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Fertility of Male and Female Broiler Breeders Following Exposure to Elevated Ambient Temperatures[1]

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ABSTRACT Because elevated ambient temperatures decrease fertility, this study was designed to segregate the male and female contribution to heat stress infertility in broiler breeders. Eighty hens and 16 roosters at 21 wk of age were divided equally among two heat stress (S) and two control (C) temperature chambers. For a 10-wk pretreatment period, all birds were maintained at an ambient temperature of 21.1 C and 40% relative humidity. Following the pretreatment period, birds in the S chambers were acclimated for 1 wk at a constant temperature of 29.4 C after which the temperature in the S chambers was increased to 32.2 C for 8 wk. The temperature in the two C chambers was maintained at 21.1 C. Hens in each chamber were artificially inseminated on a weekly basis with 5×10^7 sperm per 50 μL from either C or S males.

Egg production, semen volume, spermatocrit, and percentage dead sperm were similar during the acclimation period, even though body temperature was significantly elevated in S birds (41.8 vs 41.3 C). Sperm penetration of the perivitelline layer overlying the germinal disc (GD) was decreased in eggs from hens inseminated with semen from S males compared to eggs from hens inseminated with semen from C males (9.5 vs 23.4 sperm per GD). Following the acclimation period, body temperature remained elevated in the S birds compared to the C birds (42.2 vs 41.3 C). Also, egg production was depressed in the S vs C hens (55.8 vs 82.9%). Semen volume, spermatocrit, and percentage dead sperm were not affected by S treatment. However, when hens were inseminated with semen from S males, sperm penetration of the perivitelline layer overlying the GD and egg fertility were decreased compared to hens inseminated with semen from C males (5.4 vs 14.9 sperm per GD, 45.5 vs 73.8% fertility). In conclusion, the male bird appears to contribute more to heat stress infertility than the female.

(*Key words*: sperm-egg penetration, fertility, heat stress, broiler breeder, chicken)

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INTRODUCTION

Elevated ambient temperatures during the summer months greatly decrease fertility in broiler breeder flocks. Keirs (1982) estimated that egg fertility declines, on average, 15% during the months of July, August, and September. According to USDA Agricultural Statistics (1991), over six billion broiler chicks were produced in the U.S. Considering summer as one-fourth of yearly production, this 15% decline in fertility results in an annual loss of 279 million broiler chicks (at 19.5¢ each) for the U.S. If this 15% reduction in fertility were regained, the U.S. poultry industry would realize a $54 million increase in income.

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Research concerning the effects of heat stressing sexually mature broiler breeders on fertility and hatchability is practically nonexistent, whereas such research has been conducted on various other breeds of chickens. In White Leghorns, Heywang (1944) determined that during the summer months both fertility and hatchability declined approximately 5, 10, and 20%, when the average maximum temperature was 36.4, 38.8, or 41.6 C, respectively. Wilson (1949) found that heat stressing hens for only 1 wk at 26.7, 32.2, or 37.8 C did not alter fertility in White Leghorns, New Hampshires, and Rhode Island Reds. Clark and Sarakoon (1967) noted a 13% reduction in fertility when White Leghorn hens were subjected to diurnally fluctuating temperatures of 21 to 38 C. Most recently, Muiruri and Harrison (1991), using White Plymouth Rocks, concluded that 35 C for 3 wk did not reduce fertility but did significantly decrease hatchability by approximately 10%.

There is some debate concerning the effect of elevated ambient temperatures on avian male reproductive performance (for review see Edens, 1983). Parker and McSpadden (1943) noted that semen production decreased during the summer months. Joshi *et al.* (1980) determined that White Leghorn roosters exposed to 32 C for 40 d produced a decreased volume of semen, sperm concentration, number of live sperm, number of normal sperm, and sperm motility when compared with roosters maintained at 17 C. In contrast, Clark and Sarakoon (1967) found no reduction in semen volume, sperm quantity, or sperm quality of White Leghorns subjected to fluctuating ambient temperatures of 21 to 38 C.

The objective of the present study was to isolate the contributions of the male and female broiler breeder to heat stress infertility. Candling fertility and *in vivo* sperm-egg penetration were used to estimate fertility.

MATERIALS AND METHODS

Housing and Environment

On September 7, Eighty Arbor Acres broiler breeder hens (21 wk old) and 16 Peterson broiler breeder roosters (21 wk old) were housed. Twenty hens and four roosters were caged individually in each of four controlled temperature rooms. Two rooms were used for each of two temperature treatments (21.1 and 32.2 C). The birds were placed on a restricted diet of 430 kcal ME per bird per d and maintained on 16 h of light/d (0400 to 2000 h). The birds were allowed a pretreatment period of 10 wk to adjust to caging and the new environment of 21.1 C. After this 10-wk pretreatment period, a 1-wk acclimation period was conducted in which the temperature remained 21.1 C (control, C) in two rooms, but was elevated to 29.4 C (acclimating heat stress) in the remaining two rooms. Following the acclimation period, an 8-wk heat stress (S) treatment period was conducted by increasing the temperature in the two acclimating S rooms to 32.2 C. Relative humidity remained at 40% in both C and S rooms throughout the study.

