EFFECT OF AMBIENT TEMPERATURE ON
LAMB) PERFORMANCE

by

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B. S., Kansas State University, 1971

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A MASTER'S THESIS

submitted in partial fulfillment

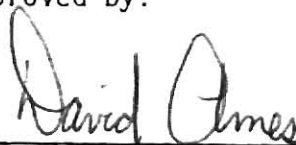of the requirements for the degree

Master of Science

Department of Animal Science

Kansas State University

Manhattan, Kansas

1975

Approved by:

Major Professor

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## ACKNOWLEDGEMENTS

# INTRODUCTION

Exposure of growing livestock to thermal stress affects voluntary feed intake and increases maintenance requirements, resulting in reduced growth rate and consequent lowering of total efficiency. Although the general affects of ambient temperature on efficiency are known, little has been reported regarding the magnitude of these responses and their ultimate effect on animal performance.

The value of predicting performance and obtaining maximum total red meat production efficiency is obvious. Yet, little has been done to either adjust prediction equations for ambient temperature or to alter feeding practices to minimize the effect of ambient temperature. For example, during cold energy for maintenance requirement increases faster than feed intake, resulting in slower growth. This lowers protein requirement. Yet, since protein is generally fed as a percent of the diet, it normally increases with increased feed intake. Contradictions of this type must be eliminated by altering rations to match requirements dictated by thermal stress.

We studied the extent of temperature changes on performance of growing wether lambs and consequent effects of thermal stress on protein utilization. Average daily gain, predicted gain, daily feed consumption, nitrogen retention, dry matter digestibility, and protein efficiency were determined.

## LITERATURE REVIEW

Graham et al., (1959) defined thermoneutral zone (TNZ) as the range of ambient temperatures below which heat production must increase (cold stress) and above which heat loss must increase (heat stress) to maintain a constant internal body temperature.

Homeotherms employ various chemical and physical means to keep their body temperature constant. (Brody, 1945; Fuller in Hafez and Dyer, 1969). These thermoregulating mechanisms (reviewed by Hardy, 1961 and Whittow, 1971) lower total efficiency.

### Effects of Environmental Temperature Feed Intake

In growing chicks, metabolizable energy intake increases from 200 Kcal/day W $kg^{0.75}$ at 40 C to 300 at 21 C (Kleiber and Dougherty, 1934). A statistically significant decrease in food intake ocurred in steers (Bianca et al., 1965) exposed to 40 C vs. 15 C. Kibler et al., (1965) found food consumption decreased by 10 to 25% in cattle at 84 F vs. 65 F. In young pigs, Fuller, (1965) found feed consumption (g/W $kg^{0.75}$/day) was 140 at 5 C, 120 at 13 C and 100 at 23 C. Winchester and Kleiber, (1938) found the feed consumption of 9 to 12 day old chicks (g/W $kg^{0.75}$/24 hr) was 14.79 at 16 C and 7.56 at 38 C. In general, food consumption increased above and declined below the TNZ.

### Nutrient Digestibility

Fuller (in Hafez and Dyer, 1969) reports that in general, energy digestibility decreases about 0.1 percent per degree centigrade. Accordingly, in fattening sheep (Graham, 1964), ration dry matter digestibility was 66.2% at 25 C, but only 54.2% at 10 C. Others (Graham et al., 1959; Blaxter and Wainman, 1961; Fuller, 1965; and Fuller and Boyne, 1972) indicate that both ruminants and non-ruminants

digest energy and protein less efficiently in cold than warm environments.

Apparent digestibility of rations at different environmental temperatures were studied in mature cows, growing calves and mature sheep by Young and Christopherson, (1974). At 18 C calves on grain and chopped alfalfa had an apparent dry matter digestibility of 69.0% but at -10 C, digestibility was 57.9%. Cold reduced apparent digestibility by 0.4% per degree C decline in temperature.

Olbrich, Martz and Hilderbrand, (1973) showed digestibility was not affected by ambient temperatures of 9, 18 and 31 C. Holmes (1973) reported that apparent digestibilities of dry matter and energy were decreased at high temperatures (33 to 35 C) vs. 25 C in growing pigs.

