International Journal of Veterinary Science and Agriculture Research
Volume 7 Issue 3, July-August 2025
ISSN: 2582-4112, Available at www.ijvsar.com

The influence of fly prevalence on fly dislodging behaviors of dairy cows

A. Kovalenko[1], R. Shaganenko[2], O. Poroshynska[2], O. Iaroshenko[2], V. Shaganenko[2], V. Honcharenko[2], A. Antipov[2], V. Koziy[2], A. Ondrejková[1], J. Mojžišová[1], Ľ. Korytár[1], M. Drážovská[1], B. Vojtek[1], M. Prokeš[1]

[1]*(Department of Epizootiology, Parasitology and Protection of One Health / University of Veterinary Medicine and Pharmacy in Košice, Slovakia)*

[2]*(School of Veterinary Medicine / Bila Tserkva National Agrarian University, Ukraine)*

***For Correspondence**

Anatolii Kovalenko
Department of Epizootiology, Parasitology and Protection of One Health / University of Veterinary Medicine and Pharmacy in Košice, Slovakia

anatolii.kovalenko@uvlf.sk

Abstract: *Fly infestation is a significant problem for dairy farms. The aim of our work was to study changes in cow behavior at different levels of fly infestation. The study was conducted on a dairy farm with an average annual milk yield per cow of about 8,000 kg. The intensity of infestation and fly defense behavior of cows was studied in March (low intensity of infestation) and July (high intensity of infestation). It was found that the intensity of fly infestation in March was 0.7±0.21 (n=25), in July - 38.4±2.39 (n=25) flies per cow. At low intensity of fly infestation, cows made only one movement by one of the body parts. At high intensity of fly infestation, cows standing near the feeding table made 21.6±0.84 tail switching, 9.1±0.61 skin twitching, 2.59±0.2 head tossing, and 2.59±0.24 and 2.29±0.19 pelvic and thoracic foot movements per minute, respectively. During milking, cows threw their heads less (0.6±0.12 moves/min, p<0.001), compensating for this with more forelimb stomps (3.4±0.2 strokes/min, p<0.001) and skin twitching (17.2±1.12 moves/min, p<0.001). Fly swatting movements in lame cows are 1.7-4.6 times less frequent than in healthy cows, indicating the development of the "acquired helplessness" syndrome.*

Keywords: *cows, daily milk yield, dislodging behaviors, fly*

I. INTRODUCTION

Flies are a common problem in dairy farming. They are attracted to carbon dioxide, methane and synthetic volatiles emitted from urine, faeces or respiratory excretions of cattle (Kovacs et al., 2024; Nordéus et al., 2014). Being a constant nuisance, flies negatively affect animal welfare, productivity and farm profitability.

Flies can carry about 200 microorganisms dangerous to humans and animals and cause more than 65 diseases, including bovine mastitis, which is a major cause of economic losses in the dairy industry (Bertolini et al., 2022). Control of flies, which can act as vectors of pathogens, should be an important measure in the complex protocols for prevention and treatment of cow diseases (McDougall et al., 2009).

Arsenopoulos et al. (2018) studied the effect of the fly repellent deltamethrin on the microbiological profile of intramammary infections and somatic cell counts in dairy cows. It was found that deltamethrin reduced the number of flies on cows, contributing to a significant reduction in the number of *S. aureus*, coagulase-negative staphylococci, *Escherichia coli* and somatic cell counts in cows throughout the study period.

In a study done by Naseem et al. (2022), skin lesions in cattle were associated with the presence of *Haematobia* species flies, which is a significant problem in Australia, North and South America and Europe. The authors found that *Staphylococcus agnetis* and *Staphylococcus hyicus* strains are important etiological factors of skin lesions in cattle. They also confirmed the significant role of vector flies in the pathogenesis of these lesions.

The results of studies conducted by Neupane et al. (2024) once again confirmed the role of houseflies as carriers of bacteria, including cattle pathogens. The scientists also draw attention to the great potential of flies in the spread of pathogenic microbes both among cattle and in neighboring environments.

