Effects of switch trimming on fly avoidance behaviors, udder cleanliness, and milk quality in lactating Holstein and Jersey dairy cows

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Abstract

The objective of this study was to observe differences in fly avoidance behaviors, udder cleanliness, and milk quality in Holstein and Jersey dairy cows due to switch trimming. Both breeds (n=12 each; half trimmed, half intact) were divided into 3 groups of 8 and observed for 1 week. Cows were assigned an udder hygiene score (**HS**) using a multi-zone system for udder cleanliness (1=very clean to 4=very dirty; Cook, 2002). Fly counts (**FC**), foot stomps (**FS**), tail swings (**TS**), and panniculus reflexes (**PR**) were recorded during a 5-min period/cow twice daily. Composite milk samples were collected and somatic cell count (**SCC**) was determined using the DeLaval Cell Counter. Milk samples were cultured and incubated for 48-hr using a Tri-plate agar (University of Minnesota Easy Culture). Statistical analysis of FC, FS, TS, and PR, and SCC were conducted using the MIXED procedure, and HS and bacterial species counts (**BSC**) were evaluated using the FREQ procedure in SAS (v9.4). No differences in TS, FS, PR, FC, SCC, or BSC were observed among treatments. Cows with an intact switch exhibited improved HS compared to cows with trimmed switches (54.17% vs. 27.08% HS 2, P = 0.02; and 22.92% vs. 554.17% HS 3, P = 0.01 for trimmed vs. intact switches). No differences in FS, PR, or BSC were observed among breeds. Jerseys swung their tails more than Holsteins (12.44 vs. 9.59 ± 0.71, P = 0.005) and had lower FC (17.43 vs. 25.40 ± 2.9, P = 0.009). However, Jerseys had greater somatic cell scores than Holstein cows (14.65 vs. 12.39 ± 0.60, P = 0.02). These results indicate that cows with a trimmed switch are equally able to perform fly avoidance behaviors as cows with intact switches, and that Holstein cows had improved milk quality over Jerseys.

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Literature Review

Mastitis in dairy cows is characterized as the inflammation of the mammary gland or udder induced by harmful bacteria entering through the teat (Plastridge, 1958). These harmful bacteria are linked to unsanitary environments and operations within a dairy including housing and milk parlor procedures. Once these bacteria have entered the gland, somatic cells are produced to fight off infection. Somatic cells, found all throughout the body, serve to replace and repair old or damaged cells. In the dairy industry, somatic cell counts (**SCC**) are conducted on individual and herd-wide milk samples to be used as an indicator of milk quality; the higher the count, the more likely there is to be infection within the herd and the risk of health concerns to consumers increase (Kline et al., 2018). Guidelines are set in place through enforcing legal limits on SCC to ensure that the highest quality milk possible reaches the market. Milk sold within the United States cannot have an SCC greater than 750,000 cells/mL and milk for importing purposes cannot have an SCC greater than 300,000 cells/mL.

If mastitis manifests itself within a herd, cows will experience a variety of symptoms. These symptoms include udders that may be red, inflamed, or tender; decreased milk production; and the milk that is produced may be clotted or even bloody (Plastridge, 1958). Though, in most cases, mastitis is not fatal, it can spread quickly throughout the herd, if not contained quickly, and lead to severe economic consequences. Infected cows' milk should be collected separately and without adding it to the bulk tank. However, this will reduce a dairy's overall output and thus their profits. In cases where the infected cow's milk is added to the bulk tank, the overall SCC rises and the milk must be dumped, should it exceed the legal limit. As a method of preventing further spread and wasted milk, yet still facing inevitable losses in profits and productivity, cows with severe mastitis are culled from the herd (Plastridge, 1958)..

In efforts to keep SCC low and prevent mastitis altogether, tail docking is a common practice performed on dairy farms with the intent to eliminate the spread of bacteria from debris on the switch and allow for improved milker comfort (Ohio Dairy Industry Resources Center). The absence of the tail switch decreases the spread of harmful bacteria to the udder; therefore, reducing the risk of common infections that lead to mastitis (Barnett et al., 1991). This procedure takes place when the cow has reached 12-18 months of age and uses a rubber ring to eliminate circulation and a knife/docking iron to remove the tail. Foreseeably, this practice provokes animal welfare concerns. Not only does tail docking fail to use any variation of anesthetics or numbing, but by not doing so, the cow experiences pain during and after the operation is complete (Ingle et al., 2017). In addition, the docking site is at risk of inflammation and possible infection, and the cow is faced with long-term acute pain associated with the nubbed tail along with altered communicative methods and fly prevention behaviors (Ohio Dairy Industry Resources Center). As a result of these welfare concerns, many countries, such as those in Europe, have banned the practice of tail docking due to the realization that there is no significant benefits to both the animals and consumer health (EFSA Journal, 2012). In contrast, an intact tail is believed to pose the threat of increased mammary gland exposure to coliform bacteria, which, as a result, can negatively impact cattle as well as milk consumers (Schreiner and Ruegg, 2002).

An intermediary solution has been devised in which the tail switch is trimmed, rather than docked completely. This method is superficial, similar to a haircut, and does not inflict pain on the animal. This is done with a Tail Well Trimmer, a tool specifically designed for switch trimming. The device is mounted onto a drill and consists of a circular blade, in which the tail is fed through, and trims the hair as close to the skin as possible without causing abrasions. As a result, the cow can perform natural behaviors without risking the spread of harmful bacteria and, in addition, provides a positive alternative to tail docking while still enabling optimum productivity and profitability. In a similar study conducted by the University of Tennessee in 2017, results suggested that udder hygiene and bacterial counts were not directly related to tail switch status. Instead, improved cleaning methods and milking procedures were thought to have higher importance in relation to these bacterial concerns (Ingle et al., 2017). In contrast, an earlier study conducted in Bu-Ali Sina University in 2015 focused on udder cleanliness and concluded that a trimmed switch lead to improvements in hygiene and overall health among dairy cattle (Bahari et al., 2015).

Mastitis

Mastitis in cattle is linked to 3 harmful bacteria: *Streptococcus agalactiae, Streptococcus uberis,* and *Micrococcus pyogenes* (Plastridge, 1958). *S. agalactiae* and *S. uberis* belong to the genus *streptococcus* and are classified as gram-positive bacteria with the tendency to rapidly reproduce and form chain-like structures. *S. agalactiae* is among the many leading bacteria causing infections within the body's soft tissues, the skin, and the urinary tract (Lyhs et al., 2016). *S. uberis* is found within the mammary gland of cattle, and has been observed as the most common *Streptococcus* species isolated from mastitis cultures (Günther et al., 2016). *M. pyogenes* belongs to the family

Micrococcaceae and are characterized as spherical bacteria commonly found within the environment in locations such as dust and soil. Altogether, these organisms manifest infection within the udders, causing chronic mastitis. Risk of this infection among a herd is heightened in environments lacking proper cleanliness and sanitation. Though the infection is not directly contagious, it can quickly spread via the milking parlor. Common symptoms that arise include inflammation, redness/tenderness, and in more severe cases, bloody or clotted milk. Despite these symptoms, mastitis can be present without visual signs.

