# Evaluation of Advanced Dairy Systems Shade Tracker (ADS-ST) Fans and Korral Kool (KK) Coolers on a Commercial Dairy in Arizona

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## TAKE HOME MESSAGES:

1. **Average milk yield was similar for cows in ADS-ST or KK (91.2 vs. 93.0 lbs/d) pens.**
2. **1st lactation heifers in the KK pen tended to produce more milk (83.4 vs. 81.0 lbs/d).**
3. **The initial investment for the ADS-ST was less ($58,500 vs. $118,067).**
    a. **ADS-ST = $234/cow vs. $472/cow for the KK coolers.**
4. **ADS-ST used less electricity, water and had lower daily costs ($27.30 vs. $33.36).**
    a. **Variable cost for ADS-ST = $0.11 vs. $0.15/cow/day for the KK coolers.**
    b. **Variable cost for ADS-ST = $0.10 vs. $0.14/cwt for the KK coolers.**

## INTRODUCTION

Evaporative cooling systems have proven beneficial for animal productivity in areas of low humidity such as Arizona (Armstrong, 1994). The two predominant cooling systems utilized on Arizona dairies are fans with sprayers/misters (**SF**) and Korral Kool (**KK**, Mesa, AZ) coolers. Both systems are mounted on shade structures and suspended below the roof. Recently, SF systems, such as those produced by Advanced Dairy Systems-Shade Tracker (**ADS-ST**, Chandler, AZ), have been equipped with a variable speed water injection into the air stream and the fans have variable ranges of motion (270ˆ) allowing for cooling under or around shade structures as the suns position changes during the day. The KK system cools the air around the cow by injecting micron-sized water droplets into fresh air moving down the cooler (Ryan et al., 1992; Armstrong, 1994). Unlike the ADS-ST system (marketed without curtains) the KK system utilizes a curtain suspended from the western edge of the shade (running N and S) to prevent exposure to solar radiation during late afternoon. A previous study, (Annen et al., 2004) evaluated and compared earlier models of the ADS-ST and KK systems on a university dairy. Annen et al., (2004) reported that milk yield was not affected by cooling system. The KK system reduced heat stress compared to ADS-ST and operation costs for both systems were similar. They concluded that the maintenance and lifespan of two systems and their impact on reproductive performance needs to be evaluated to determine which system is most economical.

The newly designed ADS-ST and KK cooling systems have never before been simultaneously tested against each other in a controlled "on-farm" setting. Therefore objectives of the current study were: 1) to evaluate the effects of ADS-ST compared to KK coolers on milk yield, milk composition, body condition score (**BCS**), body weight (**BW**), respiration rate (**RR**), body surface temperature (**ST**), and typical reproduction and animal health parameters of lactating dairy cows: 2) to compare core (vaginal) body temperature (**CBT**) of a sub set of multiparous cows (6/treatment) housed under ADS-ST or KK conditions.

## MATERIALS AND METHODS

### *Animals*

All procedures involving animals were approved by the University of Arizona Animal Care and Use Committee. The cooling trial was conducted from 06/03/04 to 09/30/04 and the CBT trial was conducted from 08/24/04 to 08/28/04 at Stotz Dairy, Buckeye, Arizona. Four hundred multiparous and 100 primiparous, bST-supplemented, Holstein cows housed in a dry lot facility (with shade over the feed manger) were randomly assigned to one of two treatments, ADS-ST or KK cooling systems. All cows were housed in open dry-lot pens (530 sq. ft/cow) with shades (48 sq ft /cow) in the center of each pen oriented North-South. Shade dimensions were 400 ft long by 30 ft wide by 13 ft high. Prior to the study, ADS-ST and KK treatments were balanced for parity (3.2 and. 3.1), stage of lactation (81.0 and. 81.4 DIM) and milk yield (106.9 and. 107.2 lbs/day). Data from thirteen animals were omitted from the ADS-ST treatment: 7 were sold during the study (4 for mastitis, 2 for cancer and 1 for lameness) and 6 were removed because time spent in the hospital disqualified them from analysis (< 9 weeks of valid data). Data from twenty animals were omitted from the KK treatment: 10 were sold during the study (6 for digestive, 2 for lameness, 1 for mastitis and 1 for an injury), 7 died during the study (3 from pneumonia, 2 from an injury, 1 from cancer and 1 from mastitis) and 3 were removed because time spent in the hospital disqualified them from analysis (< 9 weeks of valid data). As a consequence, 188 multiparous and 99 primiparous cows on the ADS-ST treatment and 180 multiparous and 100 primiparous cows on the KK treatment were included in the analysis. All animals had ad libitum access to feed and water and a total mixed ration (TMR) balanced to meet or exceed nutrient requirements (NRC, 2001) of all animals on the experiment was fed three times daily at 0500, 1200 and 2000 h to both ADS-ST and KK pens (Table 1). One mixed load of feed from the same wagon was split between the two pens. Cows were milked back to back three times daily at 0400, 1200 and 2000 h and cows from both treatments were cooled identically while in the wash and holding pen prior to milking.

