desire for food or an inability to prehend, masticate, and/or swallow [32]. Environmental causes of depressed appetite include temperature extremes and heat stress [33]. The lack of desire for food from a nutritional aspect can be caused by acidosis [9][11][13][14][15][16][17][18][31][34][35][36][37]. Causes of depressed appetite due to factors directly related to the feed provided include low palatability (e.g., offensive smell and taste, rough appearance, inappropriate texture and feel), the presence of decomposition, endophytes, mold or mycotoxins [2][5][10][21][22][23][33][38][39], or unfamiliarity with the offered diet [21][40]. Additionally, total dry matter intake per day (i.e., the appetite) can be affected by some physico-chemical properties of the diet, such as the fiber type and length, and content (e.g., neutral detergent fiber, NDF), digestibility of other carbohydrates, fat content of the diet, particle size, particle fragility, diet weight, rumen degradation and fermentation, passage rate through the digestive system, osmolarity of the rumeno-reticulum, and production of ruminal degradation products (e.g., concentration of various volatile fatty and other simple acids) [9][16][19][20][21][22][23][24][31][33][41][42][43][44][45][46][47][48][49][50][51][52][53][54][55][56][57][58]. For example, excess physical neutral detergent fiber in the diet can result in physical limitations caused by distention of various portions of the digestive tract (predominantly rumen and reticulum) [20][21][22][48][55][59][60][61][62][63]. Distension of the digestive system results in stimulation of satiety receptors [20][22][62][64]. In contrast, decreased appetite without distention of various portions of the digestive system may result from excessive availability of easy-digestible carbohydrates associated with low ruminal pH [16][20][22][37]. Finally, insufficient fiber in the diet also increases the risk of stereotypic behavior in housed cattle [65].

The appetite of cattle can be affected by delivery methods and access factors [5][10][19][21][32]. Generally, dairy cattle that have no access to food for some time, including pasture, have a good appetite when offered the usual diet [66][67]. However, the provision of food alone does not ensure good intake because appetite may be significantly influenced by the delivery method. Thus, the design and maintenance of the feeding facilities are also important. Access to feeding areas may be affected by available feeding space, social interactions/hierarchies, quality of the bunker/feedpad/ pasture surfaces, and hygiene [5][9][19][32][68][69][70]. A good ‘rule of thumb’ is to provide 120% feeding spaces for the number of cattle with 60–85 cm per feeding space. The practitioner should be aware that with greater body size the feeding space requirements increase. Availability and sorting of food is assessed by observing the residual food in the bunker/feedpad/paddock after each feeding period. The proportion of residual food in the bunker/feedpad should be no more than 3% to 4% at the end of the prescribed feeding period, just before a new batch of feed is deposited [42]. For female cattle in the transition period, the proportion of residual food may be as high as 15%. In pasture-based systems, the residual food is usually estimated as ‘residual herbage mass’; i.e., the total weight of herbage per unit area, measured after grazing to a ground level [71]. Grazing usually satisfies dairy cattle requirements provided the sward height does not drop below 8–10 cm. The feeding efficiency in pasture-based cattle decreases when the herbage mass falls below 2000 kg/ha as the bite size decreases and is offset by an increase in the required grazing times [72][73][74]. The residual herbal mass is usually assessed at the end of the grazing period just before the dairy cattle are moved to a new break/paddock.

The forage material that is less palatable, spoiled, or of a poorer quality than the rest can be sorted out by cattle during feeding and rejected [42][47][75], depending on mixing and feed allocation. This feed is of a lower digestibility or reduced palatability. If consumed, it will likely reduce the feed intake and ultimately lead to lowered productivity. Therefore, dairy cattle that are being forced to eat the residual feed left in the bunker/feedpad/pasture may be underfed as they are not consuming the calculated diet. In pasture-based systems, when provided with a choice, dairy cattle ingest the leafy portion of the plant and select green material over dead material [76]. Hence, the residual herbage mass will depend on the pasture type, pre-grazing herbage mass, and grazing pressure (time and stocking density). Additionally, the grazing efficiency, and therefore the amount of residual pasture, may also be affected by the genotype of the dairy cattle, with the New Zealand Holstein being better suited to pasture-based systems compared with the American Holstein and the milking regime, namely, once-a-day or more frequent milking [40][77][78][79][80][81][82].