<u>Breed factors affecting incidence of mastitis</u>

Risk of mastitis within a herd can be determined via SCC. Research has proven not only that elevated SCC leads to infection, but cattle with greater milk yield have higher SCC than those of lower production (Barkema et al., 2013). In a study comparing Holstein to Jersey cattle, it was observed that Holsteins mean daily milk yield was approximately 18.0 kg/d whereas Jerseys were 14.2 kg/d (Prendiville et al., 2010). Therefore, Holstein cattle are more likely to have elevated SCC to Jerseys when considering milk yield. Other factors that contribute to SCC such has external hygiene, have proven no significant difference between breeds of dairy cattle. Multiple studies have been conducted to seek correlation between SCC and hygiene scores, fly counts, environmental factors, but no evidence suggests related breed differences.

Animal welfare

Animal welfare within the agriculture industry is an ever-changing discussion that addresses livestock environmental conditions and treatment in comparison to the human need for animal products. Specifically, within dairy operations, concern of tail docking in relation to animal welfare is a largely controversial discussion. This practice was developed in efforts to increase milker comfort, improve udder hygiene, and eliminate possible infection (Welfare Implications). The operation takes place during the first 2 years of a calf's life and involves banding the base of the tail and using a form of shears to remove the tail. Despite removing a majority of the tail, an appropriate length is left in-tact to prevent manure contamination within the vulva (Welfare Implications). However, docking tails has proven little to no impact on the original goals and has actually introduced unintended consequences to both the animal and farmers. Firstly, an intact tail is the most common mode of fly prevention for cattle. Tails are used to swat biting insects and instead, cows with docked tails show more foot stomping and head turning (Botner et al., 2012). Furthermore, pain and distress are associated side effects with a docked tail. These animals show greater sensitivity to stress and altogether lower performance in milk production (Botner et al., 2012).

Fly avoidance

Tails are the tool that cattle primarily use to swat flies from their bodies. Numerous studies show that an absent/docked tail have a direct effect on increased numbers of flies per cow (Eicher et al., 2001). As expected, biting flies inflict pain and discomfort to the animal. In efforts to benefit animal welfare while also taking into account hygiene and milk quality, recent studies are being conducted to observe possible effects of trimming switches rather than completely docking the tail on fly avoidance behaviors By trimming the switch at the end of the tail, cows maintain the structure of the tail and are able to perform normal tail functions while potentially improving udder hygiene. Though this technology is relatively new, studies that have already been completed suggesting mixed results. According to research on commercial herds, results of cows with docked, trimmed, and intact tails showed no significant different in fly population, foot stomps, and udder health (Frantz et al, 2019). This verdict suggests that the tail, though imperative for the cow's wellbeing, does not have as great of an impact on hygiene and milk quality as was hypothesized.

Cow hygiene and environment

While anatomical changes to cows' bodies aid in improved hygiene, there are other environmental factors with superior influence on udder cleanliness. These factors can be controlled by dairy workers through various management practices. The goal in achieving reduced mastitis incidents involves reducing exposure to infectious pathogens within the environment that the cows live in and are worked on. The most common area of exposure is the equipment within the milking parlor. Because mastitis is classified as an infection within the udder, harmful bacteria is easily spread through the milking equipment between cows during milking. In efforts to eliminate this bacterial spread, common preventative practices are implemented by dairy workers. Teat dips are of the most imperative in prevention. Prior to milking, pre-dip should take place in order to remove any unwanted debris/bacteria from the udder before coming in contact with the machine (Preventing Losses from Contagious Mastitis). During the milking process, pathogens within the udder may surface to the teat skin and remain even after milking is over. To prevent these pathogens from progressing into infection, a germicidal post-dip should be utilized to kill remaining bacteria (Preventing Losses from Contagious Mastitis). Studies have shown that by just performing teat dips, the risk of infection is reduced by 50% (Preventing Losses from Contagious Mastitis). An additional area of concern is within cattle housing. Whether stalls, pack barns, or any other form of close-quarter housing is used, bacterial spread is rapid in housing lacking the proper cleaning measures. Loose housing systems, such as the one utilized at the MTSU dairy, should be kept dry and tilled or replaced often (Eckelkamp et al., 2016)). Not only will this maximize cow comfort, but will eliminate the growth of harmful bacteria.

Worker comfort

Dairy farm employees frequently come into close contact with cows' tails within the milking parlor. Due to the proximity of the worker and the cow's tail and the type of work being performed on the udders, workers are likely to get swatted by dirty tails. This type of interaction between workers and cows is a key area of bacterial transmission and potential spread of disease. Despite being close to each other, cows' tails still have full mobility within their milking stall. This mobility makes it easy for cattle to swat flies, each other, and the workers attaching equipment to their udders. A recent study confirmed that cattle with docked tails were proven to reduce manure exposure to both the neighboring milking cows as well as the parlor personnel (Troncoso et al., 2018). By doing so, milkers were able to perform their job without risk of coming in contact with harmful bacteria and therefore preventing further spread. On the contrary, some have concluded that docked tails show no significant benefit to both the cattle wellbeing as well as the comfort of the dairy workers (Ohio Dairy Industry Resources Center).

Objective

The objective of this study was to determine the effect of tail switch trimming on fly avoidance behaviors (**FAB**), udder hygiene (**UH**), somatic cell count (**SCC**), milk bacterial load, and milk yield (**MY**) in Holstein and Jersey dairy cows. We hypothesize that switch trimmed cows will be able to perform similar behaviors and produce similar milk yields as intact cows but will be cleaner and produce higher quality milk than intact cows.

Methodology

Two groups of lactating dairy cattle (12 Holsteins and 12 Jerseys; 24 total) were randomly assigned to 1 of 2 treatments including trimmed (**TSW**) and intact switches (**ISW**) during 3 experimental periods. Experimental periods consisted of 3 consecutive days of data collection in addition to 2 days of data analysis, each spaced 4 weeks apart; therefore, 8 cows underwent evaluation at a time during each experimental period.

Switch trimming, udder hygiene, and fly avoidance behaviors

One group of cattle had their switches left intact, and the other groups' switches were trimmed completely (**Figure 7**) using a commercial tail trimming device (Tailwell 2 Power Tail Trimmer; **Figure 8**). To determine FAB, total fly counts, TS, FS, and PR (involuntary skin twitches) were recorded for each cow for 5 total minutes 2 times per day (0800 and 1600h) for 3 consecutive days (Eicher and Dailey, 2002). A visual multi-zone hygiene scoring system was utilized to examine udder cleanliness (Cook, 2002) once per day, each day of the experimental periods (**Figure 9**).

Somatic cell count and culture plating

On the third day of each experimental period, a milk sample from each cow was collected in separate vials (**Figure 10**). These milk samples underwent SCC testing via the DeLaval cell counter. A cassette was used to draw up a small portion of each sample and was then placed into a DeLaval Cell Counter to quantify SCC (**Figure 11**). All milk samples were then plated on a tri-plate agar following the instructions listed by the Minnesota Easy Culture System User's Guide (**Figure 12**). The 3 agars on each plate were Factor TM media, MacConkey media, and Focus media; each indicating different bacterial species present in the milk samples. The plates were then stored in an incubator set to 100°F and interpreted for bacterial species culture growth after 24 and 48 hours (interpretation scenario examples: **Figures 13-16**). Observations and records of bacterial growth took place during the final 2 days of each experimental period. Lastly, production data was downloaded from the Afimilk parlor software to record daily milk yield and conductivity, which was then averaged over all treatment periods.