Other scientists (Bertolini et al., 2023) highlight the role of dipteran flies as carriers of rotavirus A and betacoronavirus, which are of great importance for human and animal health. Also, flies can be potential agents of the spread of multidrug-resistant *E. coli* on dairy farms (Alves et al., 2018).

The economic losses on dairy farms due to fly infestation are significant. According to Taylor et al. (2012), the average annual losses due to fly infestation in dairy herds reached 139 kg of milk per cow and up to 26 kg of weight gain per calf. Using data on cattle populations, average dairy prices, and average monthly infestation levels, the authors estimate the national losses in the United States due to fly infestation on dairy farms as $360 millions. The results obtained by Smith et al. (2022) indicate that the average costs of fly control in Tennessee and Texas were $9.50 and $12.40/head, respectively. The authors also argue that the costs of fly control vary depending on the level of education and income of the producer. According to Harris et al. (1987) cows protected from flies showed 1.45 kg/cow higher daily milk yield gain during the first 12 weeks of lactation.

The activity of flies on dairy farms is associated with specific management and weather conditions. The amount of flies depends on the season of the year, environmental factors, characteristics of the pen location, TMR components and the intensity of insecticide use (El Ashmawy et al., 2021).

The presented data indicate that fly infestation is a significant problem for dairy farms. Further study of the mechanisms of negative impact on both animal welfare and the economic performance of the dairy industry is required.

In this regard, the aim of our work was to study the changes of cow behavior under the different levels of fly infestation.

II. Materials and Methods

The research was conducted on a dairy farm with an average annual milk yield per cow of about 8,000 kg.

The intensity of infestation and fly repellent behavior of cows were studied in March (low intensity of infestation) and July (high intensity of infestation).

To study the intensity of infestation, 25 animals were photographed on the farm when they were in a standing position, not exposed to sunlight, and not moving for more than 5 seconds. One full picture was taken of the entire left lateral (head, neck, trunk, limbs) surface of the cow. A Nikon Coolpix digital camera was used for shooting. Flies were counted on a desktop computer monitor with a 24 inches screen diagonal. All frames were viewed sequentially in an enlarged format. The used method of visual counts correlated with the counts provided by the FlySpotter software (Gerry et al., 2011).

According to El Ashmawy et al. (2021) cattle's fly-dislodging behaviors are manifested as foot stomping (FS), head tossing (HT), tail switching (TS) and skin twitching (ST). All of these indexes were taken from a 1 min video of the cows. Each video consisted of the whole cow taken in lateral-slightly rear projection.

The fly-dislodging behaviors in March were studied in randomly chosen standing cows (n=25). The fly-dislodging behaviors in July were studied in three groups of cows. The cows of the first group (n=80) stood at the feed table but did not actively consume the feed. Cows in the second group (n=52) were milked at the time of study. The cows of the third group (n=18) were lame and stood near the feed table during the survey.

All indicators of fly-repellent behavior of cows were calculated by analyzing the video on a desktop computer monitor with a screen diagonal of 24 inches.

The obtained results were processed by the methods of variation statistics. The data in table are presented as mean±standard deviation (x ± SD). The difference between the means (p) were determined with the use of Student's tables and was considered significant at $p<0.05$.

III. Results

During the study of fly infestation intensity, it was found that in March it was 0.7±0.21 (n=25), in July - 38.4±2.39 (n=25) flies per left side of cow. These results indicate that at a low level of infestation, cows very rarely move their tail, head, limbs or subcutaneous muscles (Table 1). In general, there is one movement per minute per cow with one of these body parts.

During the study of fly repellent behavior at high levels of infestation, cows standing near the feeding table most oftenly switched their tails (21.6±0.84 moves/min) and used ST (9.1±0.61 times/min). Both limbs and the head of the animals were used to repel flies on average 2.3-2.6 times per minute.