### Heat Production and Energy Retention

Below the TNZ animals must increase metabolic heat production to avoid hypothermia (Graham et al., 1959). In lambs this increase was 115 cal per 24 hr per degree C fall in temperature. Prolonged exposure of cattle to cold resulted in increases of 8 to 40% in thermoneutral resting heat production (Young and Christopherson, 1974). The mean increase was 0.6 Kcal/W $kg^{0.75}$ per day for each degree increase in average temperature. Holmes (1973) reported a 2 to 10% increase in heat production at 33 to 35 C as compared to 25 C in growing pigs. Pigs kept for 3 weeks at 8 C lost more heat than those at 20 C (Verstegen et al., 1973), and heat loss was independent of nutritional plane. Small laboratory animals (Gelineo, 1964 and Hart, 1971) increase their thermoneutral metabolism up to 40% during cold stress. In animals kept at different temperatures, energy retention varied inversely with their heat production (Fuller in Hafez and Dyer, 1969).

When Blaxter and Wainman (1961) measured heat production and energy retention in two steers at -5, 5, 15, 25 and 35 C, heat production increased above thermoneutral metabolism at 5 and -5 C. At 35 C one steer showed a marked and the other a slight increase in heat production. At 5 C, energy retention was reduced by 1159 per day in one steer and 1809 in the other. At -5 C the decrease was 2409 and 3087 kcal per day.

Graham et al., (1959) found at a medium feeding level a thermoneutral environment allowed sheep to store approximately 200 cal/24 hr, but at 8 C they lost 1500 cal per day. Results of experiments with lambs (Graham et al., 1959) and pigs (Close, Mount and Start, 1971) agree that during thermoneutrality, plane of nutrition determines rate of heat loss. During cold stress, environmental temperature is the main determinant of heat loss. Soderquist and Knox (1967) report that in fattening lambs there is no difference in energy retention between 23 C and 0 C. However, more energy was lost as methane and heat in a hot environment (35 C). During ad libitum feeding vs. constant intake, the decline in energy retention due to falling temperature is less severe (Winchester and Kleiber, 1938).

Rogerson, (1960) concluded that net energy values of feeds vary with temperature, due to differences in heat production.

### Protein - Energy Interactions

In general, restriction in dietary energy is associated with increased catabolism of labile protein in an effort to offset caloric deficiency (Swanson in Albanese, 1959). Barnes et al., (1946) and Bosshardt et al., (1946) reported restricted caloric intake decreased protein utilization efficiency in both adult and growing animals.

Lofgren, Loosli and Maynard, (1951) using young dairy calves, concluded that if energy intake is above maintenance, but insufficient for maximum growth, and protein is sufficient for tissue synthesis needs, growth rate and nitrogen retention will be limited by energy intake. Excess protein will be used for energy. In 144 weanling barrows (Hale and Johnson, 1970) dietary energy and protein concentrations interacted significantly. Pigs fed energy (70% TDN) and low protein (14 to 10%) gained 7% faster than pigs fed on low energy and high protein (24 to 20%). However pigs fed high energy high protein diets gained about 3% faster than pigs on high energy and low protein. In growing mice with essentially constant protein intake, decreased caloric intake resulted in lower protein efficiency ratios (Bosshardt et al., 1946).

Some energy is required for protein synthesis. Ørskov and McDonald (1970) reported for growing lambs the value was 16.25 Kcal M.E. and Rattray et al., (1974), 45.6 ± 8.69 Kcal of M.E. per gram protein deposited.

### Protein Utilization

Tredwell et al., (1957) showed higher growth rates and protein efficiency ratios for growing rats at 1 C than at 25 C for diets having 5 and 10% protein, but poorer performance for diets having greater than 10%. Similarly, Meyer and Hargus (1959) found faster growth at 2 C than 25 C for rats fed 10% casein diet. The reverse was true on a 25% casein diet. Payne and Jacob (1965) reported similar results and concluded that when temperature and diet were such that animal's maximum food intake would not meet energy needs for growth and energy balance during cold stress, protein utilization efficiency was reduced. The reduction was similar to that observed

at restricted caloric intake.