Artificial Insemination

Artificial insemination was performed to create a 2 × 2 factorial arrangement with two main effects of male (C and S) and female (C and S). Hens in each room were divided equally into two groups, with one group inseminated with semen from S males and the other with semen from C males, creating four insemination treatment groups as follows: 1) C hens inseminated by C roosters; 2) S hens inseminated by C roosters; 3) C hens inseminated by S roosters; and 4) S hens inseminated by S roosters. By using two chambers for each temperature, each insemination treatment group was replicated in each one of the S chambers or in each one of the C chambers. Semen was collected from the C and S males using the abdominal massage method of Burrows and Quinn (1937). The sperm concentration in each sample was determined by sperm packed cell volume (PCV, Maeza and Buss, 1976). Semen samples were diluted with minimum essential medium (Howarth, 1981) to a concentration of 5×10^7 sperm per 50 μL. Hens were inseminated with 50 million sperm once every week of the study at 1400 h.

Variables Measured During the Acclimation Period

Rectal body temperature was measured daily using a Cole-Parmer thermistor thermometer Model 8402 and a YSI thermistor

probe 403 inserted 6 cm into the rectum.[3] Before feeding, body temperature was determined at 0800 h. Feed consumption, egg production, and mortality were determined at the end of the acclimation period. Eggs were collected twice daily at 1100 and 1700 h.

Semen volume, sperm concentration, and percentage dead sperm were quantified on Monday, Wednesday, and Friday. Sperm concentration was obtained by measuring the PCV of the semen samples. Viability of sperm was determined using the fluorometric method of Bilgili and Renden (1984), a technique that measures the fluorescence emitted by DNA-bound ethidium bromide. The intact plasma membrane of a viable spermatozoon excludes ethidium bromide, whereas the disrupted plasma membrane of a nonviable spermatozoon allows entry of ethidium bromide into the cell.

In vivo sperm-egg penetration was monitored in each egg laid postinsemination. The method used to determine sperm-egg penetration was that of Bramwell *et al.* (1992). The perivitelline layer from oviposited eggs was removed, fixed with 20% formalin, and stained with Schiff's reagent. The number of sperm penetration holes were counted in a 1.35 mm^2 area surrounding the germinal disc.

Variables Measured During the Treatment Period

Rectal body temperature, feed consumption, egg production, mortality, semen volume, sperm concentration, and percentage dead sperm were measured on a weekly basis. *In vivo* sperm-egg penetration was measured in each egg laid postinsemination during Weeks 1, 5, and 7. Candling fertility, as determined at 10 d of incubation, and hatchability of all fertile eggs was monitored during Weeks 2, 4, 6, and 8 of the study. All unhatched eggs were opened to determine true fertility. Prior to incubation, hatching eggs were stored in a cooler at 13.3 C and set on a weekly basis.

[3]Cole-Parmer, Niles, IL 60714-9930.

Statistical Analysis

Acclimation Period. To analyze rectal body temperature, an ANOVA with a 2 × 2 factorial arrangement [temperature (C and S) and sex (male and female) as main effects] with a split-plot in time (day of treatment) was utilized. A completely randomized design was used to determine the effects of heat stress on feed consumption and egg production. An ANOVA with a split-plot in time (day of treatment) was used to analyze semen characteristics. Sperm-egg penetration data were subjected to an ANOVA with a 2 × 2 factorial arrangement [male (C and S) and female (C and S) as main effects] with a split-plot in time (day postinsemination).

Treatment Period. An ANOVA with a 2 × 2 factorial arrangement and a split-plot in time (week of treatment) was used to analyze rectal body temperature. Feed consumption, egg production, and semen data were subjected to an ANOVA with a split-plot in time (week of treatment). An ANOVA with a 2 × 2 factorial arrangement and a split-split-plot in time (week of treatment and day postinsemination) was used to analyze sperm-egg penetration, fertility, and hatchability.

Room served as the experimental unit for rectal body temperature, feed consumption, egg production, and semen data analyses. Insemination group within a room was the experimental unit for sperm-egg penetration, fertility, and hatchability analyses. Arc sine square root of the percentage transformation was used to obtain homogeneous variances for percentage data (Steel and Torrie, 1980). However, statistical patterns were similar for transformed and untransformed data.

