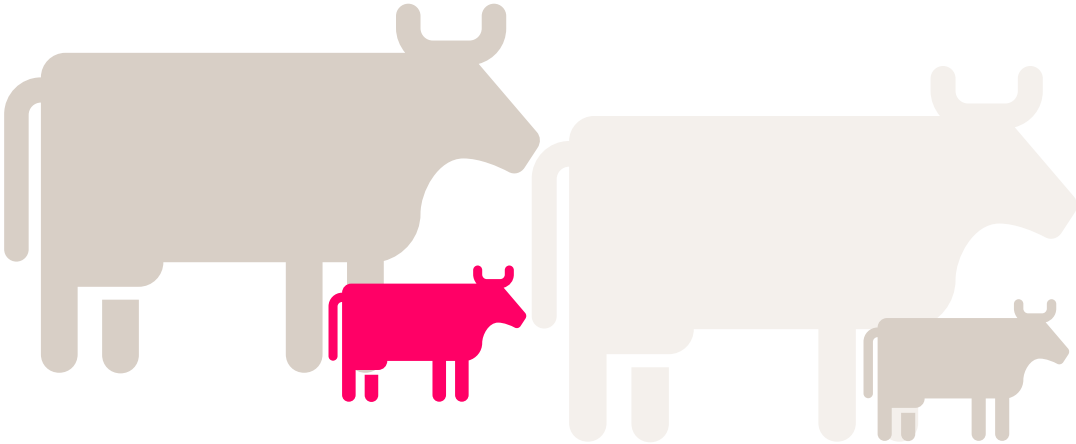
Prevention of Neonatal Calf Diarrhea in Cow Calf Operations: A Practical Guide for Veterinarians

Based on results of this scoping review: Maier et al. 10.1016/j.vas.2022.100238

This guide provides practical approaches for the diagnosis and prevention of neonatal diarrhea in cow calf operations.

Neonatal calf diarrhea, or calf scours, is one of the most common reasons for antimicrobial use in California beef cow-calf operations, according to a rancher survey conducted in 2017 by the California Department of Food and Agriculture. [1] Diarrhea is also among the most common causes of death in preweaned beef calves. [2] This guide describes opportunities for veterinarians to promote antimicrobial stewardship through judicious antibiotic use and employment of evidence-based strategies for disease prevention.



PREVENTION THROUGH MANAGEMENT

Adequate dam nutrition

Throughout pregnancy, the nutritional care of the pregnant cow significantly influences the long-term health of calves. Additionally, both macro- and micronutrient deficiencies of the dam are associated with weak labor, decreased milk production, and dystocia, which are, in turn, associated with the potential for failed transfer of passive immunity (TPI). [3]

INTERVENTION STEPS

- Before conception and throughout pregnancy, evaluate cow and heifer nutrition and trace mineral supplementation as part of a herd health plan with ranchers.
  - It may be prudent to randomly sample 5 - 10 individuals in the adult herd, from mixed parities, to do a trace mineral panel and blood selenium levels before breeding season to ensure the supplementation program is adequate/optimal.
- Instruct ranchers on how to perform body condition scoring to promote heifers calving with body condition score (BCS) of 6 and cows calving with body condition score of at least 5. [4] A BCS of more than 6 at the time of calving may increase the risk of dystocia and is not economical. See attached chart for visual guide of BCS score 5 and 6.

Adequate colostrum intake

Colostrum intake in the neonatal calf is essential for the prevention of calfhood disease, including scours. Failed TPI, or inadequate TPI, is prevalent in beef calves, with an estimated 37% of calves having serum IgG < 24 g/L, which is predictive of increased morbidity and mortality. [5] Inadequate colostrum intake in beef calves often goes unnoticed because testing is rarely performed in cow calf operations. Failed transfer of passive immunity has been associated with low calf vigor score and weak suckle reflex [6]; both of these post-calving effects may be associated with dystocia. [7] If the calf had assisted birth or a weak suckle reflex, it likely benefits from assisted colostrum intake with oral esophageal tube feeding.