Residual feedstuffs should be removed regularly, particularly when feeding high-moisture feeds, such as silage and potatoes, to minimize the risk of spoiling. In pasture-based systems, the residual herbage mass should ensure the future growth of the sward in order to maintain continual grazing.

Appetite is also affected by the position of the body of dairy cattle during feeding. It should be as similar to that adopted when they are grazing grass [19][38]. Cattle which ate with their heads in a similar position to when grazing produced more saliva, have higher intake and better rumination [19].

Availability of feedstuffs to cattle is affected by the frequency of feeding and access [68]. Increased feeding bouts and feed intake have been reported for feeding dairy cattle more than once in feedlot systems [68][83]. However, in pasture-based systems, provision of fresh breaks six times compared to two times per day did not increase the intake nor the milk production [72]. It is likely that the time of the day when the fresh break/paddock is offered and the total grazing time per day are more important for feed intake and milk production than number of fresh breaks offered per day [74]. During feeding, cattle push a proportion of the feed beyond reach. This should be regularly pushed back to maintain access and minimize overstretching and possible trauma [84]. Pushing the feedstuffs back into the bunker/feedpad may sometimes be enough to stimulate feeding activity anew [68][85][86]. Similarly, letting grazing dairy cattle on a ‘new’ break that has been previously incompletely grazed, is usually enough to stimulate feeding activity anew. In most pasture-based commercial settings, dairy cattle consume most of their daily allowance within 2–3 h from gaining access to a fresh break/paddock [72]. Ideally feeding facilities should provide 60 to 85 cm of space per cattle-head [38][69][87]. The dimensions vary depending on presence of headlocks/dividers and horns, age, breed, size and category of dairy cattle, and climate [19][38][69]. Due to reduced convective heat loss in crowded conditions, farms in hotter climates should provide a larger feeding space. Enough room for all cattle to feed at the same time is required for good food utilization and better production [19][87][88]. In pasture-based systems the stocking density on a paddock/break depends on the same factors as for feedlot-based systems in addition to the pasture/crop quality and quantity, amount of supplemental feed, antecedent experiences of each individual, and current environmental and social conditions [27][67][89][90][91][92][93][94][95][96]. This is important, as cattle are social animals and eat at the same time, often referred to as ‘social facilitation’ [19][68][97][98]. However, the social facilitation is somewhat less obvious in pasture-based automatic milking systems [67]. As feeding is affected by social ranking, younger and smaller dairy cattle, particularly heifers, are usually left aside if there is insufficient feeding space [38][68][86]. Similar behavior is usually seen in recent (less than a week) re-groupings [19].

Assessment of the appetite is usually subjective and is achieved by observing the feeding behavior of dairy cattle when fresh food is offered [19][97][99]. Proxy behavioral measures of hunger include time spent searching or acquiring food, rate of food intake, and rate of trade-offs between feeding and other activities in their time budgets [68][99]. Another measurement of appetite can be obtained by assessing prehension. Objective measures in commercial settings are difficult. Some assessment can be carried out by the use of individual feeding bins combined with video recording or electronic-identification systems, all of which are non-practical and/or expensive. On modern dairy farms, dairy cattle are kept and fed in groups; therefore, the individual feeding and recording is impractical and not a true representation. Video recording is also subjective, and it is time-consuming to assess the feeding behavior. The advantage of electronic systems is that the quality of the obtained information of some of them is very high [68][100]. Assessment of the appetite should also consider the dry matter intake per individual per day. Dry matter intake should average from 2.5% to 4.0% of the body weight, dependent on feed base, phenotype, milk yield, and stage of lactation [47][101]. In pasture-based systems, dry matter intake of up to 4.4% of the body weight at peak lactation have been achieved [71]. Lower values indicate that cattle are underfed or have a lowered appetite.