Data Analysis

Milk production, somatic cell count, and fly avoidance behaviors were analyzed using the MIXED procedure in SAS (v. 9.4, SAS Institute Inc, Cary, NC). Somatic cell counts were logarithmically transformed to a somatic cell score (**SCS**) to achieve normality of distribution (Ali and Shook, 1980). Treatment and breed were evaluated as the main effects with cow considered a random effect. The FREQ procedure in SAS was used to evaluate the effect of treatment on hygiene scores and culture results. Results are reported as least squares means (LSM) with corresponding standard error of the mean (SEM) for fixed effects of treatment and breed. Residual distribution was evaluated for normality and homoscedasticity. Statistical significance was declared at $P \leq 0.05$ and trends at $0.05 < P \leq 0.10$.

Results

Dairy cows from the MTSU farm laboratories were utilized for this project (IACUC protocol ID 19-2014). Two groups of lactating dairy cows (12 Holsteins and 12 Jerseys; 24 total) randomly received 1 of 2 treatments (**TSW** or **ISW**) during 3 experimental periods to determine any potential differences in production parameters, milk quality, and fly avoidance behaviors for cows with in-tact vs. trimmed switches. The study cows averaged 186 days in milk (**DIM**) and 2.5 lactations.

Milk yield, somatic cell score, and conductivity

Milk yield, somatic cell score, and milk conductivity values were not different between TSW and ISW cows. In-tact switch and trimmed switch cows produced 26.92 and 27.71 ± 2.13 kg of milk per day, respectively (*P* = 0.62). Similarly, ISW and TSW cows averaged 13.43 and 13.60 ± 0.21 SCS, respectively (*P* = 0.85). In-tact switch cows expressed an average milk conductivity value of 8.04 ± 0.12 mS/cm, whereas TSW cows averaged 6.95 ± 0.12 mS/cm (*P* = 0.12). Production results based on breed are summarized in **Table 1**. Unsurprisingly, Jersey cows produced less milk on average than Holstein cows with 22.11 vs. 34.84 ± 3.05 kg/d (*P* = 0.02). This difference can be seen in **Figure 1**. Holstein cows exhibited a lower SCS than Jersey cows with 12.39 vs. 14.65 ± 0.60 SCS, respectively (*P* = 0.02; **Figure 2**). Similarly, Holstein cows expressed a lower conductivity value than Jersey cows with 7.71 vs. 9.54 ± 0.12 mS/cm, respectively (*P* = 0.01; **Figure 3**).

Udder hygiene scores

No differences in udder hygiene scores were observed between breeds (*P* = 0.30); however, an overall udder hygiene score difference was found between treatments (*P* = 0.003; **Table** 2). Neither treatment group was more likely to score on the extreme ends of the hygiene scoring spectrum with a score of either very clean (score of 1) or very dirty (score of 2; *P* = 0.18 and 0.17, respectively). However, ISW cows were more likely to exhibit an udder hygiene score of 2 than TSW cows (54.17 vs. 27.08%, respectively; *P* = 0.02). On the contrary, TSW cows were more likely to exhibit an udder hygiene score of

3 than ISW cows (54.17 vs. 22.92%, respectively; *P* = 0.007). These differences are visualized in **Figure 4**.

Fly counts and fly avoidance behaviors

No treatment differences were observed for fly counts or FAB (**Table 3**). Cows in the ISW treatment group averaged a total count of 22.73 ± 2.29 flies during the observation period vs. 20.10 ± 2.29 total flies for the TSW treatment (*P* = 0.28). Similarly, cows in the ISW treatment group averaged 11.56 ± 0.72 tail swings vs. 10.47 ± 0.72 tail swings for the TSW treatment (*P* = 0.28). Very few foot stomps were recorded as a FAB for either group. In-tact switch cows stomped their feet an average of 0.36 ± 0.12 times, whereas TSW cows stomped their feet 0.17 ± 0.12 times (*P* = 0.26). Cows in the ISW treatment group expressed the panniculus reflex an average of 2.03 ± 0.43 times during the observation period, while TSW cows expressed this reflex an average of 1.96 ± 0.43 times (*P* = 0.91).

Breed differences for total fly counts and FAB can be found in **Table 4**. Holstein cows had a greater total fly count during the observation period than Jersey cows with 25.40 vs. 17.43 ± 2.88 total flies, respectively (*P* = 0.009). This difference can be observed in **Figure 5**. Conversely, Holstein cows averaged 9.59 ± 0.71 tail swings during the observation period, while Jersey cows averaged 12.44 ± 0.71 tail swings (*P* = 0.005). This difference can be observed in **Figure 6**. No breed differences were observed for foot stomps. Holstein cows stomped their feet an average of 0.24 ± 0.12 times, whereas Jersey cows stomped their feet an average of 0.29 ± 0.12 times during the observation period (*P* = 0.74). Lastly, no differences were observed for panniculus reflex between breeds.

Holstein cows expressed the panniculus reflex an average of 1.67 ± 0.43 times, while Jersey cows expressed this reflex an average of 2.32 ± 0.43 times during the observation period (*P* = 0.28).

<u>Bacterial cultures</u>

No treatment differences were observed for type of bacteria cultured after 48-hours of incubation (*P* = 0.17; **Table 5**). For both the ISW and TSW treatments, 16.67% of the samples cultured were found to have no bacterial growth. Milk samples from cows in the ISW treatment cultured *Staph*. species 58.33% of the time, while milk samples from cows in the TSW treatment culture *Staph*. species 33.33% of the time. None of the milk samples from ISW cows cultured *Strep*. species, however, 33.33% of the milk from TSW cows cultured *Strep*. species. Milk samples from cows in the ISW treatment cultured *Staph. aureus* 25.00% of the time, while milk samples from cows in the TSW treatment cultured *Staph. aureus* 16.67% of the time.

Similarly, no breed differences were observed for type of bacteria cultured after 48-hours of incubation (*P* = 0.51; **Table 6**). A no-growth reading was reported for 25.00% of Jersey milk samples and 8.33% of Holstein milk samples. Jersey milk samples resulted in *Staph*. species growth 41.67% of the time, while Holstein milk samples resulted in *Staph*. species growth 50.00% of the time. *Strep*. species were cultured in 8.33% and 25.00% of milk samples from Jerseys and Holsteins, respectively. *Staph. aureus* was cultured in 25.00% and 16.67% of milk samples from Jerseys and Holsteins, respectively.

Discussion

The given results were nearly parallel with previous studies. In comparing treatments and behaviors between Holstein and Jersey cows, some results indicated breed differences. Traditionally, Holstein cattle are expected to have a higher milk yield than Jersey cattle and according to past research, higher producing milk cows tend to experience higher SCS (Prendiville et al., 2010). However, in this study, Holstein cattle, despite having greater milk yield values, showed a slightly improved average SCS compared to Jerseys. Likewise, Holstein cattle had a lower average milk conductivity value, which together with a lower SCS indicates that Holsteins had improved milk quality over Jerseys. Additionally, Jersey cows had lower fly counts and more tails swings than Holstein cows. Regardless, there were no breed differences in hygiene scores. One might expect that cows with fewer total flies, likely due to a greater amount of tail swings, might exhibit improved milk quality; however, that was not the case in the present study. These observed differences could just be due to small sampling size (n=12 per breed).