INTERVENTION STEPS

- Instruct ranchers to ensure adequate colostrum consumption by 4 hours post-calving to help decrease the incidence of diarrhea. Calf vigor at birth assessed via suckle reflex is a good predictor for colostrum intake. [6] Calves with a poor suckle reflex may benefit from colostrum administered through esophageal tube-feeding. Several open-source publications on colostrum management are available in the reference list. [8-10]
  - Further resources on colostrum management that can be shared with clients are available at https://www.beefresearch.ca/blog/calf-911-colostrum-video/.
- Ensure ranchers have an available supply of stored colostrum or a suitable colostrum substitute. Instruct ranchers on how to recognize the difference between a *colostrum replacer* product (recommended for replacement) and a *colostrum supplement* (not a suitable replacement for colostrum). [11]
  - Harvest colostrum from a clean, disinfected udder (using a teat dip according to manufacturer's instructions). Wear gloves to minimize contamination.
  - Feed fresh colostrum within 2 hours of collection
    or
    - Store fresh colostrum up to one week in the refrigerator at 39°F.

    or
    - Store fresh colostrum for up to 1 year in the freezer at -5°F.
  - Containers should be dated to ensure appropriate use times.
  - Store in freezer in double resealable plastic bags.
  - Thaw frozen colostrum slowly (over 30 - 60 minutes) in 120°F water bath to 104°F to 110°F to avoid denaturing IgG.
  - Test colostrum quality using a Brix refractometer or with other methods to assure the colostrum contains > 100 mg/ml IgG. [12]
  - Colostrum from dairies may contain pathogens such as bovine leukosis virus or *Mycobacterium avium subspecies paratuberculosis* and is best avoided.

- Products labelled and sold as **colostrum supplements** do not contain adequate amounts of IgG to use as a replacement for colostrum. Products labelled as **colostrum replacer** are designed to be fed as a sole source of IgG.

Genetic management of the herd

A high incidence of dystocia can be addressed through selection of bulls (calving ease EPD) and heifers (pelvic scores) and with proper monitoring during calving season to assist calving when necessary. Develop a plan for calving intervention at the ranch as part of a management plan to reduce the number of calves born with low vigor.

Good hygiene in the calving area

Ensuring that heifers and cows calve in a clean, dry area can reduce the exposure of neonatal calves to infectious environmental pathogens that could cause scours. Calves from heifers should be separated from calves born to cows to help reduce the transmission of fecal pathogens.

Intervention Steps

- Suggest a breeding program that has heifers calve prior to cows, as pathogen load is lower at the start of calving season. Calves from heifers are more likely to need calving assistance and are at higher risk for disease.
- Reduce the duration of the breeding season to decrease the period of pathogen introduction into the environment from young calves.
- The Sandhills calving system was developed to separate groups of calves and their dams by calf age to prevent exposure of younger calves to fecal pathogens shed by older calves. [13] In this system, cows that have not yet calved after either a certain percentage of calves are born or after 7 - 14 days have passed are moved to a new pasture in a continuous fashion until all cows have calved.
    - For more information, visit this online resource: https://beef.unl.edu/beefreports/symp-2007-17-xx.shtml

Reduce environmental stressors

Calves that are born during inclement weather are exposed to additional health risks that could increase the prevalence of diarrheal disease. [14]

INTERVENTION STEPS

- Suggest moving the calving period to a time of year that is less prone to extreme weather (spring).
- Suggest providing shelter in the form of windbreaks and bedding to reduce environmental stress during calving and to provide protection to newborn calves.
- Always ensure adequate space between cow calf pairs to avoid overcrowding.

DISEASE DIAGNOSIS

Addressing on-going neonatal calf diarrhea cases in a herd or in single animals requires an accurate diagnosis. A wide variety of infectious organisms are associated with calf diarrhea including viral, bacterial, and protozoal pathogens. Calves can also develop diarrhea from non-infectious causes. Although calf age at disease onset, vaccination history, and clinical signs can help to identify likely etiologies, laboratory diagnosis of the pathogens involved can be helpful in guiding treatment and prevention efforts. [3] Of 234 beef and dairy calf diarrhea panels performed at the California Animal Health and Food Safety (CAHFS) Lab in 2019, 60% of animals showed infection with more than one pathogen; and, in 28% of samples, three or more pathogens were detected. [15] A multi-pronged approach to diarrhea treatment may be necessary in this scenario if more than one detected pathogen is suspected in causing disease. Fecal pathogens can also be isolated in normal feces, which complicates the diagnosis. [16, 17] Consider consulting lab personnel to help interpret diagnostic testing results.