Table 1. Changes in cow behavior at different levels of fly infestation

№ п/п	Indicators of of cows' behavior (moves/min)	Low level of infestation (0,7±0,21 flies/cow, n=25)	High level of infestation (38.4±2.39 flies/cow, n=25)		
			Near feeding table, n=80	Milking time, n=52	Lame cows, n=18
1.	Tail	0.25±0.12	21.6±0.84	22.6±1.33	7.89±1.34*
2.	Head	0.2±0.09	2.59±0.2	0.6±0.12*	0.61±0.22*
3.	Pelvic limb	0.15±0.08	2.59±0.24	2.6±0.18	0.56±0.2*
4.	Thoracic limb	0.1±0.07	2.29±0.19	3.4±0.2*	0.78±0.22*
5.	Subcutaneous muscles	0.3±0.11	9.1±0.61	17.2±1.12*	5.34±0.54*

Compared to animals standing near the feeding table, during milking, the number of movements of the tail and pelvic limb did not change. However, during milking, cows moved their heads significantly less (0.6±0.12 vs. 2.59±0.2 moves/min, $p<0.001$) and more often moved their thoracic limb (1.5 times, $p<0.001$) and subcutaneous muscles (1.9 times, $p<0.001$) comparing with cows standing near the feeding table.

The fly-repelling behavior of lame cows was much less active. Compared to animals standing at the feeding table, the number of TS, HT, pelvic and thoracic FS and ST in cows with lameness was 2.7, 4.2, 4.6, 4.4 and 1.7 times less ($p<0.001$), respectively.

IV. Discussion

Flies play a significant role in dairy farming, mainly as pests, with profound implications for animal health, productivity and economic viability of the farms. While they may have ecological value in the natural environment, their presence on dairy farms generally has negative consequences. The available research data are scarce and often not convincing and contradictive. Thus, the results of research conducted by Sanchez-Sandoval et al. (2022) indicate that fly infestation does not affect the amount of feed consumed or digestion in cattle (*Bos taurus*) kept in modern farm conditions. Vitela-Mendoza et al. (2016) found that plasma cortisol concentration is linearly increased with the increase of the number of flies and the frequency of fly-dislodging behaviors. Vitela et al. (2006) informed that high quantity of *S. calcitrans* (> 10 flies per cow) did not alter the lying behavior in dairy cows, however, the high fly prevalence modified cows' site preferences for lying down. Sjostrom et al. (2016) reported that on a herd basis physical activity of cows was moderately correlated with increased fly populations on the farm. Therefore, studying the fly prevalence and fly-avoiding behavior in dairy cows remains an important issue in cattle research.

In this research we found that during the milking time the cows used head tossing for fly dislodging almost five times less comparing with cows standing near the feeding table. At the same time the milked cows used almost twice as much front leg stomps and skin twitches to repel the flies. We are inclined to consider the latter action as a substitute for the reduced head tossing. Probably, a less active head helps the cows to concentrate on the milking process or feelings.

According to Mullens et al. (2006) older cows tended to harbour more flies and dislodge them less frequently than young adult cows. They also found that the ratio of foot moves and head tosses to fly loud decreased over time, suggesting that there may be habituation development to the pain associated with fly bites.

The results of our article show that lame cows were much more prone not to display fly-dislodging behavior comparing, with their clinically healthy counterparts. From a physiology point of view we may call the changes habituation as well. But, to emphasize the animal welfare aspect of the issue we may also consider the above data as an "acquired helplessness" phenomenon.

In other studies flies are considered a serious environmental factor affecting dairy cattle welfare. Ashmawy et al. (2019) studied the risk factors affecting protective grouping behavior, commonly known as bunching, in cows in California dairies. Bunching describes the protective aggregation of cows against the painful bites of stable flies (*Stomoxys calcitrans*). The cattle gather in a circle with their heads to the center of the circle and their tails constantly swishing to the outside to reduce stable fly attack. The authors found that cattle bunching was reduced in the condition of higher relative humidity (>50%) or when the pen is surrounded by other pens or is bordered by busy roads. Also, removal of manure along fence lines of pens was found protective against cattle bunching.

The results obtained Hansen et al. (2023) showed a strong relationship between the flies loud and numbers of defensive activity. The authors also found that younger cows attract fewer flies than older cows and that the threshold of flies numbers to lower production for pastured cows was at least 5 for stable flies, 37 for horn flies, and 1 for face flies.