3.2. Prehension

Prehension is the act of grasping the food and ability to drink with the mouth. It may be affected with disorders of the mouth cavity, nervous system, pharynx, and, rarely, esophagus and larynx. Prehension may also be impaired due to inability to swallow. It is important to differentiate between a depressed appetite and the inability to prehend food due to other causes (e.g., pain, paralysis). Dairy cattle with ad lib access to feed eat for 5.0 ± 2.5 h per day in a feedlot system (dependent on tie or free-stall system, diet, and physiological status of the dairy cattle individual of interest) and 7.0 ± 3.5 h in pasture-based systems (dependent on sward characteristics such as lush pasture or thorny bushes) in several eating bouts (4–20) [6][19][32][34][38][44][47][49][50][53][56][57][61][64][74][76][82][86][99][100][102][103][104][105][106][107][108][109][110][111][112][113][114][115][116][117][118][119][120][121]. Dairy cattle on pasture show a distinct diurnal feeding behavior [19][22][45][66][72][88][93][122]. They spend more time grazing during the day with rest and rumination around midday [27]. The diurnal feeding behavior in housed dairy cattle is less distinct or may be completely absent, particularly when fed on total mixed rations [68][85][114][123][124]. Longer grazing periods in late afternoons and early mornings are beneficial for cattle kept on pasture-based systems [42]. Incorrect milking management or insufficient pasture availability may result in extended grazing periods around midday. Grazing periods around midday should be shorter, particularly during hot days.

The average time spent eating and number of eating bouts depend largely on cow factors (e.g., age, stage and level of production, breed, social dominance), appetite, system of food delivery (e.g., feedlot or pasture-based), time of the day, and feeding related to other management practices (e.g., milking) [47][86][103][125]. The time spent on eating and number of eating bouts are heavily affected by the level of production, with high producers spending a longer time eating and, often, in more feeding bouts [38]. Additionally, the time spent eating is affected by the diet, e.g., grazing chicory and plantain requires more time on mastication at ingestion but less time on rumination compared to rye grass pasture [104][126]; diet composition and intake; fiber type and length; and age, size, breed, and production status of the dairy cattle individuals of interest [29][31][41][42][43][44][47][50][57][60][86][100][101][102][107][110][124][126][127][128][129][130]. In pasture-based systems, the time spent eating is a function of grazing time, biting rate, and the bite mass [81][94][131], which are dependent on the same factors as the residual herbage mass.

Heifers tend to eat less per feeding bout [10][48][103]. They prefer to visit the feeding facilities more frequently [9][111][114][132], probably due to their smaller rumen capacity [21][114]. Competition at the feeding platform/pasture is highest when dairy cows return from milking and when fresh food/a new pasture break/paddock is offered [19][38][67][68][75][85][86][87]. At these times, dominant dairy cattle demand priority for feeding and attempt to pick the high-quality food. Less dominant, and particularly submissive dairy cattle may have limited access to food at these times [9][10][19][38][50][68][86][97][133]. As these cattle eat less or choose to eat at times when there is less competition at the feeding platform, the available food may be of lower quality due to previous sorting by more dominant cows [5][9][19][47][68][75][116]. Sorting can be minimized by feeding a milled and properly mixed total mixed ration (TMR) diet. Aggression and competition when feeding on pasture is less common than in feeding barns, as grass is spatially distributed over large areas and all dairy cattle can feed at one time [134]. Grouping strategies can minimize the negative social interactions (e.g., avoiding grouping primiparous with multiparous cows or dairy cattle of different sizes or cows in different stages of the production cycle) [10][19][32][116]. Additionally, homogenous groups make management of nutrition easier, making it easier to formulate an appropriate ration or allowing better land use in pasture-based systems [38][116]. Dairy cattle are herd animals and eating in one individual stimulates the appetite in others, referred to as social facilitation [19][38][97][98]. Younger cattle learn to consume offered supplemental food or graze when exposed to experienced individuals than when learning to consume offered feedstuffs/grazing as a naïve group; this is referred to as social learning of feeding [90][131][135][136][137].

Assessment of prehension is usually carried out by observation or video recording. In practice, during the nutritional visit, the practitioner usually briefly assesses prehension by observing the acts of grasping, chewing, and swallowing in a several cows at the bunk/feedpad/pasture. These procedures are labor-intensive [83][130]. Video recording can be used as an alternative. Assessment of prehension can give useful information about the appetite, health, and diet quality.