Follow these steps to arrive at a diagnosis with the CAHFS lab:

Please note: The following are CAHFS submission protocols. If these samples are submitted elsewhere, be sure to follow that lab's submission guidance.

1. **Collect a patient history** including age, vaccination, nutrition, duration of illness and clinical signs. Please also include the total number of animals in the herd that are sick, and the total number of animals in the herd in your documentation—see Figure 1.

Figure 1. Table of CAHFS diarrhea panel by age of patient

Please note: Exact test name may change over time. Always reference CAHFS website or consult with staff for most up-to-date testing options.

Diarrhea Panel for Calves under 8 days old	Diarrhea Panel for Calves 8 - 60 days old
• *Salmonella* Culture—Mammalian • *Salmonella* RT PCR Screen & culture • *Cryptosporidium* antigen ELISA* • Bovine Coronavirus—Fecal material, PCR • Bovine Rotavirus—Fecal material, PCR **Additional tests for calves <8 days:** • K99 (F-5) *E.coli* antigen ELISA* • Bacterial Aerobic Culture	• *Salmonella* RT PCR Screen & culture • *Cryptosporidium* antigen ELISA* • Bovine Coronavirus—Fecal material, PCR • Coronavirus-rotavirus multiplex

Source: https://cahfs.vetmed.ucdavis.edu/lab-tests-fees

**Note: K99 and Cryptosporidium require minimum 5 grams of feces*

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2. **Submit necropsy specimens** when possible, especially during severe outbreaks. Ideally, the animal(s), carcasses, or tissues submitted for necropsy have not received antimicrobial treatment. Clinical history, including any antimicrobial treatment(s), should be provided to assist with interpretation of diagnostic results.
    a. Whenever possible, submit a sick, but live animal to the laboratory for euthanasia and fresh necropsy to reduce autolysis of tissues postmortem, which provides an increased diagnostic value to the tissue samples.
    or
    b. Submit the carcass of severely affected animals as close to the time of euthanasia as possible.
    or
    c. Submit fresh and formalin-fixed gastrointestinal tissues, such as rumen, small intestine (especially ileum), large intestine (colon or spiral colon). Fresh intestinal segments can be tied in loops or isolated using umbilical tape to contain fecal matter, or feces can be submitted separately for the diarrhea panel. Refrigerate all samples as soon as they are collected to avoid bacterial overgrowth. Transport samples to the laboratory with ice packs as soon after sampling as possible. Detailed packaging and shipping instructions for tissues are available on the CAHFS website:
        1. https://cahfs.vetmed.ucdavis.edu/submitting/packaging-guidelines
        2. https://cahfs.vetmed.ucdavis.edu/submitting/specimen-delivery
    or
    d. Submit at least 5 g of feces (the size of a large grape) for a fecal panel, ideally from multiple untreated, acutely diarrheic calves.

3. Ensure more accurate and applicable test results by **following careful collection protocols**.
    a. Avoid environmental contamination of specimens by collecting samples directly from the animal rather than from the ground. This may be done using rectal stimulation.
    b. Refrigerate fecal samples before submission and transport fecal samples to the lab with an icepack to avoid bacterial overgrowth.

4. **Discuss the case needs with your laboratory diagnostician** to select the most appropriate test(s).
    a. Full diarrhea panels, rather than individual tests, provide more complete information to help identify infections with multiple pathogens. Consider whether additional testing is warranted based on animal signalment, herd history, etc. As an example, bovine viral diarrhea virus and fecal floatation are not routinely included in fecal testing but may be warranted based on patient or herd history.
    b. For *Escherichia coli*, determine the presence of the F5/K99 attachment factor.
        - If positive for F5/K99, MIC testing is recommended.
        - If insufficient sample to test for F5/K99, MIC testing is not recommended.
        - If negative for F5/K99, MIC testing is not recommended.
    c. For *Salmonella* diagnostics, determine the serovar and antimicrobial susceptibility. Serovars may vary in their pathogenic potential, and knowledge of the serovar may benefit on-going monitoring of premise-focused *Salmonella* issues. See section below on common *Salmonella* serovars.