In the literature regarding docked tails, it was noted that cows with docked tails performed increased numbers of tail swings and foot stomps as modified acts of fly avoidance (Botner et al., 2012). No monumental difference was observed between cows of either treatment in relation to these modified behaviors. In fact, very few foot stomps were recorded during the experimental process for either treatment group. Furthermore, the number of tail swings, fly counts, and panniculus reflexes were nearly the same between both groups. In regards to hygiene scoring, contrary to our hypothesis, the hygiene scores between study groups showed that cows with in-tact switches had slightly improved hygiene scores than those with trimmed switches. The differences observed in hygiene scores between treatments were subtle, with no differences observed on either extreme end of the spectrum (very clean or very dirty). Even though the hygiene scores were assigned by the same individual throughout the trial, the subtle difference between a score of 2 or 3 could be negligible.

There were no statistical differences observed for bacterial species cultured in the milk samples for either treatment or breed groups. Given that Holstein cows produced higher quality milk than Jerseys (due to lower SCS and conductivity values), one might expect to see fewer bacterial cultures for this breed group. However, this was not the case. We hypothesized that cows with trimmed switches might have improved milk quality over cows with in-tact switches. Though our hypothesis was incorrect in this regard, we can establish from this research that cows with trimmed switches were equally able to perform fly avoidance behaviors and had similar milk quality as cows with in-tact switches. Altogether, there were no major differences between treatments in relation to FAB and milk quality.

Conclusion

Mastitis in dairy cows is among one of the largest threats to a dairy operation. In many efforts to avoid this infection from implementing its ramifications, udder hygiene has proven to be one of the most imperative characteristics that can cause or prevent the spread of harmful pathogens into the mammary gland. This study examined the relatively new method of switch trimming (rather than docking) to observe potential affects on fly avoidance behaviors, milk productivity, and overall udder health; while taking into consideration animal welfare concerns and productivity of the cow. These results indicate that cows with a trimmed switch are equally able to perform fly avoidance behaviors as cows with intact switches, and that they have similar milk quality. Additionally, we observed that Holstein cows had lower SCS and milk conductivity than Jerseys, indicating improved milk quality. No differences were observed for species of bacteria cultured from milk samples between treatments or breeds. Switch trimming resulted in similar milk quality and natural behaviors as cows with in-tact switches; however, additional research is necessary to understand if trimmed switches are a viable alternative to docking tails.

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APPENDIX

Table 1. Least Squares Means for milk yield, somatic cell score, and milk conductivity by breed.

Measure	Jersey	Holstein	***SEM***	***P*-value**
No. of cows	12	12		
Milk yield, kg/d	22.12	34.84	3.05	0.02*
Somatic cell score [a]	14.65	12.39	0.60	0.02*
Conductivity, mS/cm	9.54	7.71	0.12	0.01*

[a] Somatic cell count data was transformed using the following formula:
SCS = log2(SCC/100) + 3.

* Significant difference at $P < 0.05$.

Table 2. Hygiene score[a] frequency by treatment

Hygiene Score	In-tact switch (%)	Trimmed switch (%)	*P*-Value
Overall			0.003*
1	20.83	10.42	0.18
2	54.17	27.08	0.02*
3	22.92	54.17	0.007*
4	2.08	8.33	0.17

* Significant difference at $P < 0.05$.
[a] According to the method devised by N.B. Cook (2002), hygiene scores are as follows: 1 = very clean; 2 = slightly dirty; 3 = moderately dirty; and 4 = very dirty

Table 3. Least Squares Means for fly counts and fly avoidance behaviors (tails swings, foot stomps, and panniculus reflex) by treatment.

Measure	**In-tact switch**	**Trimmed switch**	***SEM***	***P*-value**
Fly count	22.73	20.10	2.29	0.28
Tail swings	11.56	10.47	0.72	0.28
Foot stomps	0.36	0.17	0.12	0.26
Panniculus reflex	2.03	1.96	0.43	0.91

Table 4. Least Squares Means for fly counts and fly avoidance behaviors (tails swings, foot stomps, and panniculus reflex) by breed.

Measure	**Jersey**	**Holstein**	***SEM***	***P*-value**
Fly count	17.43	25.40	2.88	0.009*
Tail swings	12.44	9.59	0.71	0.005*
Foot stomps	0.29	0.24	0.12	0.74
Panniculus reflex	2.32	1.67	0.43	0.28

* Significant difference at $P < 0.05$.

Table 5. Frequency of type of bacteria cultured after 48-hours of incubation by treatment.

Bacterial Cultures	In-tact switch, %	Trimmed switch, %	*P*-Value
Type			0.17
No bacterial growth	16.67	16.67	
Staph. species	58.33	33.33	
Strep. species	0.00	33.33	
Staph. aureus	25.00	16.67	

Table 6. Frequency of type of bacteria cultured after 48-hours of incubation by breed.

Bacterial Cultures	**Jersey, %**	**Holstein, %**	***P*-Value**
Type			0.51
No bacterial growth	25.00	8.33	
Staph. species	41.67	50.00	
Strep. species	8.33	25.00	
Staph. aureus	25.00	16.67	

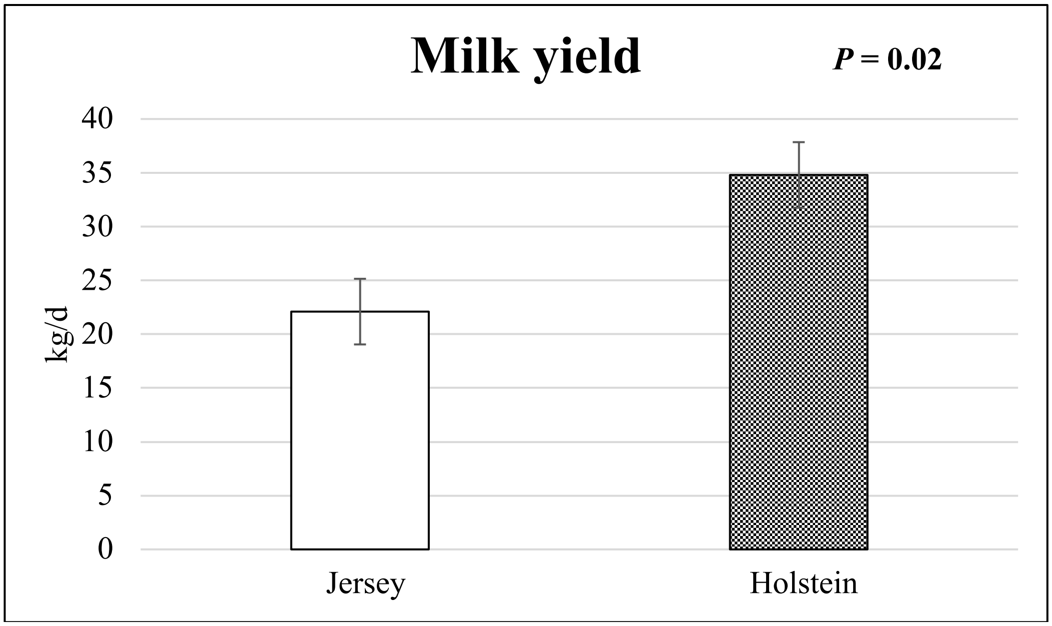

Figure 1. Mean milk yield for Holstein and Jersey cows during experimental periods. Holsteins averaged 34.84 ± 3.05 kg/cow/d and Jerseys averaged 22.11 ± 3.05 kg/cow/d ($P = 0.02$).