The fly avoidance behaviors caused by flies are an important welfare concern for dairy producers. To mitigate the problem Perttu et al. (2020) studied the effects of mesh leggings on fly pressure and fly repellent behaviors of dairy cows on pasture. Their results showed that fly avoidance behaviors of cows continued regardless of the use of leggings, but leggings reduced foot stomps by 39%. The authors conclude that the use of leggings on pastured dairy cows provides them some relief from stable fly bites.

The main purpose of the other study (Kienitz et al., 2018) was to evaluate the efficacy of a commercial vacuum fly trap to control horn flies, stable flies, and face flies on dairy farms. The results indicate that the trap was effective in reducing fly numbers on cows. Benefits in improved milk production were not evident and authors assumed that was because of relatively low fly populations at the time the research was conducted.

Many other researchers are working on the ways to alleviate cows' discomfort by reducing fly defensive behavior. Lachance et al. (2014) studied fly repellent effectiveness of several plant essential oils, sunflower oil and some natural insecticides in pastured dairy cows. It was found that essential oils have a promising perspective to be used as a fly repellent in dairy livestock production. Zhu et al. (2022) evaluated the efficacy of an attractant impregnated adhesive tape against blood-sucking flies. The authors found that adhesive tape impregnated with m-cresol provided an 80% reduction in cattle stress caused by stable fly attack. Cruz-Vazquezet al. (2015) evaluated the efficacy of *Metarhizium anisopliae* isolate to control *Stomoxys calcitrans* flies in dairy cattle. These results demonstrated the high efficacy of the formulation in controlling infestation by *S. calcitrans* and reducing animals' defensive behaviors.

Our data also shows that the most important component of fly dislodging behavior in cows is tail swishes. We found that the cows, in the high fly loud environment, swished their tails more than 20 times per minute. This means that cows use their tail to repel the flies 2-4 times more than any other body part. Meanwhile, tail docking remains a quite common practice on many dairy farms. According to Weary et al. (2011) common reason for tail docking is an issue of cow cleanliness. Yet, the same authors emphasized that there is no scientific evidence showing a positive effect of docking on cow cleanliness or udder health. They further oppose tail docking by noticing that docking is unnatural and painful for cows, and that tails are important for fly dismissal behavior.

A number of other authors emphasised the detrimental effect of tail docking on cows' comfort and welfare. Frantz et al. (2019) found that in the course of fly dislodging odds of exhibiting tail swishing were 2.63 times greater for docked cows than for switch-trimmed cows and 1.92 times greater when compared to switch-intact cows. The results obtained by Eicher et al. (2001) showed that docked cattle were attacked by more flies, and showed increased fly avoidance behaviors. The same authors in their other article (Eicher et al., 2002), while confirming their previous results, added that docked cows had increased foot stomping moves that with high probability may be estimated as compensatory strategy for fly avoidance by docked cows. The data provided are supported by Kroll at al. (2014) who found that docked cows performed rear foot stomp behavior more ($p < 0.001$) than unaltered ones.

Promising direction of research in the field of fly control in cattle is breeding the fly resistant animals. It was found that in some cattle herds, animals that are genetically similar have lower loud of flies. That led to suggestions that those animals may be fly resistant and that the trait is heritable. For example, Basiel et al. (2021) found that lower fly loads were associated with white coat coloration and gene KIT was identified as the most plausible candidate gene for fly resistance because of its role in coat pattern characteristics. Results obtained by McKay et al. (2019) indicate that farmers were willing to pay a premium of up to 60% above the base price for a fly resistant bull with the intent to improve fly control management within their herd. We consider it as important evidence of farmers' awareness of the fly discomfort issue for the cows. Our data add to further exposure of the negative impact of flies on animal behavior, wellbeing and productivity and prompt for further recognition of the problem and search for the proper solution.

