Electric Power Saving Fan Options For Cow Cooling

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Summerheat stress lowers dairy cow feed intake and productive performance. Unless measures are taken to improve cow comfort this stress can also lead to animal health problems. Various cooling methods have been used successfully to alleviate this problem (Shultz 1986 and Armstrong 1993). These methods focus on increasing feed intake, while cooling the cow and the immediate environment around her. Commonly fans are used together with water misting or drenching of cows in the milking barn cow wash/holding pens and in the rest and feeding facilities. A popular practice is to use a low volume high speed (LVHS) fan, having a 36 inch diameter with 825 rpm, for this purpose. This type of fan is effective when placed in rows for directional air movement. The LVHS fans are usually placed a few feet above the cows and have a safety cage.

The relatively high rpm and safety cage of the LVHS fan results in a large electrical power demand. This adds to milk production costs that could eventually be passed onto the consumer. Fan options exist that could move an equal amount of air with less power. One example is the ceiling fan used in homes and warehouses that cost effectively reduces heat load. However, little comparative information exists as to how effective they would be in helping the cow overcome summer heat stress in an acceptably economic manner. The objective of this report was to show comparisons of ceiling fans to the traditional LVHS fan during the summer on commercial dairies. This research was requested and supported by Southern California Edison utility company and the California Energy Commission to help reduce summer peak energy load and potential electrical shortage to the general public.

Three experiments were made over two summers on Tulare County dairies in the southern region of the San Joaquin Valley, in central California. These farms were typical of the area and averaged 2,000 corraled Holstein cows each. In all experiments temperature and humidity were gathered on automated data loggers and cow temperature/humidity heat stress index (THI) calculated by formula (Hahn 1981). Monthly bulk tank milk yields were recorded for all cows. Animal behavior was monitored in each pen at predetermined times and intervals by the "glance method" (Shultz 1984) for indication of changes in heat stress. All experiments had factorial designs and were analyzed for variance and covariance, means ranked by Duncan multiple range test, and main effects were subjected to correlation and regression analyses.

Experiment #1: Two high volume low speed (HVLS) ceiling fans, having 20 ft. diameter and 50 rpm, were suspended over a 200 cow wash and holding pen of a milking barn. During the summer fans were on for 3 days and off for 3 days. On the third day of each period random cow respiration rates were counted from the time wash pen sprinklers were turned off until cows entered for milking. Pooled bulk tank milk yield was tabulated for each period. Data logger weather information was correlated with cow performance for comparison of when fans were on or off during peak afternoon temperatures. Feeding and milking procedures were unchanged throughout the summer.

A reduction ($P<.05$) in relative humidity and a decrease ($P<.10$) of temperature and THI were seen with fans on than when off in the milking barn wash and holding pens of Experiment #1. Values are listed in Table 1. Cow respiration rates increased faster ($P<.01$) as THI increased with fans off than when on during peak afternoon temperatures. This increase in respiration rate with the fans off correlated negatively (-0.78) with milk yield, while the effect was minimal (-0.09) with fans on. Regression analysis showed with THI stress factors of 80 and 90 there were respective drops in milk yield of 0.3 and 0.6 gallons/cow daily when fans were off as compared to fans on. Respiration rates and milk yields are depicted in Figures 1 and 2 and are consistent with reviews by others (Hahn 1981, Armstrong 1993).

The two overhead HVLS fans used 0.88 kwh/hour. For adequate cooling, pens of this size would require twelve 3 ft. LVHS fans at 0.54 kwh/hour for each fan used. Electrical power savings with HVLS fans would be 86% for the cow comfort benefits observed. New fan installation costs, in the given 6:1 ratio, would be similar for both fan types. Energy savings would cover replacement cost of existing LVHS with HVLS fans in 3 years. A cost analysis is listed in Table 2. The results of Experiment 1 indicated the HVLS fan could cost effectively reduce cow heat stress in the relatively cramped and high humidity milk barn wash and holding pens. The next step was to make observations in a cow resting and feeding barn.

Experiment #2: LVHS fans were compared to HVLS fans in free stall resting and feeding barns. A ratio of 6 LVHS fans to 1 HVLS fan was used on an equal area and cow population basis. Each fan type serviced 2 cow pens that were on both sides of a central feed delivery alley. One pen had cows with artificial insemination (A.I.) and one had cows with several breeding bulls (Bull). Each pen averaged 290 cows. LVHS fans were mounted on top of feeder stanchions and HVLS fans were hung from the center of the roof over the feed delivery alley. All cows had the same feeding, milking and herd health management. All feeder stanchions had water emitters overhead with preset timer and temperature control. All fans had a preset automated on/off temperature control set at 85°F.