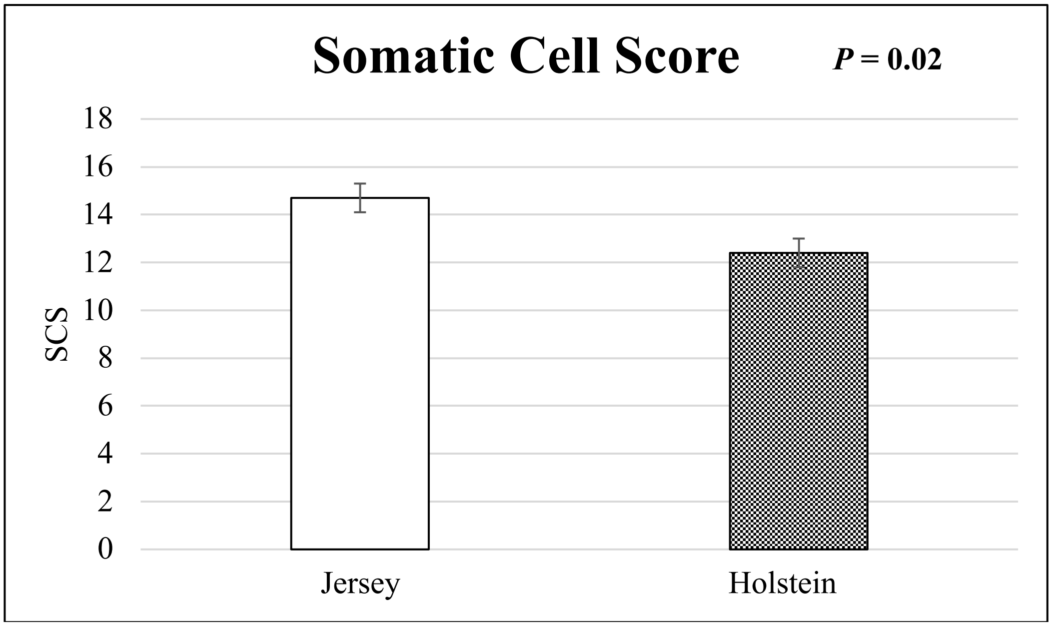

Figure 2. Mean somatic cell score for Holstein and Jersey cows during experimental periods. Holsteins averaged 12.39 ± 0.60 SCS and Jerseys averaged 14.65 ± 0.60 SCS (*P* = 0.02). Somatic cell count data was transformed using the following formula: SCS = log2(SCC/100) + 3.

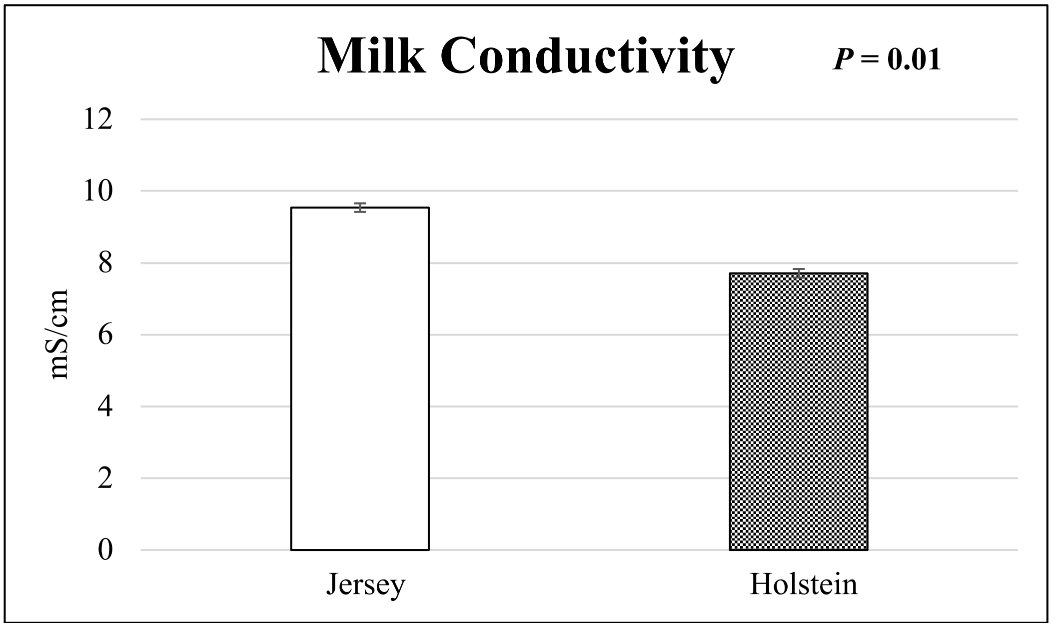

Figure 3. Mean milk conductivity for Holstein and Jersey cows during experimental periods. Holsteins averaged 7.71 ± 0.12 mS/cm and Jerseys averaged 9.54 ± 0.12 mS/cm (*P* = 0.01).

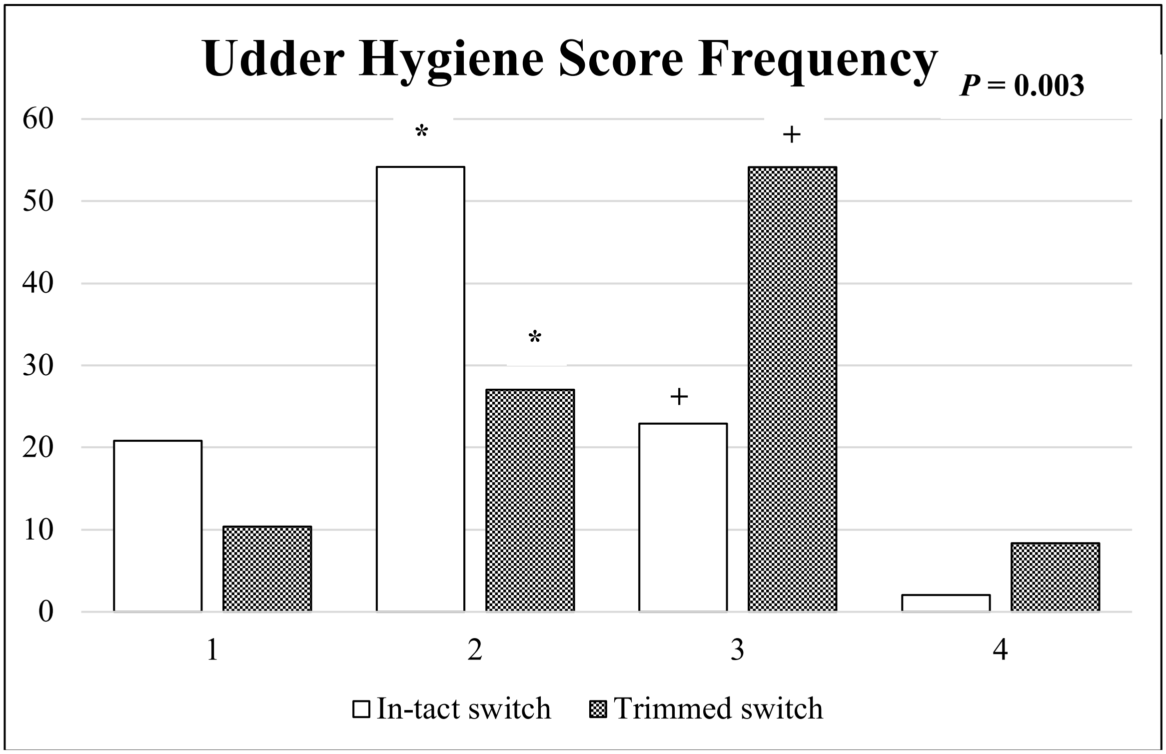

Figure 4. Mean udder hygiene score frequencies by treatment ($P = 0.003$). Cows were not more likely to score a 1 or 4 in either in-tact or trimmed switch treatment ($P = 0.18$ and $P = 0.17$, respectively). In-tact cows scored 2^{*} more frequently ($P = 0.02$) and trimmed cows scored 3^{+} more frequently ($P = 0.007$).