V. Conclusion

On the studied dairy farm the fly infestation intensity in March was 0.7±0.21 (n=25), in July - 38.4±2.39 (n=25) flies per left side of cow. At the low fly infestation intensity, (March) the cows committed only one move by one of their body parts (head, tail, under-skin muscles and pelvic and thoracic limb). At the high fly infestation intensity (July) the cows standing near feeding table did 21.6±0.84 tail switching, 9.1±0.61 skin twitching, 2.59±0.2 head tossing and pelvic and thoracic foot stomping 2.59±0.24 and 2.29±0.19 per minute, respectively. During the milking time the cows did less head tossing (0.6±0.12 moves/min, $p<0.001$) compensating it with more thoracic foot stomping (3.4±0.2 moves/min, $p<0.001$) and skin twitching (17.2±1.12 moves/min, $p<0.001$). The fly dislodging movements of lame cows were 1.7–4.6 times less frequent than their healthy counterparts, which is indicative of the development of "acquired helplessness" syndrome.

The results of our study further pinpoint the importance of management, production and welfare issues of fly infestation on dairy farms. That means that improvements of prevention, control and mitigation measures are relevant today and require further attention of veterinary research and practice.

VI. Acknowledgements

Funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V01-00151 and project VEGA 1/0316/23.

References

[1] Alves, T. D. S., Lara, G. H. B., Maluta, R. P., Ribeiro, M. G., & Leite, D. D. S. (2018). Carrier flies of multidrug-resistant Escherichia coli as potential dissemination agents in dairy farm environment. Science of the Total Environment, 633, 1345–1351. doi: 10.1016/j.scitotenv.2018.03.304.

[2] Arsenopoulos, K., Triantafillou, E., Filioussis, G., & Papadopoulos, E. (2018). Fly repellency using deltamethrin may reduce intramammary infections of dairy cows under intensive management. Comp Immunol Microbiol Infect Dis, 61, 16-23. doi: 10.1016/j.cimid.2018.11.001.

[3] Basiel, B. L., Hardie, L. C., Heins, B. J., & Dechow, C. D. (2021). Genetic parameters and genomic regions associated with horn fly resistance in organic Holstein cattle. Journal of Dairy Science, 104(12), 12724–12740. doi: 10.3168/jds.2021-20366.

[4] Bertolini, A. B., Prado, A. M., Thyssen, P. J., de Souza Ribeiro, Mioni, M., de Gouvea, F. L. R., da Silva Leite, D., et al. (2022). Prevalence of bovine mastitis-related pathogens, identified by mass spectrometry in flies (Insecta, Diptera) captured in the milking environment. Letters in Applied Microbiology, 75(5), 1232–1245. doi: 10.1111/lam.13791.

[5] Bertolini, A. B., Thyssen, P. J., Brandão, P. E., Prado, A. M., Silva, S. O. S., Mioni, M. S. R., et al. (2023). Flies (Insecta, Diptera) collected in the environment of dairy farms as carriers of Rotavirus A and betacoronavirus. Journal of Applied Microbiology, 134(3), lxad020. doi: 10.1093/jambio/lxad020.

[6] Cruz-Vazquez, C., Carvajal Márquez, J., Lezama-Gutiérrez, R., Vitela-Mendoza, I., & Ramos-Parra, M. (2015). Efficacy of the entomopathogenic fungi Metarhizium anisopliae in the control of infestation by stable flies, Stomoxys calcitrans (L.), under natural infestation conditions. Veterinary Parasitology, 212(3–4), 350–355. doi: 10.1016/j.vetpar.2015.07.003.

[7] Eicher, S. D., & Dalley, J. W. (2002). Indicators of acute pain and fly avoidance behaviors in Holstein calves following tail-docking. Journal of Dairy Science, 85(11), 2850–2858. doi: 10.3168/jds.s0022-0302(02)74372-5.

[8] Eicher, S. D., Morrow-Tesch, J. L., Albright, J. L., & Williams, R. E. (2001). Tail-docking alters fly numbers, fly-avoidance behaviors, and cleanliness, but not physiological measures. Journal of Dairy Science, 84(8), 1822–1828. doi: 10.3168/jds.S0022-0302(01)74621-8.

[9] El Ashmawy, W. R., Williams, D. R., Gerry, A. C., Champagne, J. D., Lehenbauer, T. W., & Aly, S. S. (2019). Risk factors affecting dairy cattle protective grouping behavior, commonly known as bunching, against Stomoxys calcitrans (L.) on California dairies. PLoS One, 14(11), e0224987. doi: 10.1371/journal.pone.0224987. Erratum in: PLoS One, 15(7), e0235775. doi: 10.1371/journal.pone.0235775.