A core (vaginal) body temperature trial using a subset of 12 multiparous cows (6/treatment) from the same study which were balanced for milk yield, stage of lactation and parity was conducted over a four day period. The study was a "switch back" design, and monitored and evaluated cows CBT every minute of every hour 24 hours/day. Vaginal temperatures were recorded using temperature data loggers (HOBO® U12 Stainless Temp Data Logger (Part @ U12-015) from Onset Computer Corporation, Bourne, MA). These devices were attached to a plastic intravaginal drug delivery device (CIDR) and inserted into the vagina on 08/24/04 at approximately 1300 h. Cows were allowed 18 h to acclimate to the devices. Beginning at 0700 on 08/25 and again every morning for 4 days cows were switched from ADS-ST to KK or from KK to ADS-ST and CBT was measured every minute. The data presented in this paper consists of 18 out of 24 hours for the 4 day study. Milking times (0400 to 0600; 1200 to 1400 and 2000 to 2200) were omitted from the analysis to prevent time spent out of pen effects on CBT. During the four day trial period, RR and ST were taken from each cow at 1200, 2000 and 0400 h to compare the differences between actual CBT, RR and ST.

### *Evaporative cooling systems*

The ADS-ST group was cooled with 20 oscillating fans and misters placed 20 ft apart below the eastern edge of the shade roof based upon manufacturer's guidelines. This system was computer driven and used photo-electric cells to enable the fans to "track" and cool the shaded areas throughout the day and to enable continuous adjustment of water flow through the misters based on ambient temperature and humidity. Fan oscillation radius was 270º, each fan was 36 inches in diameter and driven by a 2.0 Hp motor and oscillations and the shade tracker function were powered by a 0.5 Hp gear motor. The water pump for the misters was a 10.0 Hp variable frequency drive pump. Depending on the temperature and humidity, 0.25 to 1.25 gal/min of water were pumped through the misters, but droplet size was not altered. This system was designed to provide both improved sensible heat loss by cooling the microenvironment around the cow and increase body surface water evaporation (Table 2).

The KK cooled pen consisted of 17 coolers placed 20 ft apart in the center of the shade roof based upon manufacturer's guidelines. Each KK cooler was 60 inches in diameter and driven by a 3.0 Hp motor. Two 5.0 Hp water pump motors were used to facilitate water flow to the coolers. This system cools by pulling fresh outside air down through the coolers while injecting the airstream with micron-sized water droplets to cool cow environment and increase body surface water evaporation directly from the surface of the cow. This system is also computer operated and is programmed to increase cooling as ambient temperature increases. The KK system can operate based on the actual environment ambient temperature or on a max-cool setting to cool for one degree above the ambient temperature per max-cool setting (Table 2).

***Ambient temperature (AT), RR, ST, BCS and BW***

Throughout both trials, daily and hourly environmental data were obtained from the Arizona Meteorological Network (**AZMET**) weather station located ~ 1 mile from the experimental site (Figures 1, 2). Figure 3 shows the average THI by week for the experimental period (06/03/04 to 09/30/04) and an average of the past 6 summers collected over the same time period. Interestingly, the THI average for the past 6 years (1998 to 2003) was higher ($P < 0.05$) compared to THI over the same time period (06/03/04 to 09/30/04) of the 2004 trial reported in this paper. Thus, on average this study was conducted under cooler conditions than is typical for this area. Surface temperature and RR, from 40 multiparous and 10 primiparous (20%) cows were taken randomly from 5 zones within pen, every Thursday at 1200 and 2000 h. Surface temperature and RR during the CBT trial were taken at 0400, 1200 and 2000 h for each of the sub set of 12 multiparous cows (6/treatment) used in the 4 day CBT trial. All ST measurements were taken with a Raynger®MX™ model RayMX4PU infrared temperature gun (Raytek C., Santa Cruz, CA). The ST measurement was taken from the left side of the cow in the thurl region just cranial of the pin bone. Measurements were taken with the gun ~4 to 6 ft away from the surface of the cow. Respiration rate was determined by counting flank movements over a 10 second interval and multiplying by 6 to establish breaths per minute. Cows were scored for body condition at freshening and at 28 d intervals and BW was collected from 20 multiparous and 20 primiparous cows monthly.

***Milk yield, milk composition, dry matter intake (DMI), Reproduction and Herd Health***

Daily milk weights were measured electronically by Boumatic computer software (Madison, WI) for each cow's milking throughout the 17 week study. Monthly milk composition analysis and SCC was conducted at Arizona DHIA Tempe, AZ. Pen DMI was monitored daily and recorded using PROFEED2000® (Tempe, AZ) feed management software. Milk yield was recorded at each milking and transferred to daily milk yield data and then collapsed into weekly averages for statistical analyses. In order to have a weekly mean, an animal must have greater than four daily milk weights for the week. Otherwise, the weekly means were considered to be missing data. Reproductive measurements and herd health information normally monitored at Stotz dairy were collected and evaluated. The reproductive measurements were: 1) % pregnant within 65 days of the voluntary waiting period (VWP), 2) % cows open within 65 d VWP, 3) cows not yet diagnosed as pregnant; 4) average DIM at pregnancy. The herd health measurements were classified as cows that went to the hospital for: 1) mastitis, 2) digestive disorders, 3) respiratory, 4) lame/injury, 5) reproductive and 6) other.