Temperatures were higher ($P<.05$), humidity lower ($P<.05$), and THI higher ($P<.10$) in the afternoon than evening of Experiment #2. Differences between fan types were minimal and are listed in Table 1. Regression analysis and correction for days in milk (DIM) showed identical milk yields of 90 lbs/cow daily at 150 DIM from cows with HVLS or LVHS fans. However, a 2 lbs/cow/day advantage ($P<.05$) at 75 DIM for LVHS fan cows and a 2 pound advantage ($P<.05$) for HVLS fan cows with 225 DIM were observed. This is illustrated in Figure 3. As a side note, the HVLS fans were relatively noiseless in comparison to the LVHS fans and poses an additional effect to be researched in future observations.

The percentage of cows in the free stall barn eating during the evening was lower ($P<.05$) than peak afternoon temperatures, with no significant differences between pens or fan types. There was a higher ($P<.01$) percentage of cows with HVLS fans laying in free stalls during both afternoon and evening than cows with LVHS fans. Cows in A.I. pen with LVHS fans had a higher ($P<.01$) percentage standing in barn lanes than those with HVLS in the afternoon, while these evening values were higher ($P<.01$) than in the afternoon. These results are depicted in Figures 4 and 5. Increases in eating and laying and decreases in standing have been associated with less heat stress and higher milk yield (Hahn 1981, Shultz 1984, 1986 and 1992). Table 2 shows a similar 86% electrical savings with HVLS as in Experiment #1, but for a 1,000 cow free stall rest and feeding barn.

Experiment #3: The relatively large 20 ft. diameter HVLS fan may not fit in some barns. Consequently, in Experiment #3 the LVHS fans were compared to 5 ft. diameter low volume and 330 rpm low speed ceiling fans (C), or a combination of the two (LVHS+C) or no fans, in free stall barns. The two types of fans were used in a 1:1 ratio on an area and cow population basis. LVHS fans were atop feeder stanchions and C fans were hung from roof over free stall cow beds. All pens averaged 290 cows and each had similar feeding, milking and herd health management. All feeder stanchions had water emitters overhead with preset timer and temperature control and all fans had a similar operation control as that used in Experiment #2.

Table 1. shows that differences between fan options of Experiment #3 for barn temperature, humidity and THI in the afternoon were not significant. However, milk yields were lower ($P<.05$) with no fans when compared to fan options. Differences between fan option milk yields did not reach statistical significance when corrected for DIM and lactation number. The averages at 150 DIM were 60.9, 62.1, 63.5 and 49.8 lbs/cow daily for LVHS, Ceiling , and LVHS + Ceiling and no fans respectively, and they are illustrated in Figure 6. Improved milk yield in cows cooled with fans was also seen in Experiment #1. Lack of added milk yield has been seen elsewhere (Brouk et al. 2001) when small ceiling fans were coupled with feed manger LVHS fans.

Percentage of cows eating was higher (P<.01) in the afternoon than evening, with small differences between fan options. More (P<.01) cows laid in free stalls with ceiling fans only, while cows with no fans was lowest (P<.01). The percentage of cows standing in barn lanes was higher (P<.10) with LVHS and LVHS+C than others in the afternoon. These effects are illustrated in Figures 7, 8 and 9. The favorable effect of fans on cow comfort and animal performance has been seen by others (Armstrong 1993, Brouk et al. 2001) and in Experiment #1. The trend of more cows laying with ceiling fans and more cows standing with LVHS fans in these observations were also seen in Experiment #2 and can be associated with more heat stress. However, effect on milk yield was not as big as with no fans. Table 2 shows an 83% electrical savings from the 5 ft. ceiling fan as compared to the LVHS and offers an option where large HVLS fans may not fit.