5. **Consider evaluating TPI in calves** between 24 hours and 7 days of age through measurements of serum IgG or serum total protein concentrations to determine if failed TPI may be related to the development of diarrhea. For IgG testing, the CAHFS lab prefers to receive samples in serum separator tubes that have been centrifuged, but they can also process samples in red top tubes without prior centrifugation, if there is no serum separator. It is important that these samples are received in the lab within 24 - 48 hours following collection and that they are kept cool (refrigerated or with ice packs) until received.

Salmonella serovars

Salmonella serovars can be separated into non-host adapted and host-adapted. The host-adapted serovar for cattle is *Salmonella* Dublin, and infections may result in the establishment of asymptomatic carriers in the herd that shed the pathogen in milk and colostrum, often resulting in pneumonia, septicemia and acute death in calves. In contrast, non-host adapted serovars often lead to transient infections. [18]

Vaccines for *Salmonella* in neonatal calves have not shown effectiveness in field trials, and cross-protection between serotypes is poor; however, anecdotally, vaccination of calves for *Salmonella* has shown benefits. If vaccination of calves is considered as a prevention measure, determining the serotype present in the herd is important to gauge the likelihood of success for commercial vaccines or whether an autogenous vaccine should be considered. Additional information is available in the table and chart at the end of this resource.

PREVENTION THROUGH VACCINATION

Vaccines for calves or dams are available for bovine rotavirus, bovine coronavirus, enterotoxic *E. coli* (F5/K99), and *Salmonella*. The decision to vaccinate for these pathogens should be based on a risk-benefit analysis considering the cost of vaccination and possible adverse events versus the benefit of improved immunity for the prevention of neonatal calf diarrhea. [19] A history of diagnosed cases supports adding a scours vaccine to a herd health plan. However, vaccination should not replace good hygiene protocols, colostrum intake, or other preventative measures mentioned above.

As with all vaccines, the manufacturer's recommendations for timing of vaccination should be followed as closely as possible. Published field trial studies using commercial vaccines for bovine rotavirus, bovine coronavirus, and *E. coli* often evaluated combination vaccines, making it difficult to interpret the contribution of each component. The reported efficacy of vaccines for the prevention of calf diarrhea for these combination vaccines varies. Recently published field trials with products that are currently available in the U.S. are, for the most part, lacking.

- **Bovine Rotavirus:**
  - Divided into 8 groups A - H; group A is the most prevalent.
  - Subdivided into strains based on G (glycoprotein) and P (protease-sensitive) types, with the predominant strain being G6P[5]. [20, 21]
  - Vaccine failures have been attributed to a mismatch between the field and vaccine strains. [22, 23]
  - Vaccines are currently marketed in the U.S. for the vaccination of pregnant dams in late gestation with a killed virus vaccine or are available as a modified live vaccine for oral administration to newborn calves less than 24 hours of age or for pregnant dams. Oral vaccination of calves may result in PCR-positive feces for a minimum of 3 days. [18]

- **Bovine Coronavirus:**
  - Coronavirus has been isolated from diarrheic calves and adult cattle (called winter dysentery) as well as in cattle with respiratory disease. Antigenic variation seems unrelated to different disease syndromes. [24-26]
  - Modified-live vaccines are available for intranasal and oral vaccination of calves starting at 1 day of age, or for injectable vaccination of calves or pregnant dams at ages specified on the vaccine label.

- ***E. coli:***
  - Out of multiple pathotypes, enterotoxigenic (ETEC) *E. coli* is the major cause of calf diarrhea and affects calves in the first week of life. [27]
  - Pilus antigens were formerly classified as K-antigens but have been reclassified as F-antigens, where K99 is now F5. Vaccine labels may still use the term K99 to describe the pathogen.
  - Killed vaccines for vaccination of pregnant dams, as well as antibodies administered orally to calves, are available. [19]