***Statistics***

Data were analyzed using PROC MIXED procedures of SAS (SAS Institute, Inc, Cary, NC). Previous 305 day mature equivalent milk yields were included as a covariate in the analysis for multiparous cows. Dependent variables tested were milk yield, milk fat, protein, SCC and ST, RR, CBT, BCS, BW, water and electrical usage. Independent variables included treatment, parity, time and respective interactions. The level of significance was set at $P < 0.05$ for all main effects and interactions.

## RESULTS

Average daily milk production did not differ ($P = 0.15$) for multiparous cows housed in ADS-ST or KK (91.2 vs. 93.0, lbs/d Figure 4) pens. However, average daily milk yield for primiparous cows housed in the KK pen (83.4 lbs/d) tended ($P = 0.09$) to be higher than the ADS-ST pen (81.0 lbs/d; Figure 4). Weekly DMI were similar between the two pens (Figure 5) and there was no difference ($P = 0.45$) in BW change between multiparous cows (-3 vs. + 12 pounds) in the ADS-ST or KK pens respectively. However, primiparous cows housed in ADS-ST pens gained less BW (19 vs. 88 lbs, $P < 0.01$) than those housed in KK pens (Table 3). Multiparous cows housed in ADS-ST pens had a higher RR (60.5 vs. 58.3 breathes/minute, $P < 0.01$) compared to multiparous cows in KK cooled pens. However, RR (59.3 vs. 58.6 breathes/minute) in primiparous cows housed in ADS-ST or KK pens were not different ($P = 0.15$). There was no difference in body surface temperature for multiparous (90.0 vs. 89.8 ˆF; $P = 0.35$) or primiparous (90.1 vs. 90.2 ˆF; $P = 0.81$) cows housed in ADS-ST or KK pens, respectively (Table 3).

Milk fat percentage, SCC and BCS were not different between treatments ($P > 0.05$) regardless of parity. Although protein percentage was not different between multiparous cows housed in ADS-ST or KK (2.86 vs. 2.86%) pens, primiparous cows in the ADS-ST pen had higher ($P = 0.02$) percentages of protein compared to those housed in the KK pen (2.84 vs. 2.77%; Table 3). The percentage of cows pregnant within 65 days of their VWP for ADS-ST and KK was 40.3 and 44.3% and average DIM at pregnant was 122 for ADS-ST and 129 for the KK pen respectively. Approximately 3.0% of cows had not been checked for pregnancy by the end of the study (Table 4). One hundred seventeen cows (47%) from the ADS-ST and 113 (45%) from the KK treatment visited the hospital during the 17 week study. Mastitis was the number one reason for going to the hospital for both ADS-ST (88/117) and KK (72/113) cows. Of the remaining ADS-ST cows that went to the hospital, 15, 6, 5, 2 and 1 went for lame/injury, digestive, respiratory, cancer or reproductive disorders respectively. Of the remaining KK cows that went to the hospital, 15, 14 and 12 went for digestive, respiratory and lame/injury disorders respectively (Table 5). Fourteen animals housed in the ADS-ST pen left the herd during the 17 week study. Twelve were sold, 6 were lame, 4 had mastitis and 1 had cancer. Two animals died, both were downers (Table 5). Twenty animals housed in the KK pen left the herd during the 17 week study. Twelve were sold, 6 for digestive reasons, 5 were lame and 1 had mastitis. Eight animals died, 3 from pneumonia, 3 were downers, 1 from mastitis and 1 had cancer (Table 5).

The average outside ambient temperature during the four day CBT trial was 81.8 ˆF (ranging from 68 to 94) and the THI averaged 85 (ranging from 70 to 97). Although it was not extremely hot, the THI was only below 72 for 4 hours per day, indicating at least 20 h/day of mild to moderate heat stress (Figure 6). There was no difference ($P = 0.47$) in mean core (vaginal) body temperature between the 2 groups (6/treatment) of multiparous cows used in the switch back design trial between 08/24/04 and 08/28/04 (Figure 6). During the time spent in the ADS-ST or KK pens cows had an average CBT of 102.2 and 102.1 ˆF. The mean RR (61.4 vs. 62.5 breathes/minute) and ST (91.0 vs. 90.3 ˆF) of cows in the ADS-ST and KK pens were not different ($P = 0.83$ and $P = 0.20$; Table 6). However, there was an effect of time; both groups had the highest ($P = 0.02$) RR at 1200 h (66.7) followed by 2000 h (63.4) and then 0400 h (50.2 breathes/minute). Surface temperatures were also highest ($P = 0.02$) at 1200 h (91.6) followed by 2000 h (90.5) and then 0400 h (89.8ˆF; Table 7). Specifically, the ADS-ST and KK pen of cows had mean RR over the 3 time periods collected of 67.6 vs. 65.9, 61.9 vs. 64.8, and 50.6 vs. 50.0 breathes/minute at 1200, 2000 and 0400 h respectively. Surface temperature for the ADS-ST and KK pen of cows over the 3 time periods collected were 92.3 vs. 90.5, 90.7 vs. 89.6, and 90.9 vs. 90.5 ˆF at 1200, 2000 and 0400 h respectively (Table 7).