Other Considerations

There are factors that should be considered before installing fans. The first is whether fans would be beneficial with existing breeze and natural ventilation at the dairy. Also, whether there is relatively easy removal of obstacals to natural ventilation. In a limited finance situation, the milking barn cow wash and holding pen can be a relatively lower cost improvement priority than other barns. Where improved feed intake is a priority, fans can help this and eventually cow performance. Installation of the LVHS fans upon feeder stanchions or walls can be relatively less complicated than the ceiling fans. Because the 20 ft. diameter fan is large, the manufacturer mounting guidelines should be followed. Adding a variable speed drive control can reduce momentum changes at start and stop of the HVLS fan.

Some fans are not designed for the high summer temperature and barn air conditions of a dairy, or the condensing moisture in the winter. The fans used in this report were selected within this criteria. The LVHS fans last from 3 to 5 years before replacement is needed. Manufacturers stated ceiling fans life in home and warehouse conditions can be 10 years without problems. Longevity of these fans under typical commercial dairy environmental conditions have not as yet been demonstrated. However, rising electrical power costs make the cost effectiveness of these fans attractive and utility companies and energy conservation agencies have proposed incentives and cost sharing possibilities.

Conclusions

Under the environmental conditions of these experiments it was observed that some type of fan is needed to ventilate cows during summer heat stress. Fans improved cow comfort and performance in both the milking barn, as well as in the resting and feeding area. The high volume low speed 20 ft. diameter ceiling fan can give similar positive animal response to that of the traditionally used low volume high speed 3 ft. diameter fan, but with considerably less electrical power demand. A 5 ft. diameter low speed ceiling fan offered another option, along with power savings, where a larger fan may not fit. Observations with the 20 ft. fans were over two summers, while the 5 ft. fans were monitored one summer. Additional studies are needed regarding longevity of these ceiling fans in a commercial dairy environment.
The electrical power savings with the ceiling fans warrant their consideration in both new dairies and retrofit into existing farms. These electric power savings can benefit both the dairy producer and indirectly the general public.

Abstract

Fans are essential for reducing summer heat stress in order to improve dairy cow performance. Traditionally used low volume high speed fans are effective but demand a relatively large amount of electricity. High volume low speed ceiling fans maintained cow performance while using over 80% less electrical power than the smaller model. Cow behavior heat stress indicators help to evaluate animal performance and cost benefits in fan comparisons.

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Acknowledgments

Authors thank Tulare dairies Riverbend, McMoo and Nunes Brothers for use of facilities and animals. Also they wish to cite Southern California Edison, California Energy Commission and the Biological & Agricultural Engineering Dept., University of California at Davis, for project support.

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Table 1. Average Barn Temperature, Relative Humidity and Temperature/Humidity Index (THI)*

`Observation Times	2:00 to 6:00 p.m.		6:00 to 10:00 p.m.	
Experiment #1	Fans On	Fans Off	Fans On	Fans Off
Temperature, F +/-s.d.**	88.1+/-3.0	92.9+/-3.3	81.2+/-2.9	85.2+/-3.0
Humidity, % +/-s.d.	24.8+/-4.1	31.9+/-4.4	35.3+/-4.7	38.8+/-4.9
THI +/- s.d.	75.5+/-2.4	80.0+/-3.1	73.1+/-2.8	76.9+/-2.5
Experiment #2	HVLS	LVHS	HVLS	LVHS
Temperature, F +/- s. d.	92.4+/-6.2	91.2+/-6.1	84.9+/-6.9	84.8+/-6.8
Humidity, % +/- s.d.	20.7+/-5.8	22.6+/-6.4	29.9+/-9.9	29.1+/-9.6
THI +/- std. dev.	77.3+/-3.0	76.9+/-3.0	75.3+/-3.5	75.1+/-3.4
Experiment #3	LVHS	C. Only	LVHS+C	No Fan
Observation Time		2:00 to 6:00 p.m.		
Temperature, F +/- s.d.	91.2+/-6.2	91.4+/-6.2	91.0+/-6.2	91.5+/-6.2
Humidity, % +/- s.d.	20.1+/-6.0	20.5+/-6.1	20.1+/-6.0	20.4+/-6.3
THI +/- std. dev.	76.3+/-3.1	76.6+/-3.0	76.0+/-3.1	76.8+/-3.3

*THI = Temperature Humidity Index: Stress Factor 72-79 Mild; 80-89 Moderate; 90-98 Severe.
**Average +/- Standard Deviation

Table 2. Comparative Dairy Fan Option Install Cost and Electrical Saving Estimations.*