The relationship between sperm-egg penetration and fertility was determined by correlating the replicate means of each insemination treatment group. The correlation of rectal body temperature with sperm-egg penetration and fertility was also determined. Control and S week means were used as separate points in the analysis.

RESULTS

Acclimation Period

As shown in Table 1, an ambient temperature of 29.4 C for 1 wk elevated body temperature .5 C. The main effect for sex

TABLE 1. Effects of an ambient temperature of 29.4 C for 1 wk on body temperature, feed consumption, and egg production

Treatment	Rectal body temperature[1]	Feed consumption		Hen-day egg production[3]
		Male[2]	Female[3]	
	(C)	(g/bird/d)		(%)
Control	41.30	147.0	140.0	84.0
Heat stress	41.80	147.0	130.0	85.0
SEM	.05	. . .	1.3	1.1
$P<$	.02	. . .	.03	.5

[1]Values represent the replicate means of the 1st through the 7th d of treatment of two replicates with 20 hens each and two replicates with four roosters each per treatment per day (n = 28).

[2]The male birds consumed all the feed that they were given.

[3]Values represent the replicate means of two replicates with 20 hens each per treatment (n = 2).

indicated that both sexes had similar body temperatures (male = 41.55 C, female = 41.54 C; $P < .97$). A treatment by sex by day interaction ($P < .045$) was noted. On Day 1 of the acclimation period, body temperatures of stress males were elevated 1.1 C over those of C males (42.48 vs 41.38), whereas the body temperatures of S females were only elevated .66 C over those of C females (41.87 vs 41.21). Even though body temperature was increased in the S birds, there was no mortality during the acclimation period.

Male feed consumption was unaffected by treatment, in that the roosters consumed all the feed they were given (Table 1). However, female feed consumption was reduced 7% (10 g per bird per d) when the hens were subjected to 29.4 C. This decrease in feed consumption, however, did not affect egg production.

TABLE 2. Effects of an ambient temperature of 29.4 C for 1 wk on semen characteristics[1]

Treatment	Semen volume	Sperm packed cell volume	Dead sperm
	(mL)	(%)	
Control	.53	16.4	10
Heat stress	.56	15.6	9
SEM	.04	.6	3
$P<$	.6	.4	.9

[1]Values represent the replicate means for 3 d of semen collection from two replicates with four roosters each per treatment per day (n = 6).

All of the semen characteristics measured appeared to be unaffected by heat stressing the male broiler breeder (Table 2). However when semen from S males was used to inseminate hens, sperm-egg penetration was decreased compared with insemination with semen from C males (Figure 1). Heat stressing the female broiler breeder did not decrease sperm-egg penetration ($P < .5$). The male by female interaction was not significant ($P < .85$) for sperm-egg penetration.

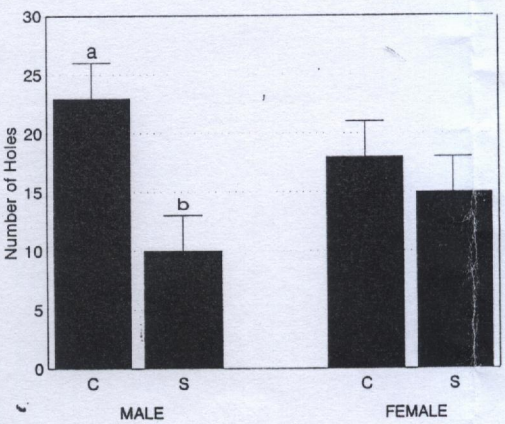

FIGURE 1. Sperm-egg penetration in eggs laid during the acclimation period when males or females were maintained under control (C) or heat stress (S) temperatures. Values are expressed as mean ± SEM. Bars that have different letters are significantly different ($P < .04$). Values represent the replicate means of the 2nd through the 8th d postinsemination of four replicates of 10 hens each (n = 28).

A significant male by day postinsemination interaction was detected for sperm-egg penetration, as illustrated in Figure 2. When C male semen was used to inseminate hens, a linear relationship existed in the number of sperm penetration holes from eggs laid each day postinsemination. When S male semen was used to inseminate hens, a quadratic relationship was detected in sperm penetration holes from eggs laid each day postinsemination. On Day 2 postinsemination, approximately 50% less sperm penetrated the perivitelline layer of the egg when semen from S males was used to inseminate hens than when insemination occurred with semen from C males. This difference in sperm-egg penetration between the two male treatment groups decreased with increasing time postinsemination.