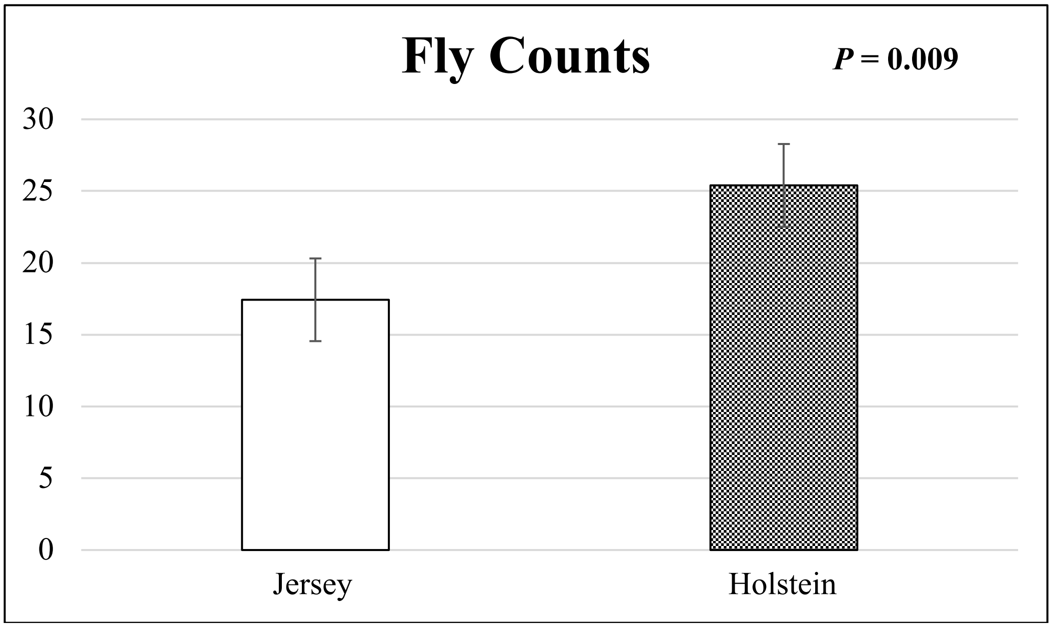

Figure 5. Mean number of flies counted for Holstein and Jersey cows during experimental periods. Holsteins averaged 25.40 ± 2.88 total flies and Jerseys averaged 17.43 ± 2.88 mS/cm (P = 0.009).

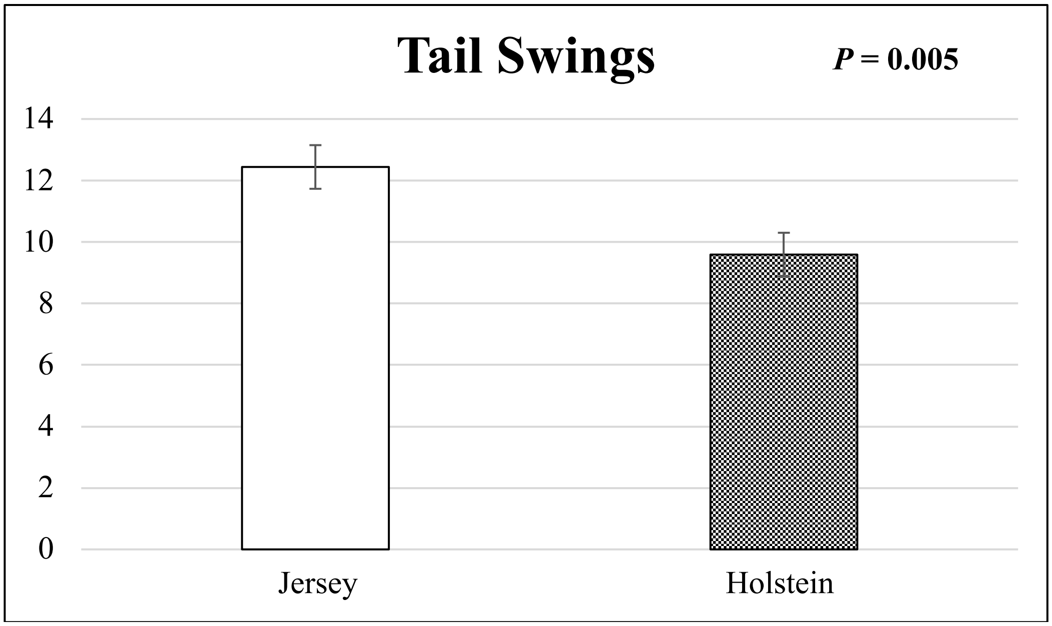

Figure 6. Mean number of tail swings for Holstein and Jersey cows during experimental periods. Holsteins averaged 9.59 ± 0.71 total tail swings and Jerseys averaged 12.44 ± 0.71 mS/cm (*P* = 0.005).

Figure 7. Example of a cow with trimmed switch in the trimmed switch treatment.

Figure 8. Using the TailWell 2 Power Tail Trimmer device to remove the switch hair from tails of cows in the trimmed switch treatment.

Figure 9. A hygiene scoring card used to determine the degree of manure contamination on a 1-4 scale for each of three zones, the udder, the lower leg and the upper leg and flank. For this study, we focused only on udder hygiene scores. Score sheet available at http://www.vetmed.wisc.edu/dms/fapm/fapmtools/4hygiene/hygiene.pdf