The initial investment for the ADS-Shade Tracked system used in this study was $58,500 ($234/cow) compared to $118,067 ($472/cow; [which included $90/cow for curtains]) for the Korral Kool system. The ADS-ST cooling system used less ($P < 0.01$) electricity (526 vs. 723 kwh/day) and water (76.9 vs. 80.6 gallons/day) than the KK coolers. The daily cost of electricity ($0.0446/Kw hour) for the ADS-ST and KK system was $23.42 vs. $32.33 respectively. The daily cost of water ($0.05/gallon) for the ADS-ST and KK was $3.84 vs. $4.03 respectively. The variable cost of the ADS-ST system was $27.30 and the KK system was $33.36/day. The cost per cow for the ADS-ST and KK systems was $0.11 and $0.15 respectively, and per hundred pounds of milk the costs were $0.10 and $0.14 for ADS-ST and KK coolers (Table 8). Lifespan, depreciation or amortization factors were not measured in this experiment.

## SUMMARY

Average daily milk production for multiparous cows housed in ADS-ST compared to KK did not differ. However, milk yield for primiparous cows housed in the KK pen tended to be higher compared to primiparous cows housed in the ADS-ST pen. Weekly DMI were similar between the two pens. Multiparous cows housed in ADS-ST pens had a higher RR compared to multiparous cows in KK cooled pens, however, RR in primiparous cows housed in ADS-ST or KK pens and body surface temperature for multiparous and primiparous were similar. Reproductive, herd health and reasons for leaving the herds did not appear to be different between groups. There was no difference in mean CBT, RR or ST between the 2 groups of multiparous cows used in the switch back design trial. However, there was an effect of time; both groups had the highest RR and ST at 1200 followed by 2000 and then 0400 h. The initial investment for the ADS-Shade Tracker system used in this study was lower compared to the Korral Kool system. The ADS-ST cooling system used less electricity and water than the KK coolers and variable costs per cow and per hundred pounds of milk for ADS-ST was lower than the KK coolers.


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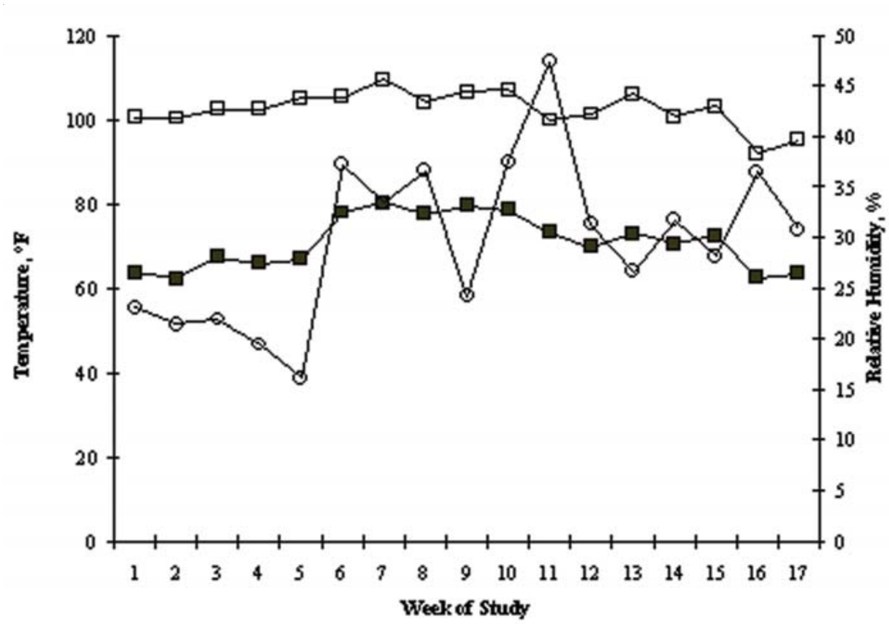


**Figure 1.** Temporal pattern of environmental conditions for the duration of the study. Temperature and humidity data used to calculated the temperature-humidity indexes were obtained from the Arizona Meteorological Network weather station approximately 1 mile from the experimental site.

Key: □ = Maximum Ambient Temperature, ■ = Minimum Ambient Temperature, ○ = Average Daily Relative Humidity

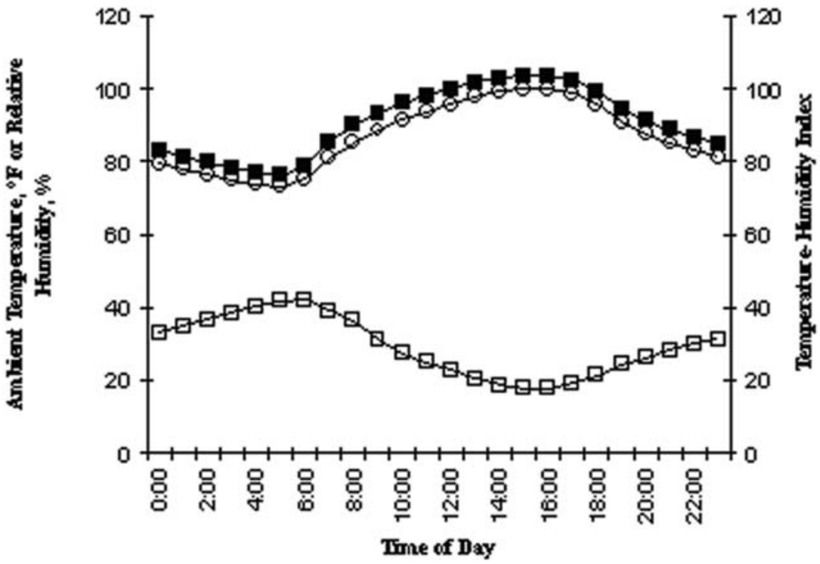


**Figure 2** Average diurnal patterns for ambient temperature, relative humidity, and temperature-humidity index during the experimental period of June 3, 2004 to September 30, 2004. Temperature and humidity data used to calculate the temperature-humidity indexes were obtained from the Arizona Meteorological Network weather station approximately 1 mile from the experimental site.