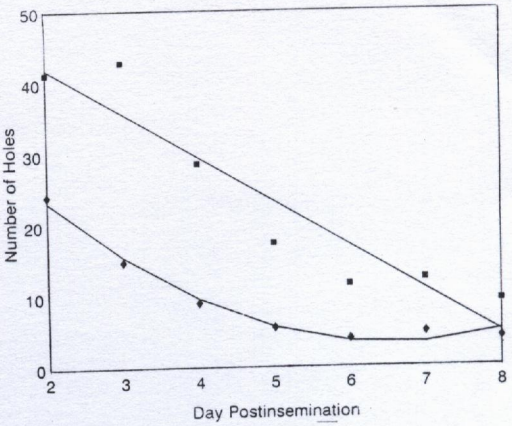

FIGURE 2. Sperm-egg penetration in eggs laid each day postinsemination during the acclimation period when semen from control (■) or heat-stressed (♦) males was used for insemination (male treatment group by day postinsemination interaction, $P < .04$). For control males, a linear relationship was detected between sperm-egg penetration and day postinsemination ($y = 54 - 6.2x$, $r^2 = .89$, $P < .002$). For heat-stressed males a quadratic relationship was detected between sperm-egg penetration and day postinsemination ($y = 45 - 13x + .9x^2$, $r^2 = .99$, $P < .0002$). Values represent the replicate means of four replicates of 10 hens each (n = 4).

Treatment Period

Heat stressing at 32.2 C for 8 wk increased body temperature .91 C compared with body temperature of birds in the C environment (Table 3). Male and female birds had similar body temperatures (41.70 vs 41.73 C, $P < .86$). A temperature by week of treatment interaction indicated a linear relationship between body temperature and week of treatment for birds at 32.2 C (Figure 3). In the S birds, body temperature increased with increasing length of S treatment. In contrast, for the C birds body temperature was similar throughout the experiment.

In addition, male feed consumption was not affected by S treatment (Table 3). Female feed consumption was reduced 22% (32 g per bird per d) when the hens were heat stressed. Possibly due to the decrease in feed consumption, S hens laid fewer eggs than hens not heat stressed. Egg production

TABLE 3. Effects of an ambient temperature of 32.2 C for 8 wk on body temperature, feed consumption, egg production, and mortality

Treatment	Rectal body temperature[1]	Feed consumption		Hen-day egg production[3]	Weekly hen mortality[3]
		Male[2]	Female[3]		
	(C)	(g/bird/d)		(%)	
Control	41.26	147	143	83	.3
Heat stress	42.17	138	111	56	3.4
SEM	.03	4	1	3	.2
$P<$	.002	.3	.004	.02	.01

[1]Values represent the replicate means for the 1st through the 8th wk of treatment of two replicates with 20 hens each and two replicates with four roosters each per treatment per week (n = 32).

[2]Values represent the replicate means for the 1st through the 8th wk of treatment of two replicates with four roosters each per treatment per week (n = 16).

[3]Values represent the replicate means for the 1st through the 8th wk of treatment of two replicates with 20 hens each per treatment per week (n = 16).

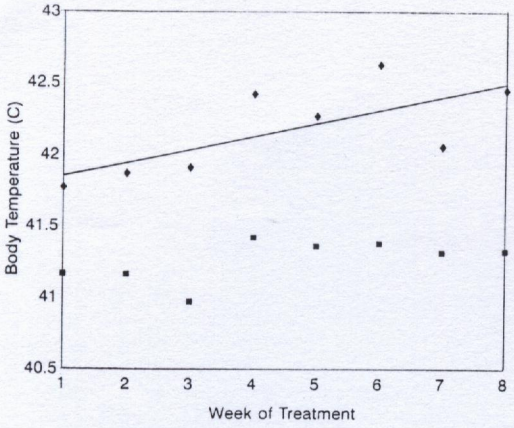

FIGURE 3. Rectal body temperature of control (■) and heat-stressed (♦) birds during each week of the treatment period (treatment by week interaction, $P < .1$). For heat-stressed birds a linear relationship was detected between body temperature and week of treatment ($y = 41.8 + .09x$, $r^2 = .51$, $P < .05$). Values represent the replicate means of two replicates with 20 hens each and two replicates with 4 roosters each per treatment (n = 4).

decreased with increasing time (data not shown, $P < .0008$). Also, weekly hen mortality was elevated in the S hens compared with the C hens. Male mortality was unaffected by treatment. Only one C and two S males died during the treatment period.

Similar to the acclimation period, all of the semen variables measured appeared to be unaffected by heat stressing the male broiler breeder (Table 4). However, when semen from S males was used to inseminate hens, sperm-egg penetration was reduced by 67% (10 holes) compared with sperm-egg penetration by sperm from C males (Figure 4). Sperm-egg penetration was similar between the C and S female treatment groups ($P < .11$). The male by female interaction was not significant ($P < .68$).