3.3. Rumination

The act of chewing the cud (rumination) starts with an abdominal contraction followed by antiperistalsis of the esophagus from where the bolus (food bolus; cud) is delivered into the mouth [22][86][138][139][140][141]. In the mouth, the bolus is driven between the molar teeth by a single stroke of the jaw. Thereafter, chewing of the cud is carried out on one side of the mouth only, in a methodical grinding manner [138][139][140][141][142][143], and then re-swallowed [86][144]. Rumination is required to reduce the size of ingested particles in order to pass through the reticulo-omasal orifice, and also increases saliva production, which plays a role in buffering of the rumen fluid [30][43][51][52][63][86][107][126][143][144][145][146][147]. The rumen microbial degradation of ingesta hardly, if at all, influences the particle size, even when plant fiber is weakened by microbial fermentation. Chewing activity, particularly during rumination, is necessary to decrease the particle size. This increases the particle surface/volume ratio, and thus results in improved microbial access and rumen fermentation [86][126][144][145][148][149]. The act of re-chewing the food bolus is essential for its utilization by ruminants [6][43][51][63][107][143][147][150]. As the particle size decreases, the feed particles pass more readily and rapidly through the reticulo-omasal orifice (the critical particle size is assumed to be 1.18 mm) [118][151], the rumen fill decreases, and satiety receptors become inactive. Thus, rumination has a significant effect on the appetite of dairy cattle [30][86][144].

Rumination can be affected by diet composition and access, estrus, painful conditions, rumen movement dysfunction caused by metabolic or neurological conditions, rumen acidosis, and time budgets, in particular lying times. Factors affecting rumination such as individual dairy cattle signalment, climatic conditions, including heat stress and rain, day length, exercise, production status and level, stress, and time of day have been reviewed [2][20][21][22][23][31][35][111][114][141][144][152][153][154][155]. Time spent on rumination in dairy cattle depends on various factors, including feed quality and quantity (particularly the adequacy of fiber content and length), type of feeding, and body size, as well as on management factors such as the availability and quality of space for rest in a stress-free environment [19][29][31][41][43][47][48][52][53][57][60][102][138][141][142][143][144][145][147][156][157] and, in pasture-based systems, available grazing time [125]. Diets rich in fiber generally increase the chewing activity [11][43][50][57][67][108][126][127][158]. In contrast, diets rich in concentrate or roughage chopped to particles less than 1 cm in length reduce the chewing activity [19][31][42][44][101][127][142]. Unfortunately, fiber content alone is not a good predictor of the risk of ruminal acidosis [11][13][119]. Excessively long fiber particles can paradoxically increase the risk of acidosis [9]. Sorting of feedstuffs may result in both dominant and very submissive dairy cattle suffering from acidosis due to preferential concentrate uptake [9][10][13][17][56][158]. The theory of variable chewing time and effort being dependent on the fiber length alone is not consistently supported by research findings. Increased chewing during rumination has not always resulted in improved rumen fluid pH and decreased risk of subacute rumen acidosis [13][50][155]. Other factors that influence rumination time and chewing activity during rumination are the different rumen fermentation rates of various diets [42], reduced saliva production in cows that chew food at a faster rate when eating resulting in longer periods of no chewing activity [108], and rumen digestive potential, which influences the rumen pH and the volatile fatty acid composition [11][42][47][120][127]. Restricted feed availability, seen in many dairy feedlot systems, usually results in faster eating [38][155], swallowing of larger feed particles, and is associated with longer rumination times [9][29] but not always with a decreased risk of acidosis. In fact, the risk of acidosis may even be increased [13][155]. A comfortable and normal lying posture enhances rumination [19][116][124][147][159][160]. Most dairy cattle, during relaxed rumination, lie down with a slightly extended neck during the night and nearly 50% of all dairy cattle ruminate standing during the day [111][124][141][145][150][152]. Chewing movements stimulate production of saliva [9][11][30][31][35][42][50][55][56][59][86][107][119][142][143][147][150], lowering the risk of reduced fiber digestion, milk fat depression, displaced abomasum, fat cow syndrome, sub-acute ruminal acidosis (SARA), and associated conditions, including lameness, ruminitis, liver abscessation, metabolic acidosis, and caudal vena cava syndrome [5][9][11][13][14][15][16][18][23][31][34][35][37][42][50][51][107][118][127][147]. Dairy cattle lying down in a low-stress environment ruminate for a longer period [19] and this is associated with improved digestibility of the feedstuffs, feed conversion efficiency, and productivity.