Key: ○ = Ambient Temperature, □ = Relative Humidity, ■ = Temperature Humidity Index.

—— Line represents 72 THI.

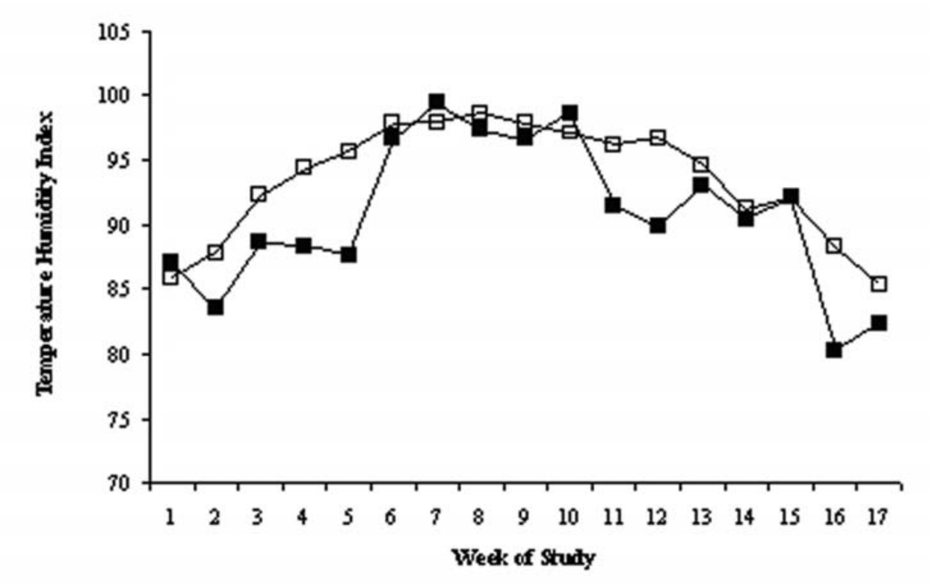


**Figure 3** Average diurnal patterns temperature-humidity index during the experimental period (06/03/04 to 09/30/04) and the average temperature for the same time period from 1998 to 2003. Temperature and humidity data used to calculated the temperature-humidity indexes were obtained from the Arizona Meteorological Network weather station approximately 1 mile from the experimental site.

Key: □ = Temperature Humidity Index 1998-2003, ■ = Temperature Humidity Index 2004.