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Experiment #1	Milking Barn 200 Cow Wash & Holding Pen	
Fan Type & Model	3 ft. LVHS	20 ft. HVLS
Power Demand, kW/fan	0.538	0.440
Fan Run, hrs./yr.	4,000	4,000
Fan Air Volume Ratio	12	2
Fan & Install Costs, $/fan	700	5,325
Energy Cost/yr. @.10$/kwh	2,582	352
Power Demand Costs, $/yr.	307	42
Experiment #2	1,000 Cow Free Stall Barn	
Fan Type & Model	3 ft. LVHS	20 ft. HVLS
Power Demand, kW/fan	0.538	0.440
Fan Run, hrs./yr.	2,000	2,000
Fan Air Volume Ratio	100	17
Fan & Install Costs, $/fan	700	5,325
Energy Cost/yr.@.10$/kwh	10,760	1,496
Power Demand Costs, $/yr.	2,560	356
Experiment #3	1,000 Cow Free Stall Barn	
Fan Type & Model	3 ft. LVHS	5 ft. Ceiling
Power Demand, kW/fan	0.538	0.090
Fan Run, hrs./yr.	2,000	2,000
Fan Air Volume Ratio	100	100
Fan & Install Costs, $/fan	700	330
Energy Cost/yr.@.10/kwh	10,760	1,800
Power Demand Costs, $/yr.	2,560	428

*Values based on costs as of 9/23/01.

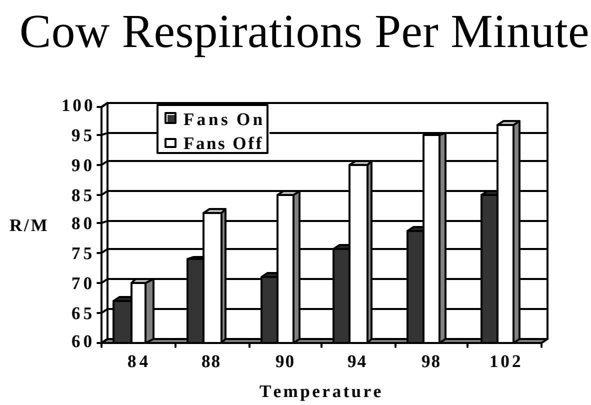


Figure 1. Effects of ambient temperature on cow respiration rate.

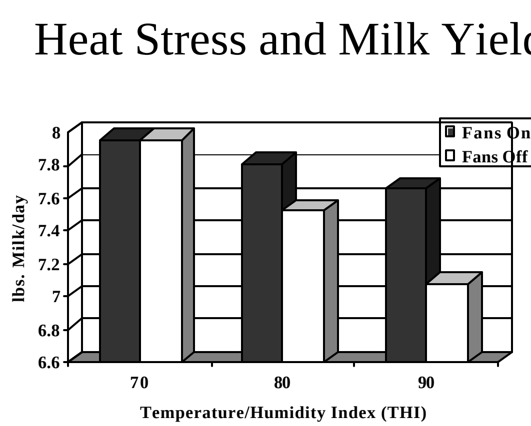


Figure 2. Temperature/Humidity Index (THI) heat stress effects on milk yield.

Milk Yields

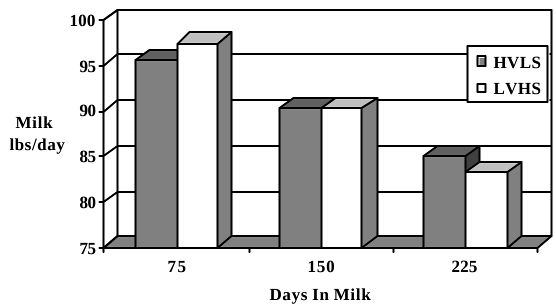


Figure 3. HVLS and LVHS fan effects on milk yield at specific days in milk.

Percent Cows Laying In Stalls

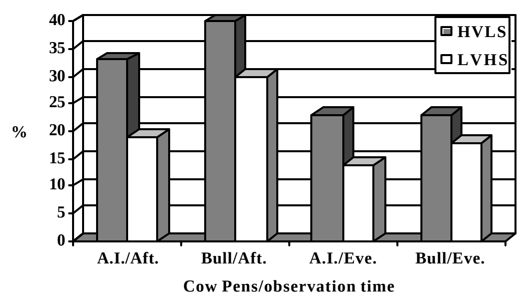


Figure 4. HVLS and LVHS fan effects on percent cows laying in free stalls.