[10] El Ashmawy, W. R., Abdelfattah, E. M., Williams, D. R., Gerry, A. C., Rossow, H. A., Lehenbauer, T. W., & Aly, S. S. (2021). Stable fly activity is associated with dairy management practices and seasonal weather conditions. PLoS One, 16(7), e0253946. doi: 10.1371/journal.pone.0253946.

[11] Frantz, L. M., Morabito, E. A., Dolecheck, K. A., & Bewley, J. M. (2019). Short communication: A comparison of cow cleanliness, fly population, and fly avoidance behaviors among docked, switch-trimmed, and switch-intact dairy cows in 3 commercial dairy herds. Journal of Dairy Science, 102(2), 1584–1588. doi: 10.3168/jds.2018-14921.

[12] Gerry, A. C., Higginbotham, G. E., Periera, L. N., Lam, A., & Shelton, C. R. (2011). Evaluation of surveillance methods for monitoring house fly abundance and activity on large commercial dairy operations. J Econ Entomol, 104(3), 1093-1102. doi: 10.1603/ec10393.

[13] Hansen, A. C., Moon, R. D., Endres, M. I., Pereira, G. M., & Heins, B. J. (2023). The defensive behaviors and milk production of pastured dairy cattle in response to stable flies, horn flies, and face flies. Animals (Basel, 13(24), 3847. doi: 10.3390/ani13243847.

[14] Harris, J. A., Hillerton, J. E., & Morant, S. V. (1987). Effect on milk production of controlling muscid flies, and reducing fly-avoidance behavior, by the use of Fenvalerate ear tags during the dry period. Journal of Dairy Research, 54(2), 165–171. doi: 10.1017/s0022029900025309.

[15] Kienitz, M. J., Heins, B. J., & Moon, R. D. (2018). Evaluation of a commercial vacuum fly trap for controlling flies on organic dairy farms. J Dairy Sci, 101(5), 4667-4675. doi: 10.3168/jds.2017-13367.

[16] Kovacs, E. M., Pinard, C., Gries, R., Manku, A., & Gries, G. (2024). Carbon dioxide, methane, and synthetic cattle breath volatiles attract host-seeking stable flies, Stomoxys calcitrans. Journal of Chemical Ecology, 50(11), 643–653. doi: 10.1007/s10886-024-01502-0.

[17] Kroll, L. K., Grooms, D. L., Siegford, J. M., Schweihofer, J. P., Daigle, C. L., Metz, K., & Ladoni, M. (2014). Effects of tail docking on behavior of confined feedlot cattle. Journal of Animal Science, 92(10), 4701–4710. doi: 10.2527/jas.2014-7583.

[18] Lachance, S., & Grange, G. (2014). Repellent effectiveness of seven plant essential oils, sunflower oil and natural insecticides against horn flies on pastured dairy cows and heifers. Medical and Veterinary Entomology, 28(2), 193–200. doi: 10.1111/mve.12044.

[19] McDougall, S., Parker, K. I., Heuer, C., & Compton, C. W. (2009). A review of prevention and control of heifer mastitis via non-antibiotic strategies. Vet Microbiol, 134(1-2), 177-185. doi: 10.1016/j.vetmic.2008.09.026.

[20] McKay, L., DeLong, K. L., Schexnayder, S., Griffith, A. P., Taylor, D. B., Olafson, P., & Trout Fryxell, R. T. (2019). Cow-Calf Producers' Willingness to Pay for Bulls Resistant to Horn Flies (Diptera: Muscidae). Journal of Economic Entomology, 112(3), 1476–1484. doi: 10.1093/jee/toz013.

[21] Mullens, B. A., Lii, K. S., Mao, Y., Meyer, J. A., Peterson, N. G., & Szijj, C. E. (2006). Behavioral responses of dairy cattle to the stable fly, Stomoxys calcitrans, in an open field environment. Medical and Veterinary Entomology, 20(1), 122–137. doi: 10.1111/j.1365-2915.2006.00608.x.