As demonstrated in Figure 5, a significant male treatment group by day postinsemination interaction occurred during the treatment period for sperm-egg penetration. A quadratic relationship was seen between sperm-egg penetration and day postinsemination when hens were inseminated with semen from C males. On the other hand, when semen from S males was used for insemination, a linear relationship was detected between sperm-egg penetration and day postinsemination. As was evident during the acclimation period, on Day 2 postinsemination the difference in sperm-egg penetration between the two male treatment groups averaged 25 holes (71%). However with increasing time postinsemination, this difference in sperm egg penetration decreased until Day 5 postinsemination, when the male treatment groups had similar sperm-egg penetration.

A significant male treatment group by week of experiment interaction was also

TABLE 4. Effects of an ambient temperature of 32.2 C for 8 wk on semen characteristics[1]

Treatment	Semen volume	Sperm packed cell volume	Dead sperm
	(mL)	(%)	
Control	.45	15	11
Heat stress	.44	15	13
SEM	.05	1	6
$P<$	.9	.9	.8

[1]Values represent the replicate means for the 1st through the 8th wk of treatment of two replicates with four roosters each per treatment per week (n = 16).

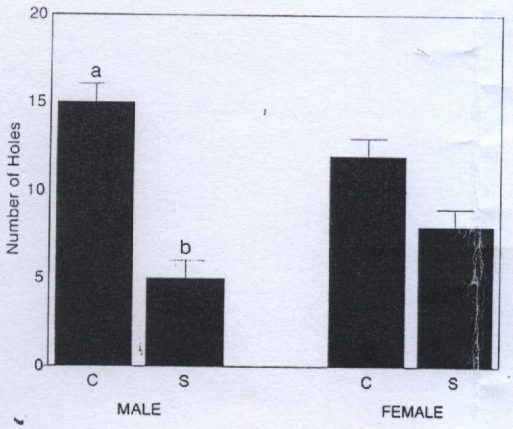

FIGURE 4. Sperm-egg penetration in eggs laid during the treatment period when males or females were maintained under control (C) or heat stress (S) temperatures. Values are expressed as mean ± SEM. Bars that have different letters are significantly different ($P < .007$). Values represent the replicate means of the 1st, 5th, and 7th wk of treatment and the 2nd through the 8th d postinsemination of four replicates with 10 hens each (n = 84).

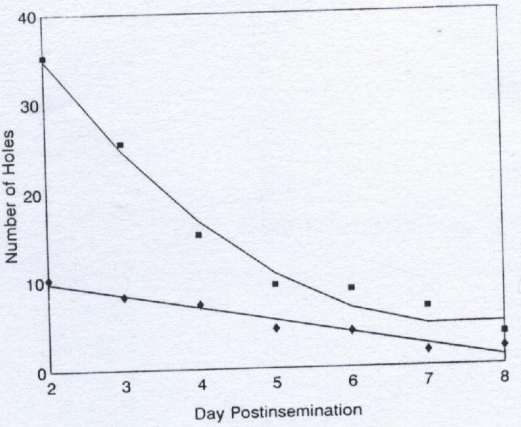

FIGURE 5. Sperm-egg penetration in eggs laid each day postinsemination during the treatment period when semen from control (■) or heat-stressed (♦) males was used for insemination (male treatment group by day postinsemination interaction, $P < .0001$). For control males, a quadratic relationship was detected between sperm-egg penetration and day postinsemination ($y = 61 - 15x + 1x^2$, $r^2 = .98$, $P < .0003$). For heat-stressed males a linear relationship was detected between sperm-egg penetration and day postinsemination ($y = 12.7 - 1.5x$, $r^2 = .96$, $P < .0001$). Values represent the replicate means of the 1st, 5th, and 7th wk of treatment of four replicates with 10 hens each (n = 12).

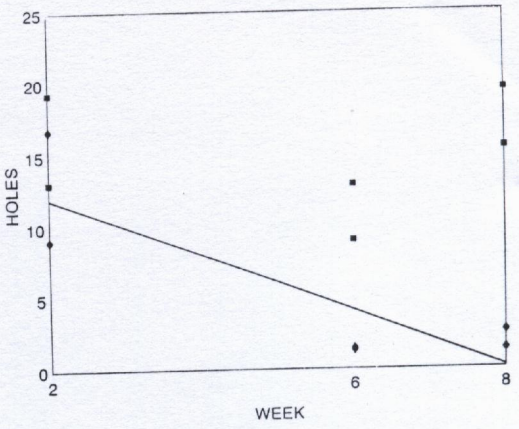

FIGURE 6. Sperm-egg penetration in eggs laid each week of the treatment period when semen from control (■) or heat-stressed (♦) males was used for insemination (male treatment group by week of treatment interaction, $P < .04$). A linear relationship was detected between sperm-egg penetration and week of treatment when semen from heat-stressed males was used for insemination ($y = 16 - 2x$, $r^2 = .73$, $P < .03$). Control and heat-stressed hen means were used as separate points in the analysis. Values represent the replicate means of the 2nd through the 8th d postinsemination of two replicates with 10 hens each (n = 14).