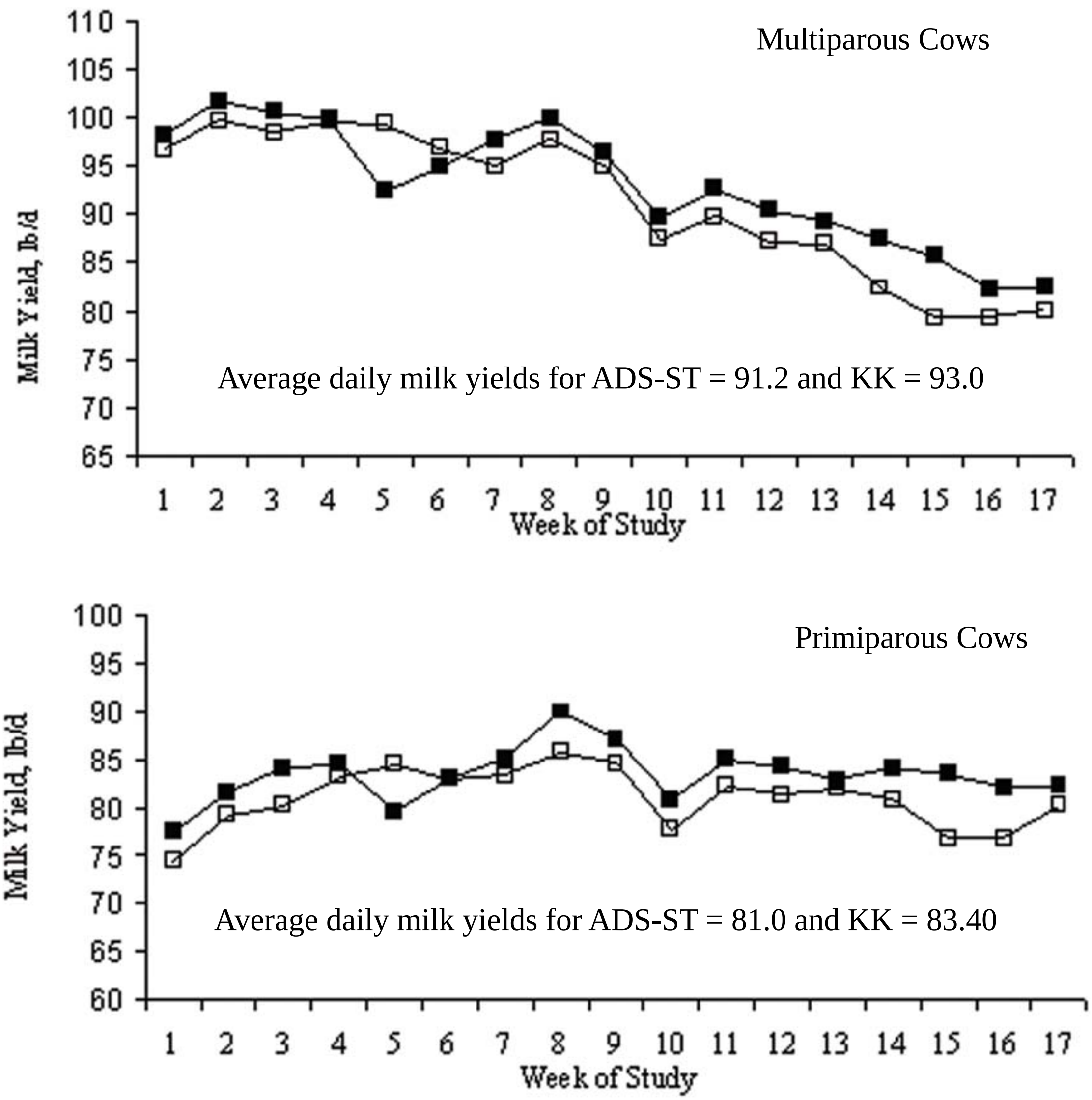


**Figure 4.** Temporal pattern of milk yield in primiparous and multiparous cows cooled with ADS-ST or KK.

Key: □ = ADS-ST, ■ = KK

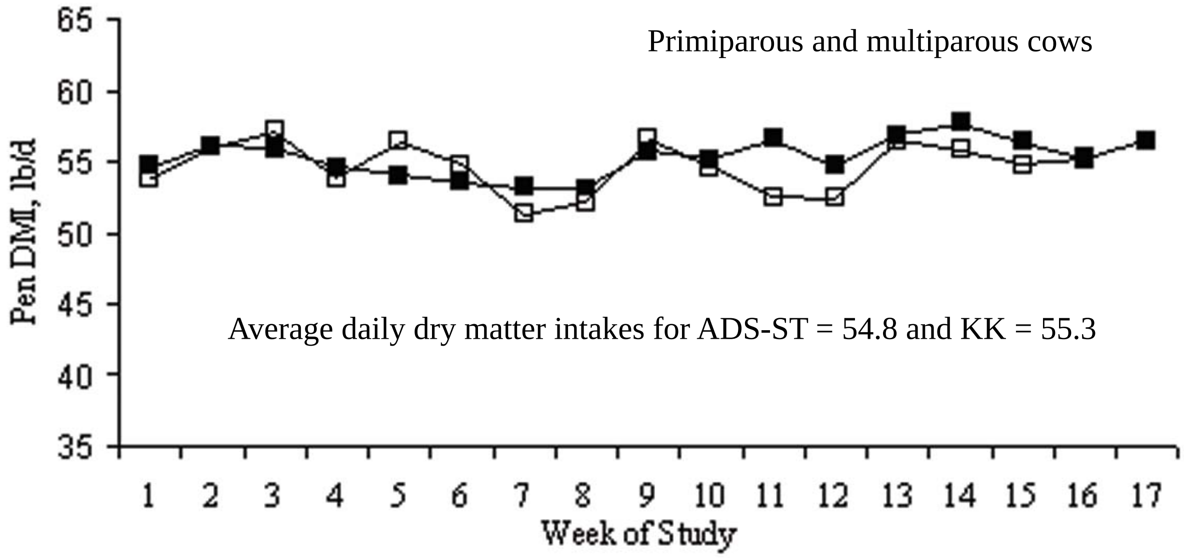


**Figure 5**. Temporal pattern of dry matter intake in cows cooled with ADS-ST or KK.
Key: □ = ADS-ST, ■ = KK

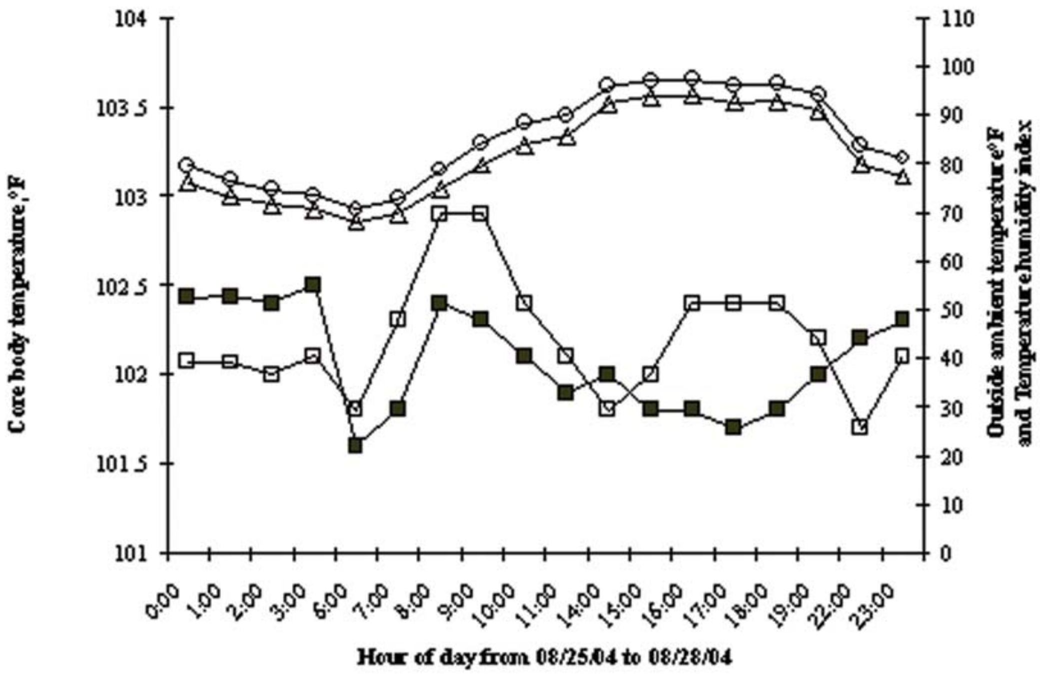


**Figure 6**. Vaginal body temperature of cows cooled with ADS-ST or KK, outside ambient temperature, and THI (minus milking times) during the CBT trial from 08/25/04 to 08/28/04. Temperature data were obtained from the Arizona Meteorological Network weather station approximately 1 mile from the experimental site.

Key: □ = ADS-ST, ■ = KK, △ = Outside ambient temperature, ○ = Temperature humidity index

Table 1. Composition of the total mixed ration fed during the experimental period.[1]

| Ingredient | % DM |
|---|---|
| Alfalfa Hay | 25.0 |
| Alfalfa Greenchop | 14.8 |
| Soybean Meal | 3.3 |
| Corn Silage | 12.2 |
| Molasses | 2.8 |
| Tallow | 0.9 |
| EnerG II | 2.0 |
| Whole Cottonseed | 4.8 |
| Barley | 31.5 |
| Protein mineral buffer vitamin premix | 2.7 |
| | |
| Nutrition Composition | |
| Dry Matter, % | 53.9 |
| Crude Protein, % | 16.6 |
| RUP, % of Crude Protein | 30.1 |
| NEL, Mcal/lb | 0.9 |
| NDF, % | 27.3 |
| ADF, % | 17.6 |
| Fat, % | 5.8 |
| NFC, % | 40.5 |

[1]Vitamin and mineral mix formulated to meet or exceed NRC, 2001 requirements.

**Table 2.** System parameters for each of the evaporative cooling systems

| Variable | ADS-ST | KK |
| --- | --- | --- |
| Size of Fan (inches) | 36.0 | 60.0 |