Daily growth rate was depressed by $17.8 \pm 2.3$ gms for each 1 C
fall of temperature in growing pigs studied at 23, 13 and 3 to 5 C
by Fuller and Boyne (1972). Taking the mean of two estimates (balance
method and comparative slaughter) they noted a reduction in nitrogen
retention of $.38 \pm .055$ g/day/1 C at a constant energy intake, with no
significant temperature x energy interaction.

Fuller (1965) showed that young pigs fed _ad libitum_ used dietary
nitrogen with equal efficiency at all temperatures studied between
10 and 30 C. In contrast, Piatkowski _et al._, (1958) and Moustgaard
_et al._, (1959) (both cited by Fuller, 1965) indicated that pigs kept
at different temperatures, but given the same amount of feed retained
less nitrogen in a cold than a thermoneutral environment. According
to Moustgaard _et al._, (1959) daily nitrogen retention studied at 15
and 8 C fell by 1.31 and 1.22 g per degree C, respectively.

Chicks 6 to 15 days old gained 4.88 g per day at 21 C, 4.64 at
27 C, 4.39 at 32 C, 2.97 at 38 C and 2.91 at 40 C. Protein deposition
showed the same trend; 1.10 g per day at 21 C and 0.68 at 49 C.

## MATERIALS AND METHODS

Eight ambient temperatures, -5, 0, 5, 10, 15, 20, 30 and 35 C were studied. All temperatures except 20 C were controlled using a Forma Scientific Walk-In Room (11 m x 15 m x 8 m) with a temperature sensitivity of ± 0.5 C. Temperatures were randomly assigned experimental period prior to the initiation of the experiment.

Crossbred wether lambs approximately 3 months old and averaging 25 kg were used. Previous records indicate that lambs of this type continue to grow up to 45 kg; hence lambs were defined as growing. Lambs were housed in a 20 C room for 14 days prior to trial one and fed ad libitum. Two groups of four lambs were randomly selected and sheared before the initiation of each trial to provide a constant external insulation.

At the beginning of each trial fecal collection harnesses were placed on the lambs. One group was placed in digestion crates and housed in the environmental room at assigned temperature. Group two (also placed in digestion crates) remained in the 20 C room. Data were simultaneously collected on both groups for 12 days. Urine and feces were collected following the seventh day. At the end of each trial lambs were allowed 3 days out of crates and then groups were rotated so the same group was not subjected to thermal stress for two consecutive trials.

Lambs were fed twice daily at 8:00 a m and 5:00 p m At each feeding period 1500 g of feed were presented to each lamb. Feed was removed after one hour. Consumption was measured by difference.

The ration (AH118) was pelleted (3/8" diameter). Composition and proximate analysis of this ration are reported in table 1.

Initial weights for each trial were made following a 12 hr fast. Final weights were measured following final collection for each trial, also preceeded by a 12 hr fast.

Proximate analysis (A.O.A.C., 1970) was made on individual fecal samples and on a random sample of feed for each trial. Kjeldahl method (A.O.A.C., 1970) was used to determine nitrogen content of urine samples. Calculations of nitrogen retention and dry matter digestibility were made according to Crampton and Harris (1969). Protein efficiency (gram of gain/gram of protein consumed) was calculated according to Allison (in Albanese, 1959). Predicted gains were calculated from net energy equations of Rattray et al., (1973).

KSU statistical laboratory program, STEPDEL, a multiple regression program was used for statistical analysis of data. Plots were made with a plotting routine on Wang 700 B calculator.

## RESULTS AND DISCUSSION

Average daily gain (ADG) was quadratically (P<.01) effected by ambient temperature. Mean values of ADG are listed in table 2. Maximum gains of 236 and 231 g per day were measured at 10 C and 15 C, respectively. As temperature decreased below 10 C or increased above 15 C ADG decreased (figure 1). Based on these observations the TNZ of lambs as defined previously is between 10 C and 15 C.