- ***Salmonella:***
  - *Salmonella* serovars Typhimurium and Dublin are most commonly isolated from cattle with clinical disease. [28] *S.* Dublin is the host-adapted serotype in cattle and can result in calf diarrhea and pneumonia outbreaks, as well as subclinical infections in cattle which can serve as pathogen carriers.
  - Published field trials showing efficacy of vaccines to prevent diarrhea from *Salmonella* are currently lacking.
  - Failure of killed *Salmonella* vaccines has been attributed to the wide antigenic variety of *Salmonella* and the inability to stimulate a cell-mediated immune response. [29, 30]
  - Fecal shedding of the vaccine strain, colonization of lymphoid tissue, and anaphylactic or endotoxic reactions to vaccination, especially when given with other vaccines for Gram negative bacteria, are concerns associated with modified-live vaccine use.
  - Bacterins, modified live, and SRP (Siderophore Receptors and Porin) vaccines are available for vaccination of calves or dams.
  - Anecdotally, vaccines are helpful in reducing *Salmonella* in herds when combined with improved sanitation, routine testing, and culling. [19]

- ***Cryptosporidium:***
  - Although preliminary studies have shown some success in vaccinating calves for *Cryptosporidium parvum,* one field trial was unsuccessful in showing effectiveness of the vaccine under investigation. [31-35] Currently there are no commercial vaccines available for *C. parvum*—hygiene is the most effective preventative method.

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Figure 2. Table of common pathogens causing scours, with information to inform infection control measures

Pathogen **bacteria, †viruses, ‡protozoa*	Typical age at onset (in days)	Strain types	Clinical signs Severity depends on co-infections, age, and immunity	Vaccine availability	Survival in environment
Enterotoxigenic *E. coli** [18]	1-7	F5 (formerly K99), F41	Variable, peracute syndrome with shock and death; weakness, comatose, dehydration, voluminous diarrhea or fluid pooling in intestines, rectal temperature normal or low, bradycardia from hyperkalemia; need to distinguish from *E. coli* septicemia through lab testing	Vaccines are available for pregnant dams; oral antibodies are available for calves	
***Cryptosporidium parvum*‡** [36, 37]	5-30	*C. parvum*: zoonotic *C. bovis*, *C. andersoni*: Non-zoonotic, non-pathogenic in neonatal calves	Profuse, watery diarrhea with mucus, up to 7 days duration; dehydration, anorexia	No vaccines are available	Resistant in cool, moist environment, inactivated by desiccation and ultraviolet light, resistant to disinfectants
Bovine coronavirus† [17, 18, 38]	5 - 30 Most commonly 7 - 10	Single serotype	Less common than rotavirus; profuse watery, bloody diarrhea, 3 - 6 days duration; dehydration; high mortality if combined with other pathogens	Vaccines are available for pregnant dams and calves	Enveloped virus, sensitive to detergents, easily inactivated by disinfectants, formalin, and heat
Bovine Rotavirus† [17, 18, 21, 39]	14 - 21	Serogroups A - H, A is most prevalent; further subdivision into G and P types, G6P[5] is most common (approx. 50%)	Pale yellow, non-bloody diarrhea, 4 - 8 days duration; +/- fever, depression, recumbency	Vaccines are available for pregnant dams and calves	Non-enveloped virus, resistant to inactivation, can remain in environment for up to 9 months, susceptible to diluted bleach or phenolic disinfectant
Salmonella enterica* subsp. *enterica* [18]	14 - 60	Serogroups A, B, C, D, E, most common B - E, *Salmonella* Dublin (type D) mostly respiratory disease; is host-adapted to cattle Serovars Tyhpimurium, Dublin Antibiotic resistance is common	Fever, diarrhea with fresh blood and mucus, sepsis, pneumonia, arthritis, physitis, meningitis	Vaccines are available but have not shown benefits in field trials. Anecdotally, vaccines for calves lead to improved outcomes.	Survives several weeks in dry and several months in wet environments, inactivated by ethanol products and Virkon S

Figure 3. Comparative chart of scours pathogens demonstrating typical age range of disease onset