detected in sperm-egg penetration during the treatment period (Figure 6). Sperm-egg penetration declined during each week of treatment when semen from S males was used to inseminate hens. In contrast, sperm-egg penetration was similar for each week of treatment when hens were inseminated with semen from C males. For the S males a linear relationship existed between sperm-egg penetration and week of treatment.

As was expected, candling fertility responded in a manner similar to that of sperm-egg penetration. Indeed, sperm-egg penetration was highly correlated with fertility (Figure 7, $r = .96$, $P < .04$). When semen from S males was used to inseminate hens, fertility was depressed compared to insemination with semen from C males (Figure 8). The difference in fertility between the two female treatment groups was not significant ($P < .2$). Also, the male by female interaction was not significant ($P < .51$). A typical decline in fertility with increasing time postinsemination was observed (data not shown, $P < .0001$). The hatchability of fertile eggs was unaffected

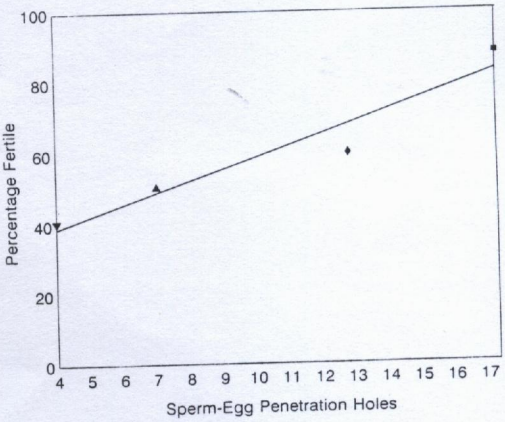

FIGURE 7. Correlation between sperm-egg penetration and candling fertility ($r = .96$, $P < .04$) for control females inseminated by control males (■), stressed females inseminated by control males (♦), control females inseminated by stressed males (▲), and stressed females inseminated by stressed males (▼). Values represent the replicate means over week of treatment and the 2nd through the 8th day postinsemination of two replicates with 10 hens each (n = 42 for sperm-egg penetration and n = 56 for fertility).

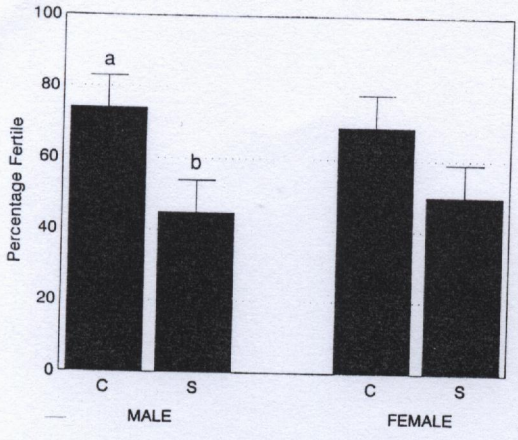

FIGURE 8. Candling fertility in eggs laid during the treatment period when males or females were maintained under control (C) or heat stress (S) temperatures. Values are expressed as mean ± SEM. Bars that have different letters are significantly different ($P < .08$). Values represent the replicate means of the 2nd, 4th, 6th, and 8th wk of treatment and the 2nd through the 8th d postinsemination of four replicates with 10 hens each (n = 112).

by heat stressing the male ($P < .6$) or female ($P < .3$) broiler breeder (Figure 9).

Male body temperature was negatively correlated with sperm-egg penetration and fertility (Figure 10). No relationship was detected between female body temperature and sperm-egg penetration (data not shown, $P < .21$). However, female body temperature was negatively correlated with fertility (data not shown, $r = -.87$, $P < .005$).

DISCUSSION

As in previous work (Ahmad *et al.*, 1967; Harrison and Biellier, 1969; Arad and Marder, 1982), body temperature increased with an increase in ambient temperature. Interestingly in the present study, body temperature of the cock increased more drastically than that of the hen on the 1st d of heat stress. However, this increase in body temperature of the male was not concurrent with a decrease in livability, feed consumption, semen volume, sperm concentration, or percentage of live sperm. Livability, feed consumption, and egg production were decreased when the hen was heat stressed.