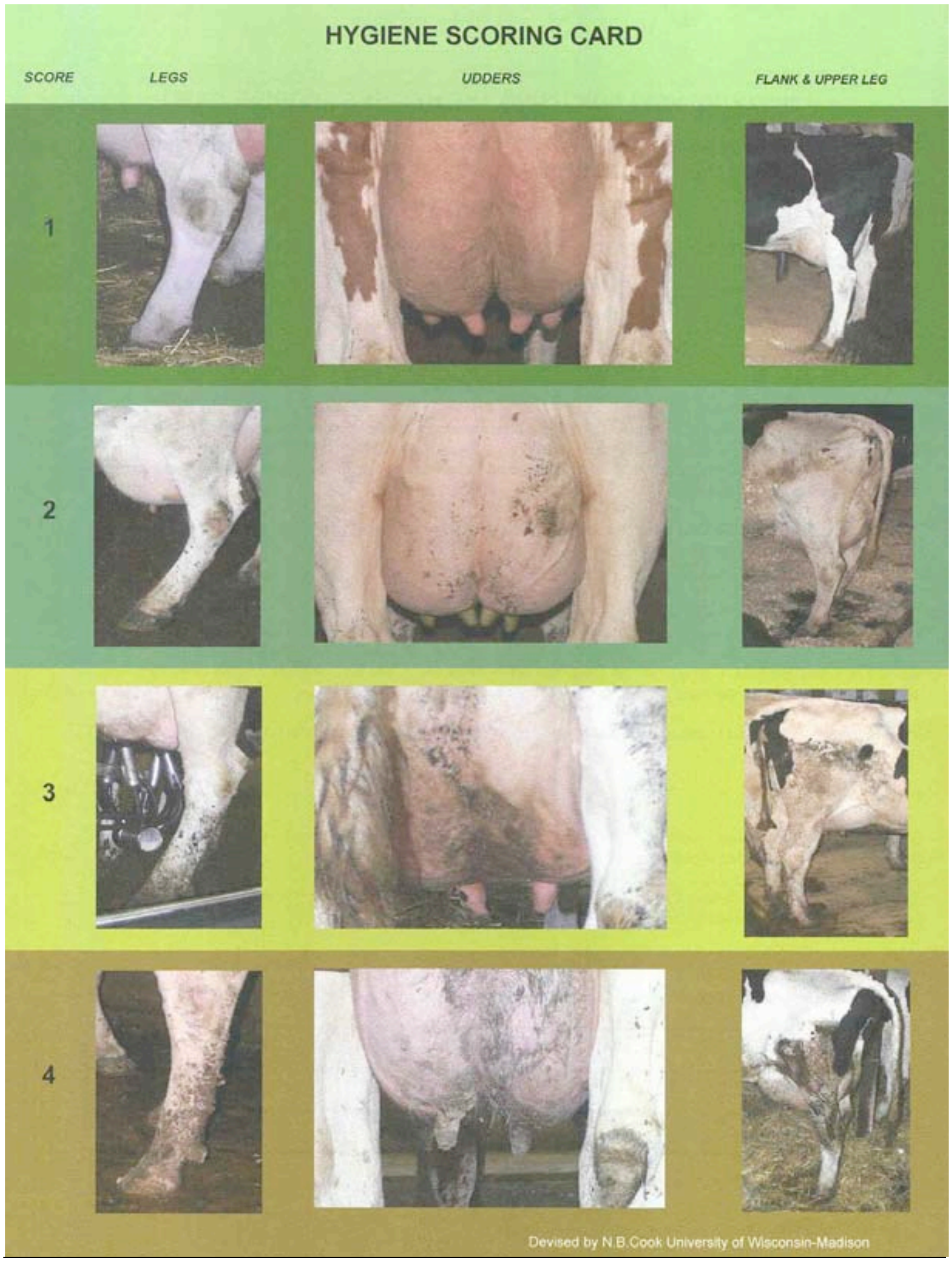

Figure 10. Collecting milk samples into sterile milk tubes from study cows in the parlor during milking.

Figure 11. Determining and recording the somatic cell count of each milk sample using the DeLaval Somatic Cell Counter.

Figure 12. Plating milk samples on a tri-plate culture medium using a sterile swab. The deep red section (top left) is the Focus media, the scarlet section (bottom) is the Factor media, and the pink section (top right) is the MacConkey media. Growth on the Focus and Factor media indicate gram-positive bacterial growth; growth on the MacConkey media indicates gram-negative bacterial growth.

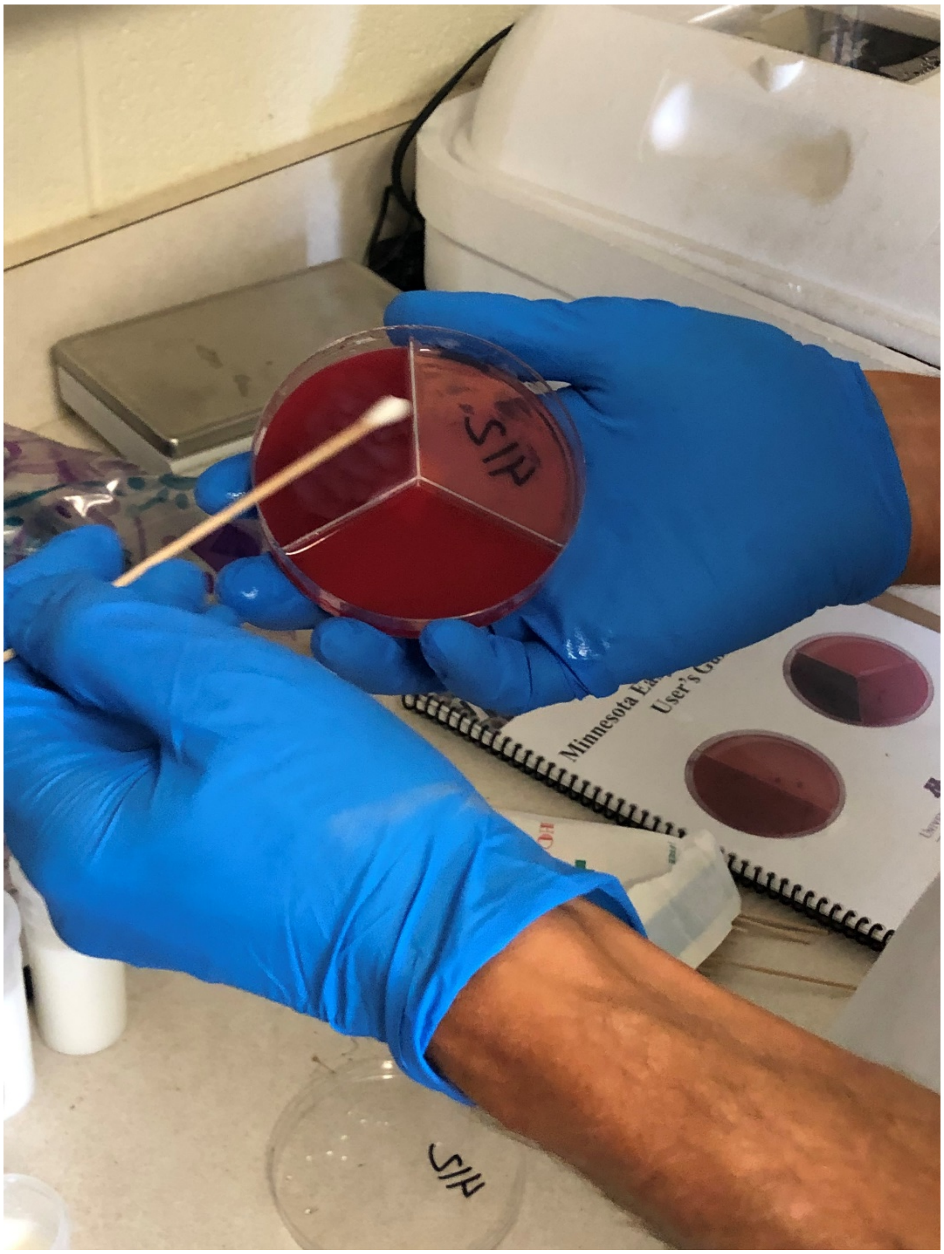

Figure 13. A tri-plate culture medium showing "no growth." No bacteria grew after the 48-hour incubation period.