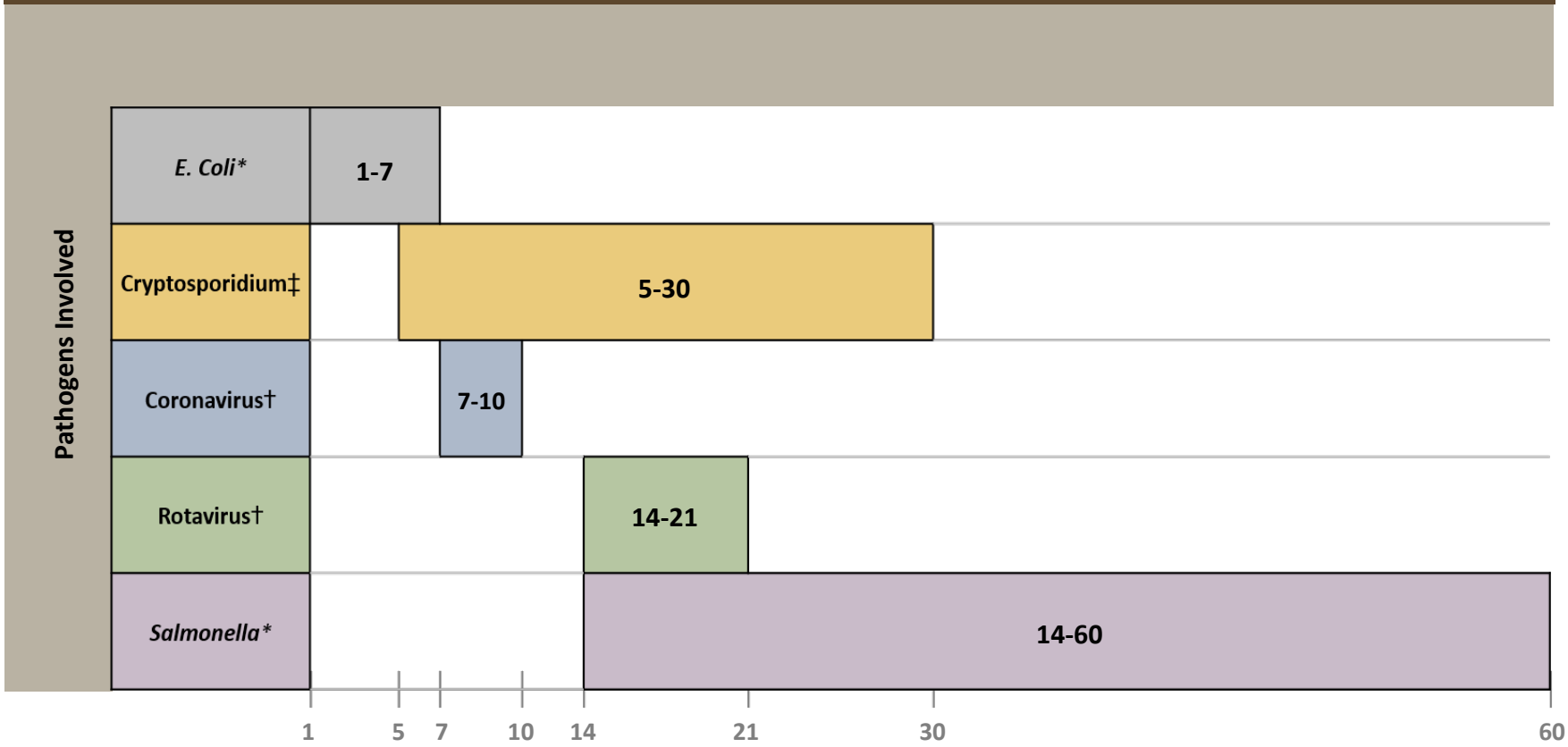
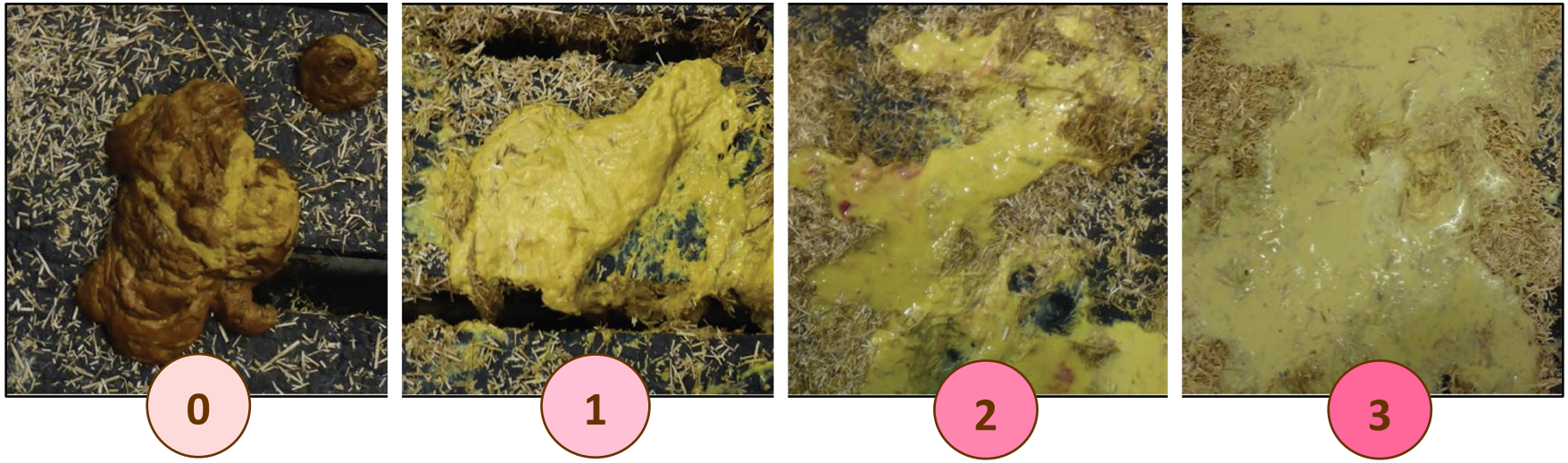