Although lactating dairy cattle seldom ruminate over 10 h per day in total, cattle on a very rough diet may ruminate up to 12 h per day [86]. The maximum total chewing time has been estimated at 16 h per day [86]. Normal, healthy cattle ruminate for 7.0 ± 3.5 h a day in several rumination bouts (10 to 20) [19][30][34][35][38][43][47][50][53][56][60][61][74][99][102][104][106][107][108][109][111][112][113][114][115][117][118][119][120][124][127][128][141][144][146][147][152][156][160][161]. Each bout lasts 10–60 min (range 0.5–120.0 min) [60][86]. The length of each rumination bout varies with the availability of acceptable space, availability, composition, digestibility and type of the diet [29][43][59][60][86][162], interactions within a group [19][86][162], and social ranking. A diurnal pattern of rumination is seen in most dairy cattle [30][34][38][53][88][145][163], contrary to the diurnal pattern of appetite, meaning cattle ruminate when they are not prehending [27][88]. Additionally, a circadian pattern with most of the rumination occurring during night has been reported in dairy cattle in pasture-based systems [27][86][125].

The number of movements of the jaw required to chew a cud is usually indicative of the food quality. The number of chews is particularly, but not exclusively dependent on the fiber content [42][47][59][86]. The number of chews per cud also depends on the type, quality, and length of fiber particles [34][42][101][108]. Furthermore, the number of chews can be affected by many other factors [30]. For example, heifers and old cows with developing and/or malocclusive teeth usually make more chewing movements per cud to achieve the same grinding effect as cows of age 4–7 years [30]. Diets of acceptable quality should result in 60 ± 10 chewing movements per cud [29][30][43][60][102][124][129][146]. Less than 50 chewing movements per cud is indicative of insufficient fiber in the diet (e.g., lush pasture) [34]. A lower number of cud-chewing movements may also result from a significant stress or health problem [164]. Some studies have reported fewer than 50 chews per cud, but these are mainly older studies and investigated the effect of the addition of concentrate to the diet on milk production, with no concurrent measurements of rumen pH and rumen health assessment [60][129]. More than 70 chewing movements per cud is indicative of excessive fiber in the diet (e.g., low-quality straw) [1][5]. Generally, a higher number of chews per cud is not indicative of danger for the health of dairy cattle. However, the energy spent on chewing and associated depression in appetite results in decreased dry matter and energy intake and, therefore, lower milk production [43]. Less chews per cud are expected in pasture-based systems. Dairy cattle graze succulent plants in preference to drier, more mature plants [21]. Therefore, it is likely that less fibrous feed results in a reduced number of chews per cud. Increased fiber content and particle size usually results in increased chewing per unit of dry matter [57][86] and thus depressed appetite. Therefore, the total rumination time per day may remain unchanged [34][43][124]. This is important for assessments based only on total rumination time.

3.4. Thirst

Thirst is the desire to drink water. It may be normal (eudipsia), increased (polydipsia), decreased (oligodipsia), or completely absent (adipsia). Drinking behavior and volume of water drunk are likely to affect both feed intake and production [165][166][167]. Drinking promotes further eating [165], which is particularly important for dairy cows for improved production. Feedstuffs with a higher water content result in decreased thirst at the population level. Conversely, feedstuffs with a high dry matter content result in an increased thirst. Dairy cattle tend to drink quickly, up to 20 L of water per minute [165][166]. Drinking from a large, calm surface elevated from the ground rather than from flowing water is preferred by dairy cattle [165][168][169]. Drinking from a bowl changes cattle behavior to more but shorter-duration drinking bouts per day [165].

Thirst and drinking behavior are affected by factors such as climatic conditions, diet composition, pregnancy, stage and level of production, and water quality [20][25][33][167][170][171]. The water intake is proportional to the increase in the ambient temperature [167]. Higher proportion of concentrates in the diet requires higher water intake [167]. Generally, lactating dairy cows drink 40–120 L/day and dry cows 17–70 L/day [166][168][172][173][174][175]. Additionally, thirst may be affected by the water availability, quality and quantity, access to the watering facility, and social dominance [19][33][165]. Dairy cattle should drink at intervals during the day [114]. On pasture, the number of drinking bouts and volume of water consumed may be affected by the distance between the grazing area and the water trough [165][172]. Water consumption in lactating cows is greatest at feeding and just after milking [55][165][166]. Whilst it may be disruptive to the cow flow, having water available at the exit of the milking shed as well as the feeding area may be beneficial [166]. Drinking behavior is also affected by social interactions [159][165][172][176]. Dairy cattle with a higher dominance in the group usually drink less frequently but larger volumes per drinking bout [165].

When assessing thirst, the availability and quality of the food and environmental temperature should also be considered. As dairy cattle eliminate a significant portion of their body heat through increased respiration, and exhale moisture rich air, higher environmental temperatures result in an increased thirst.

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