Percent Cows Standing In Lanes

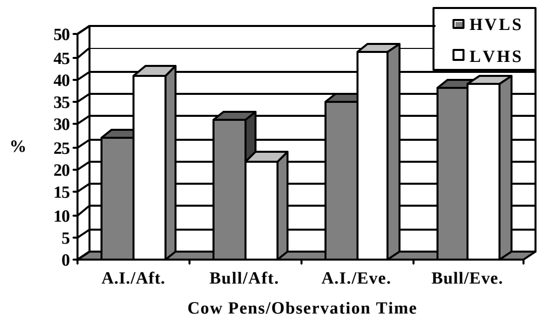


Figure 5. HVLS and LVHS fan effects on percent cows standing in barn lanes.

Milk Yield @ 150 Days In Milk

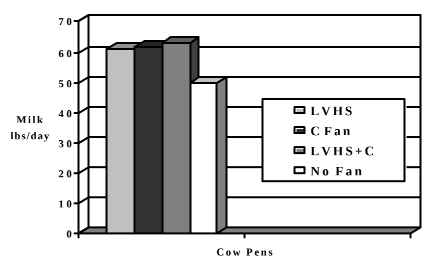
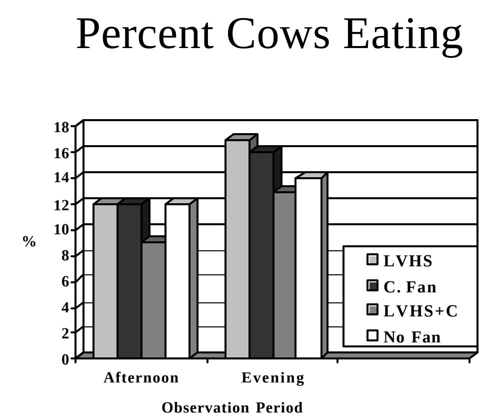


Figure 6. Fan option effects on milk yield at 150 days in milk.



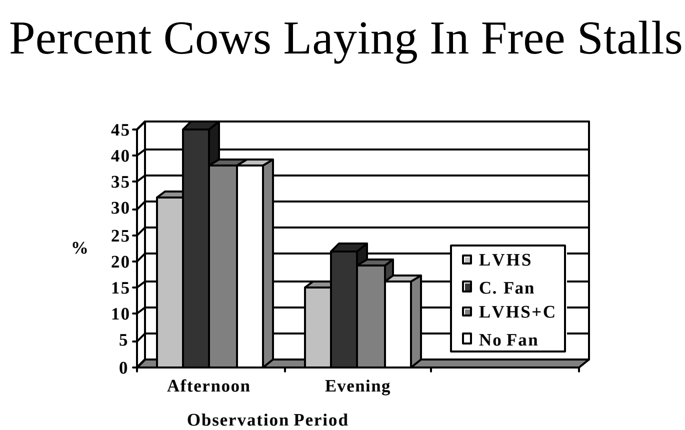


Figure 7. Fan option effects on percent cows eating.

Figure 8. Fan option effects on percent cows laying in free stalls.

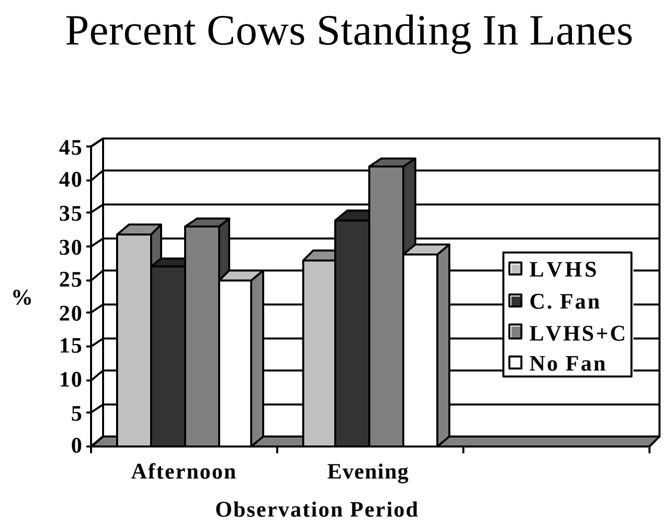


Figure 9. Fan option effects on percent cows standing barn lanes.