Temperature had a quadratic effect (P<.01) on deviation of actual from predicted gain. Actual ADG was less than predicted at -5, 0, 5 and 35 C (figure 1). Mean values of actual minus predicted gain are shown in table 2. Knox and Handley (1973) reported during seasons when temperature decreased steers in feedlots gained less than predicted. They concluded that increased maintenance requirements in response to thermal stress caused this difference. Data presented in table 2 indicates that above and below the TNZ maintenance requirements increase at expense of net energy for production. Increased maintenance requirements occur due to increased metabolism during heat and cold stress (Blaxter, 1967). Acutal gains exceed predicted gains at 10 through 35 C. It is possible that this positive difference is due to digestibility (Kroman, 1973). During warm temperatures the increase in digestibility could result in more metabolizable energy and therefore more energy for production. Actual gains may exceed predicted gains due to differences in maintenance requirements. Since originally, net energy for maintenance values were determined under a variety of environmental conditions (Knox and Handley, 1973). Also differences in composition of lambs could be a major factor.

A linear effect (P<.01) of temperature on dry matter digestibility was found (figure 2). Mean values for dry matter digestibility are reported in table 3. At -5 C percent digestible dry matter was 54.22 while at 10 C dry matter digestibility was 57.63. This is a decrease of 0.23 percent per degree C. Young and Christopherson (1974) report a decline of 0.4 percent units for each degree C drop in temperature. At 30 C and 35 C dry matter digestibility was 62.14 and 60.89%, respectively. During cold temperatures the decrease in digestibility could result in less metabolizable energy and therefore less energy for maintenance or production.

Mean values of digestibility of the various components of proximate analysis are shown in (table 3). Crude fiber, and ether extract were linearly affected by temperature (P<.01). Crude protein and nitrogen free extracted were linearly affected (P<.05). Digestible energy was not significantly affected by temperature.

Utilization of dietary protein is a function of available energy. In cases where energy supply is not great enough to meet energy demand protein can be used as an energy source to meet the requirements. (Albanese, 1959). In addition a certain amount of energy is required for protein synthesis (Ørskov and McDonald, 1970) and Rattray et al., 1974. Effects of these factors are indicated by nitrogen retention and protein efficiency data which indicate under thermal stress changes in maintenance requirements alter utilization of dietary protein.

Means of nitrogen retention values are reported in table 4. Nitrogen retention was quadratically (P<.01) affected by temperature (figure 3). Temperature quadratically (P<.01) affected percent nitrogen retained of intake (figure 4). Mean values are reported in table 4.

At 10 and 15 degrees, mean values of protein efficiency were 0.33 and 0.31, respectively, however, at -5 and 35 C mean values were .08 and .05, respectively, (table 4). Protein efficiency was quadratically (P<.01) affected by temperature (figure 5).

The decrease in protein efficiency and percent nitrogen retained of intake decrease during thermal stress may occur because protein is used as an energy source to meet increased maintenance requirements which would agree with conclusions made by Tredwell et al., (1957) and Payne and Jacob (1965) from experiments with growing rats.

When protein is used for energy, an increase in urinary nitrogen is expected. Data in table 4 and figure 6 indicate that percent urinary nitrogen of nitrogen consumption increases during cold and heat stress. Percent urinary nitrogen was quadratically (P<.01) affected by temperature. Possibly some protein was not used for tissue synthesis (even though maintenance requirements were met), because sufficient energy for tissue synthesis was not present.

Mean daily consumption values per unit of metabolic size are reported in table 5. A linear effect (P<.01) of temperature on daily consumption was found (figure 7). The mean daily consumption a -5 C was 120.73 grams per unit of metabolic size and at 35 C was 60.02. This data indicates that during cold stress an increase in feed intake is accompanied by an increase in protein intake and when exposed to heat stress a decrease in protein intake occurs due to the decrease in *voluntary consumption*.

These observations are of practical significance; they indicate that more efficient utilization of dietary protein can be accomplished by adjusting protein levels to match the thermal environment where

lambs are grown. The increase in protein intake and decrease in protein utilized for growth would indicate that during cold stress protein levels can be decreased with no decrease in gain. Heat stress resulted in a decrease in protein intake but an apparently greater decrease in protein utilized for growth. Therefore, a decrease in protein levels during heat stress is also suggested.