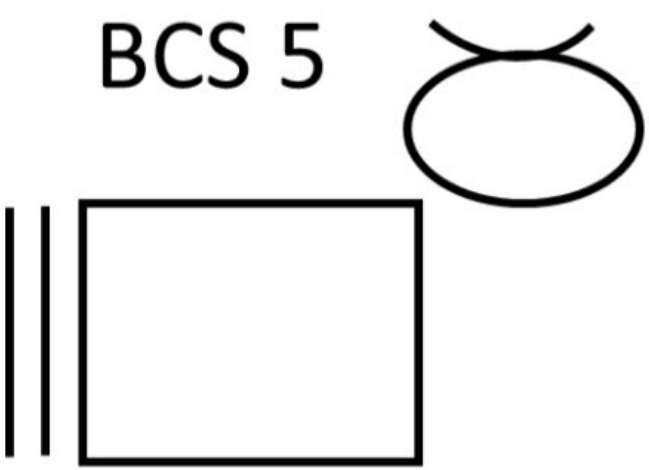
Figure 4. Visual description of fecal consistency score. *From: Renaud D.L. et al. Technical note: Is fecal consistency scoring an accurate measure of fecal dry matter in dairy calves? J Dairy Sci, 103 (11) 2020.*

A score of **≥2** indicates the presence of diarrhea.

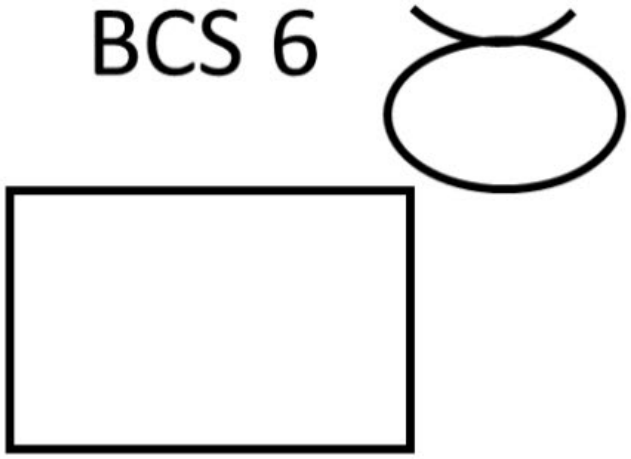


0	1	2	3
normal	**soft**	**runny**	**watery**
Firm but not hard	Does not hold form, piles but spreads slightly	Spreads readily	Liquid consistency, splatters

Figure 5. Body condition score (BCS) of 5 (cows) or 6 (heifers) out of 9, as pictured below, at calving can help reduce incidence of scours. *Pictures and diagram courtesy of Dr. Gaby Maier.*



Last 2 ribs visible



Last 2 ribs *not* visible