[22] Naseem, M. N., Turni, C., Gilbert, R., Raza, A., Allavena, R., McGowan, M., et al. (2022). Role of Staphylococcus agnetis and Staphylococcus hyicus in the pathogenesis of buffalo fly skin lesions in cattle. Microbiology Spectrum, 10(4), e0087322. doi: 10.1128/spectrum.00873-22.

[23] Neupane, S., Park, Y., Watson, D. W., Trout Fryxell, R. T., Burgess, E. R., & Nayduch, D. (2024). Bacterial communities of house flies from dairy farms highlight their role as reservoirs, disseminators, and sentinels of microbial threats to human and animal health. Insects, 15(9), 730. doi: 10.3390/insects15090730.

[24] Nordéus, K., Webster, B., Söderquist, L., Båge, R., & Glinwood, R. (2014). Cycle-characteristic odour of cow urine can be detected by the female face fly (Musca autumnalis). Reprod Domest Anim, 49(6), 903-908. doi: 10.1111/rda.12393.

[25] Perttu, R. K., Heins, B. J., Phillips, H. N., Endres, M. I., Moon, R. D., & Sorge, U. S. (2020). Short communication: Effects of mesh leggings on fly pressure and fly avoidance behaviors of pastured dairy cows. J Dairy Sci, 103(1), 846-851. doi: 10.3168/jds.2019-17267.

[26] Sanchez-Sandoval, U. A., Figueroa-Zamudio, J. J., Ramirez, J., Löest, C. A., Soto-Navarro, S. A., & Smy the, B. G. (2022). The effect of horn fly (Diptera: Muscidae) infestation on behavior, water, and feed intake, and digestion characteristics of beef cattle. Journal of Economic Entomology, 115(1), 365–370. doi: 10.1093/jee/toab208.

[27] Sjostrom, L. S., Heins, B. J., Endres, M. I., Moon, R. D., & Paulson, J. C. (2016). Short communication: Relationship of activity and rumination to abundance of pest flies among organically certified cows fed 3 levels of concentrate. Journal of Dairy Science, 99(12), 9942–9948. doi: 10.3168/jds.2016-11038.

[28] Smith, K. V., DeLong, K. L., Griffith, A. P., Boyer, C. N., Martinez, C. C., Schexnayder, S. M., & Trout Fryxell, R. T. (2022). Costs of Horn Fly (Diptera: Muscidae) control for cow-calf producers in Tennessee and Texas, 2016. Journal of Economic Entomology, 115(1), 371–380. doi: 10.1093/jee/toab239.

[29] Taylor, D. B., Moon, R. D., & Mark, D. R. (2012). Economic impact of stable flies (Diptera: Muscidae) on dairy and beef cattle production. J Med Entomol, 49(1), 198-209. doi: 10.1603/me10050.

[30] Vitela, I., Cruz-Vázquez, C., & Orihuela, A. (2006). A note on the effect of controlling stable flies (Stomoxys calcitrans) in the resting activity and pen distribution of dairy cows. Journal of Applied Animal Welfare Science, 9(3), 241–248. doi: 10.1207/s15327604jaws0903_6.

[31] Vitela-Mendoza, I., Cruz-Vázquez, C., Solano-Vergara, J., & Orihuela-Trujillo, A. (2016). Short communication: Relationship between serum cortisol concentration and defensive behavioral responses of dairy cows exposed to natural infestation by stable fly, Stomoxys calcitrans. Journal of Dairy Science, 99(12), 9912–9916. doi: 10.3168/jds.2016-11484.

[32] Weary, D. M., Schuppli, C. A., & von Keyserlingk, M. A. (2011). Tail docking dairy cattle: responses from an online engagement. Journal of Animal Science, 89(11), 3831–3837. doi: 10.2527/jas.2011-3858.

[33] Zhu, J. J., Roh, G. H., Asamoto, Y., Bizati, K., Liu, J. C., Lehmann, A., et al. (2022). Development and first evaluation of an attractant impregnated adhesive tape against blood-sucking flies. Insect Science, 29(2), 603–612. doi: 10.1111/1744-7917.12952.