Clark and Sarakoon (1967) heat stressed White Leghorns at fluctuating temperatures of 21 to 38 C and, as in the present study, found an increase in hen mortality rather than male mortality. Also, it has been established that elevated ambient

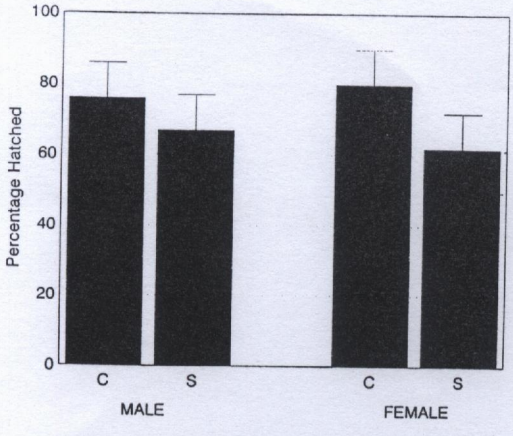

FIGURE 9. Hatchability of fertile eggs laid during the treatment period when males or females were maintained under control (C) or heat stress (S) temperatures. Values are expressed as mean ± SEM. Values represent the replicate means of the 2nd, 4th, 6th, and 8th wk of treatment and the 2nd through the 8th d postinsemination of four replicates with 10 hens each (n = 112).

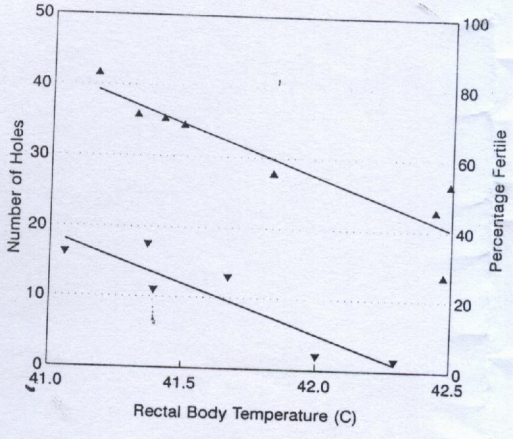

FIGURE 10. Correlation of weekly male body temperature with candling fertility (▲, $r = -.90$, $P < .002$) and sperm-egg penetration (▼, $r = -.91$, $P < .01$). Control and heat-stressed male means were used as separate points in the analysis. Values represent the replicate means of the 2nd through the 8th d postinsemination of four replicates with 10 hens each (n = 28).

temperatures decrease hen feed consumption and egg production (Wilson, 1949; Muiruri and Harrison, 1991).

There is some controversy concerning the influence of heat stress on semen characteristics of birds. Using 60-wk-old White Leghorns, Joshi *et al.* (1980) found that an ambient temperature of 32.2 C for 40 d decreased semen volume, sperm concentration, number of live sperm, number of normal sperm, and motility. However, Clark and Sarakoon (1967) found no detrimental effects on semen characteristics of 34- to 55-wk-old White Leghorn males that were heat stressed at a fluctuating temperature of 21 to 38 C from 19 wk of age onward. The results of the present study are in agreement with those of Clark and Sarakoon. The advanced age of the males heat stressed by Joshi *et al.* (1980) may explain the conflicting results. The older males may be more susceptible to S treatment. Another important difference between the present study and previous studies is that broiler breeder males were used in the current study and not light-weight White Leghorn males.

This study examined the elevated ambient temperature effects on sperm-egg penetration. Bramwell *et al.* (1993) and the present study have demonstrated that sperm-egg penetration is highly correlated with fertility and is an excellent predictor of fertility. Also, Wishart (1987) has shown that the number of spermatozoa trapped on the perivitelline layer is positively correlated with fertility. It appears that a given number of sperm must bind to and penetrate the perivitelline layer before fertilization is successful. Therefore as was found in the current study, any effect on sperm-egg penetration should alter fertility in oviposited eggs. The depression in fertility, when the male bird was heat stressed, was most likely due to fewer sperm penetrating the perivitelline layer overlying the germinal disc.

In the present study, sperm-egg penetration and fertility were more affected by heat stressing the male broiler breeder than by stressing the female. Using White Leghorns, Clark and Sarakoon (1967) reported that female fertility and not male fertility was reduced by heat stressing at a fluctuating ambient temperature of 21 to 38 C. On the other hand, Muiruri and Harrison (1991) noted that 35 C did not alter fertility of White Plymouth Rocks. Perhaps in the lighter breeds of chickens, the mechanisms responsible for heat stress infertility are different.