| Fan Motor (Hp) | 2.0[1] | 3.0 |
| Water Pump Motor (Hp) | 10.0[2] | 5.0[3] |
| Gear Motor[1] (Hp) | 0.5 | N/A |
| Mean On/Off Temperature (°F) | 80.0/80.0 | 82.0/80.0 |
| Mean Cooler Settings | Automatic adjustment by the system based on temperature and humidity | Automatic adjustment by the system based on temperature and humidity |

ADS-ST = Advanced Dairy Systems Shade Tracker Cooling System, KK = Korral Kool Cooling System, [1]Programmed to run at 70% capacity, [2]Variable frequency drive pump ranges from 1.5 to 7.5 Hp, [3]The control module contains two 5.0 Hp motors that pump water to the coolers.

**Table 3**. Summary of the milk yield, percentage of milk fat and protein, SCC, ST, RR, BCS, and BW change in primiparous and multiparous cows cooled with ADS-ST or KK evaporative cooling systems.

| | Primiparous | | | | Multiparous | | | |
|---|---|---|---|---|---|---|---|---|
| Item | ADS-ST | KK | SEM | P | ADS-ST | KK | SEM | P |
| Milk yield, lb/d | 81.0 | 83.4 | 1.4 | 0.09 | 91.2 | 93.0 | 1.3 | 0.15 |
| Milk fat, % | 3.59 | 3.71 | 0.09 | 0.19 | 3.64 | 3.65 | 0.05 | 0.84 |
| Milk protein, % | 2.84 | 2.77 | 0.03 | 0.02 | 2.86 | 2.86 | 0.02 | 0.99 |
| Somatic Cells X 1,000 | 211 | 215 | 80 | 0.95 | 570 | 448 | 80 | 0.13 |
| ST, ºF | 90.1 | 90.2 | 0.2 | 0.81 | 90.0 | 89.9 | 0.1 | 0.35 |
| RR, breaths/min | 59.7 | 58.6 | 0.8 | 0.15 | 60.5 | 58.3 | 0.5 | <0.01 |
| Body Condition Score | 3.53 | 3.51 | 0.02 | 0.38 | 3.61 | 3.65 | 56 | 0.48 |
| BW change, lbs | 19.0 | 87.8 | 24 | <0.01 | -3.0 | 12.5 | 21 | 0.45 |

ADS-ST = Advanced Dairy Systems Shade Tracker Cooling System, KK = Korral Kool Cooling System.