Figure 14. A tri-plate culture medium showing "*Staph. aureus*" growth (indicated by zones of hemolysis around the bacterial growth).

Figure 15. A tri-plate culture medium indicating general "*Staph.*" growth.

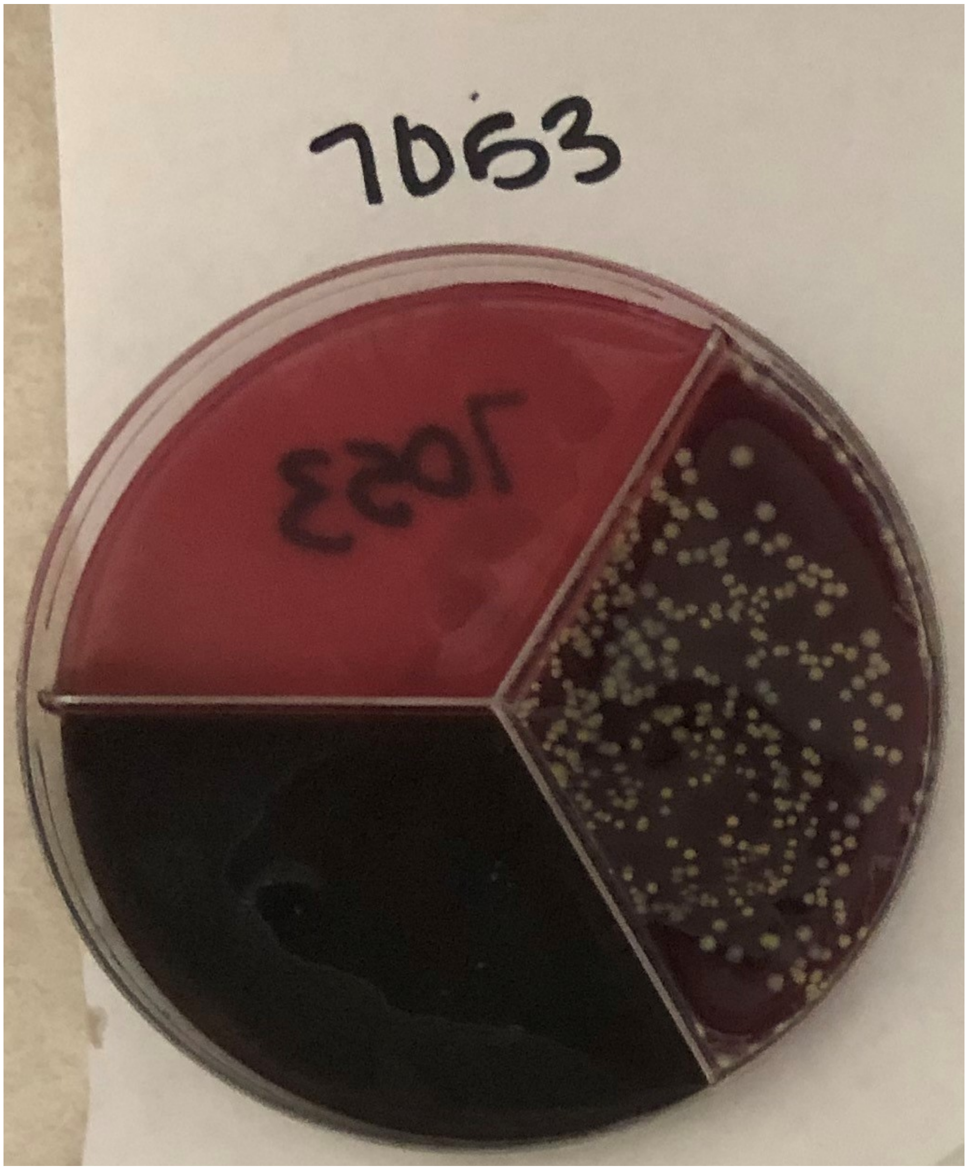

Figure 16. A tri-plate culture medium showing "*Strep.*" species growth. Concentration of the bacterial growth in both the Factor and Focus medias.

IACUC
INSTITUTIONAL ANIMAL CARE and USE COMMITEE
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129

IACUCN001: PROTOCOL APPROVAL NOTICE

Thursday, April 18, 2019

Senior Investigator	**Maegan Hollis** (ROLE: Faculty Advisor)
Co-Investigators	Dillon Arnold
Investigator Email(s)	*magen.hollis@mtsu.edu; dae4w@mtmail.mtsu.edu*
Department	Agriculture
Protocol Title	***Effect of switch trimming on fly avoidance behaviors, udder cleanliness and milk quality in lactating Holstein and Jersey dairy cows***
Protocol ID	**19-2014**

Dear Investigator(s),

The MTSU Institutional Animal Care and Use Committee has reviewed the animal use proposal identified above under the ***Designated Member Review (DMR) mechanism*** and has approved your protocol in accordance with PHS policy. A summary of the IACUC action(s) and other particulars of this this protocol is tabulated as below:

IACUC Action	**APPROVED for one year**	
Date of Expiration	**4/30/2020**	
Number of Animals	30 (THIRTY)	
Approved Species	**MTSU Bovine**	
Category Subclassifications	☐ **Teaching** ☐ Classroom ☐ Laboratory	☒ **Research** ☐ Laboratory ☒ Field Research ☐ Field Study ☒ Handling/Manipulation ☐ Observation
	Comment: NONE	
Approved Site(s)	MTSU Dairy Farm	
Restrictions	**Satisfy DMR requirements AND annual continuing review**	
Comments	NONE	

This approval is effective for three (3) years from the date of this notice. This protocol **expires on 4/30/2022** The investigator(s) MUST file a Progress Report annually regarding the status of this study. Refer to the schedule for Continuing Review shown below; NO REMINDERS WILL BE SENT. A continuation request (progress report) must be approved by the IACUC prior to **4/30/2020** for this protocol to be active for its full term. Once a protocol has expired, it cannot be continued and the investigators must request a fresh protocol.

Continuing Review Schedule: Refer tp the following table to request your CR:

Reporting Period	Requisition Deadline	IACUC Comments
First year report	3/31/2020	TO BE COMPLETED
Second year report	3/31/2021	TO BE COMPLETED
Final report	3/31/2022	TO BE COMPLETED

MTSU Policy defines an investigator as someone who has contact with live or dead animals for research or teaching purposes. Anyone meeting this definition must be listed on your protocol and must complete appropriate training through the CITI program. Addition of investigators requires submission of an Addendum request to the Office of Research Compliance.

The IACUC must be notified of any proposed protocol changes prior to their implementation. Unanticipated harms to subjects or adverse events must be reported within 48 hours to the Office of Compliance at (615) 494-8918 and by email – compliance@mtsu.edu.

Post-approval Protocol Amendments:

Date	***Amendment(s)***	***IRB Comments***
NONE	NONE	NONE

All records pertaining to the animal care be retained by the MTSU faculty in charge for at least three (3) years AFTER the study is completed. Be advised that all IACUC approved protocols are subject to audit at any time and all animal facilities are subject to inspections at least biannually. Furthermore, IACUC reserves the right to change, revoke or modify this approval without prior notice.

Sincerely,

Compliance Office
(On behalf of IACUC)
Middle Tennessee State University
Tel: 615 494 8918
Email: iacuc_information@mtsu.edu (for questions) and
Iacuc_submissions@mtsu.edu (for sending documents)