It is noteworthy that during the acclimation period the birds were only heat stressed for approximately 12 h before semen was collected and used to inseminate hens. Therefore, the results of this acclimation period insemination revealed that sperm-egg penetration was depressed when the male bird was heat stressed for only 12 h at 29.4 C. In the broiler belt of the U.S., it is not uncommon for the environmental temperature to remain above 29.4 C for 12 h during the summer months. Hence, even a temperature as mild as 29.4 C during the daylight hours may decrease broiler breeder fertility. Indeed, Boone and Huston (1963) determined that heat stressing male White Plymouth Rocks for 2 to 3.5 h at 39.2 to 40 C decreased semen and sperm production. However, results in the field may differ from those obtained in the present study, in which birds were caged and artificially inseminated.

Sperm-egg penetration declines with each day postinsemination (Bramwell *et al.*, 1992). Interestingly, this decline in sperm-egg penetration was different between hens inseminated with semen from the C and S males. On Day 2 postinsemination sperm-egg penetration was much less when hens were inseminated with semen from S males than with semen from C males. One possible explanation for this drastic difference in sperm-egg penetration on Day 2 postinsemination may involve sperm motility. If sperm from S males were less motile than sperm from C males, they may have been unable to cross the vagina and reach the sperm storage tubules (SST) in the uterovaginal junction. Allen and Grigg (1957) have demonstrated that motility is essential for sperm to traverse the vagina. However, sperm motility was visually observed during the 5th wk of treatment and appeared excellent for both S and C males.

The declining difference in sperm-egg penetration with increasing time postinsemination between the two male treat-

ment groups may be due to the method of release of sperm from the SST. If a given percentage of sperm are released from the SST on each day postinsemination, a pattern in sperm-egg penetration similar to that seen in the current study would be expected for sperm from the C and S males.

However, the results of the present study do not reveal the mechanism responsible for the decrease in sperm-egg penetration when the rooster is heat stressed. It is possible that sperm from S males is stored normally in the SST but is unable to bind to and penetrate the ovum. On the other hand, the sperm may normally bind to and penetrate the ovum but are not stored properly in the SST. The present study did demonstrate that body temperature (especially male) is negatively correlated with fertility and sperm-egg penetration. Therefore, it is possible that the elevated body temperature of heat-stressed birds may instigate the decrease in fertility and sperm-egg penetration. In conclusion, it appears that the male broiler breeder contributes more to heat stress infertility than the female.

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Incidence of Prelay Squatting Behavior Is Not Related to Subsequent Egg Laying in Turkey Breeder Hens[1]

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ABSTRACT Sexual receptivity of turkey hens as indicated by squatting (sexual crouch) was evaluated in three strains of breeder hens, Nicholas (N), Hybrid (H), and British United (B). The incidence of squatting was compared among strains through 84 d of photostimulation and related to egg production characteristics. Significant strain, time, and strain by time interaction effects occurred for the incidence of squatting. In all three strains, squatting started within the 1st wk of photostimulation, rapidly peaked (75.0, 65.6, and 43.0% for H, B, and N hens, respectively) at 14 d of photostimulation, then returned to lower, basal levels at or before attainment of 50% hen-day egg production. Squatting incidence was highly variable within and between strains but was generally lower in N hens than H and B hens, which showed similar squatting expression. The incidence of prelay squatting was not correlated to onset or rate of egg production. However, there was a negative correlation between squatting behavior and percentage floor eggs in H ($P = .03$) hens. It was concluded that squatting incidence varies within and between strains of hens and is not related to subsequent egg laying performance.

(*Key words*: turkey, squatting behavior, egg production, strain, age)

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INTRODUCTION

In turkeys, the female initiates mating activity (Margolf *et al.*, 1947; Smyth and Leighton, 1953; Hale and Schein, 1962). This is prominently expressed by assuming a mating position in the vicinity of males. This is commonly referred to as a sexual crouch or squatting and indicates receptivity (Hale and Schein, 1962). This behavior varies considerably among hens and becomes most intense immediately prior to the start of egg laying (Hale 1953, 1955; Smyth and Leighton, 1953; Hale and Schein, 1962; Carte and Leighton, 1969). Thus, prelay squatting behavior is commonly acknowledged to indicate advanced sexual development, which is soon followed by egg laying.

Squatting behavior can occur in the absence of turkey males and is frequently observed when approaching or entering a pen of hens near or into their period of egg laying (Hale and Schein, 1962). Mating behavior and squatting by turkey hens appears to be quite variable, particularly with respect to genetics (Hale and Schein, 1962). There are no such reports available for present commercial strains of hens. Furthermore, there appears to be no reports of the relationship between squatting behavior (receptivity) and subsequent reproductive performance in modern turkey strains.

Because squatting behavior likely has complex endocrine and neural components and is highly variable among turkey hens, it is not unreasonable to suspect this behavior may be related to an important commercial performance trait. Indeed, many behavioral traits, including squat-

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