**Table 4**. Summary of the reproductive, herd health and culling parameters of cows cooled with ADS-ST or KK evaporative cooling systems.

| | All Cows | |
|---|---|---|
| Item | ADS-ST | KK |
| % Pregnant @ VWP + 65d[1] | 40.33 | 44.34 |
| % Open @ VWP + 65d | 57.14 | 52.17 |
| % Not diagnosed[2] | 2.52 | 3.47 |
| Average DIM | 122.43 | 129.44 |

ADS-ST = Advanced Dairy Systems Shade Tracker Cooling System. KK = Korral Kool Cooling System. [1]VWP = Voluntary waiting period, [2]As of September 30th

**Table 5**. Summary of the reproductive, herd health and culling parameters of cows cooled with ADS-ST or KK evaporative cooling systems.

| | All Cows | | | | | |
|---|---|---|---|---|---|---|
| | Visited hospital | | Left herd[1] | | Died[2] | |
| Disorder | ADS-ST | KK | ADS-ST | KK | ADS-ST | KK |
| Mastitis | 88 | 72 | 4 | 2 | - | 1 |
| Digestive | 6 | 15 | - | 6 | - | - |
| Respiratory | 5 | 14 | - | 3 | - | 3 |
| Lame/Injury | 15 | 12 | 8 | 8 | 2[4] | 3[4] |
| Reproductive | 1 | - | - | - | - | - |
| Other | 2 | - | 2[3] | 1[3] | - | 1[3] |

ADS-ST = Advanced Dairy Systems Shade Tracker Cooling System, KK = Korral Kool Cooling System, [1]Number of cows (ADS = 7, KK = 20) that left the herd from 06/03/04 to 09/30/04, [2]Number of cows (ADS = 2, KK = 8) that died from June 06/03/04 to 09/30/04, [3]Cancer, [4]Downer.

**Table 6**. Summary of the CBT, ST, RR, in multiparous cows cooled with ADS-ST or KK evaporative cooling systems from 08/25/04 to 08/28/04.

| | Multiparous | | | |
|---|---|---|---|---|
| Item | ADS-ST | KK | SEM | P |
| Mean CBT, ?F | 102.2 | 102.1 | 1.3 | 0.47 |
| Mean ST, ?F | 91.0 | 90.3 | 0.1 | 0.83 |
| RR, breaths/min | 61.4 | 62.5 | 0.5 | 0.20 |

ADS-ST = Advanced Dairy Systems Shade Tracker Cooling System, KK = Korral Kool Cooling System

**Table 7**. Summary by time of the CBT, ST, RR, in multiparous cows cooled with ADS-ST or KK evaporative cooling systems from 08/25/04 to 08/28/04.

| | Multiparous | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ADS-ST | | | KK | | | | |
| Hourly measurements | 1200 | 2000 | 0400 | 1200 | 2000 | 0400 | SEM | P |
| CBT, ?F | 102.2 | 102.1 | 102.1 | 102.1 | 101.6 | 102.0 | NA | NA |
| ST, °F | 92.3 | 90.7 | 90.9 | 90.5 | 89.6 | 90.5 | 0.5 | 0.02 |
| RR, breaths/min | 67.6 | 61.9 | 50.6 | 65.9 | 64.8 | 50.0 | 1.9 | <0.01 |

ADS-ST = Advanced Dairy Systems Shade Tracker Cooling System, KK = Korral Kool Cooling System

**Table 8.** Summary of investment and operating costs of ADS-ST and KK systems.[1]

| Variable | ADS-ST | KK | **Difference** |
|---|---|---|---|
| Cooling System Investment, \$[2] | 58,500.00 | 118,067.51 | **\$59,567.51** |
| Cooling System Investment, \$/cow | 234.00 | 472.00 | **\$238.00** |
| Electrical Usage, KWh/d | 526 | 723 | **197** |
| Electrical Cost, \$/d | 23.46 | 32.33 | **\$8.87** |
| Electrical Cost, \$/cow/d | 0.09 | 0.13 | **\$0.04** |
| Water Usage, gal/d | 76.9 | 80.6 | **3.70** |
| Water Cost, \$/d | 3.84 | 4.03 | **\$0.19** |
| Water Cost, \$/cow/d | 0.015 | 0.016 | **\$0.00** |
| Variable Cost, \$/day[3] | 27.30 | 36.36 | **\$9.03** |
| Variable Cost, \$/cow/day | 0.11 | 0.15 | **\$0.04** |
| Variable Cost, \$/cwt/day | 0.10 | 0.14 | **\$0.04** |

ADS-ST = Advanced Dairy Systems Shade Tracker Cooling System, KK = Korral Kool Cooling System, [1]Per day computations were divided by 119 days and per cow computation were divided by 250, [2]Seventeen 36 inch ADS-ST fans and twenty 60 inch KK coolers (curtains included), [3]Water (\$0.05/gallon) and electrical (0.0446/KWh) rates were calculated from Stotz Dairy, Buckeye, AZ.