Adjusting protein levels to match thermal conditions should include two additional considerations: (1) TNZ for lambs deviate due to insulation, plane of nutrition, exercise and radiation, therefore, accurate adjustments for all lambs should be based on the deviation from TNZ. (2) Effective temperature[1] instead of absolute dry bulb temperature should be used.

[1]Effective temperature is defined as the cooling or heating power of the physical environment in terms of dry bulb temperature.

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Table 1. Composition Of Ration Fed To Lambs.

| Ingredient | % |
|---|---|
| Soybean meal | 5.0 |
| Ground sorghum grain | 39.4 |
| Molasses | 5.0 |
| Dehy. alfalfa | 50.0 |

Proximate Analysis

| % Protein | % Dry matter | % Ether extract | % Crude Fiber | Energy cal/gm |
|---|---|---|---|---|
| 13.50 | 87.18 | 2.35 | 15.37 | 4057 |

| % Ash | Mg N/gm |
|---|---|
| 6.41 | 21.59 |

Table 2. Effect Of Temperature On Mean Actual Gain, Predicted Gain And Difference Between Actual And Predicted Gain.

| Temperature (C) | Actual gain (g) | S. E. | Predicted gain (g) | S. E. | Difference actual minus predicted gain (g) | S. E. |
|---|---|---|---|---|---|---|
| -5 | $102^{d,e}$ | 39 | $193^{f}$ | 15 | $-91^{c,d,e,f}$ | 31 |
| $0^{a}$ | $107^{d,e,f}$ | 45 | $172^{e,f}$ | 17 | $-66^{c,d,e,f}$ | 36 |
| 5 | $97^{d}$ | 39 | $147^{d,e,f}$ | 15 | $-51^{c,d,e,f}$ | 31 |
| 10 | $250^{g,h,i}$ | 39 | $101^{d}$ | 15 | $149^{h}$ | 31 |
| 15 | $232^{g,h,i}$ | 39 | $175^{e,f}$ | 15 | $57^{e,f,g,h}$ | 14 |
| $20^{b}$ | $177^{d,e,f,g,h}$ | 18 | $137^{d,e}$ | 7 | $40^{e,f,g}$ | |
| 30 | $142^{d,e,f,g}$ | 39 | $178^{f}$ | 15 | $-37^{c,d,e,f}$ | 31 |
| 35 | $28^{c}$ | 39 | $50^{c}$ | 15 | $-18^{c,d,e,f}$ | 31 |

[a]Means consists of 3 observations.

[b]Means consists of 18 observations.

[c,d,e,f,g,h,i]Values with same superscript are not significantly different (P<.05).

Table 3. Mean Values Of Digestibility Of Proximate Analysis Components.

| Temp. (C) | Dry matter dig. % | S. E. | Crude fiber dig. % | S. E. | Crude protein dig. % | S. E. | Ether extract dig. % | S. E. | Nitrogen free extract dig. % | S. E. |
|---|---|---|---|---|---|---|---|---|---|---|
| -5 | 54.22$^{c,d}$ | 1.29 | 3.50$^c$ | 0.52 | 7.94$^{c,d,e}$ | 0.39 | 1.99 | 0.19 | 50.53$^e$ | 3.59 |
| 0$^a$ | 57.50$^{d,e}$ | 1.49 | 4.71$^{c,d,e}$ | 0.60 | 8.69$^{c,d,e,f}$ | 0.45 | 1.37$^{c,d,e}$ | 0.22 | 39.08$^{c,d}$ | 4.14 |
| 5 | 57.03$^{d,e}$ | 1.29 | 3.56$^{c,d,e}$ | 0.52 | 7.86$^{c,d,e}$ | 0.39 | 0.97$^{c,d}$ | 0.19 | 41.33$^{c,d,e}$ | 3.59 |
| 10 | 57.63$^{d,e}$ | 1.29 | 3.59$^{c,d,e}$ | 0.52 | 7.38$^c$ | 0.39 | 0.80$^c$ | 0.19 | 41.21$^{c,d,e}$ | 3.59 |
| 15 | 50.86$^c$ | 1.29 | 2.78 | 0.52 | 7.55$^{c,d}$ | 0.39 | 1.08$^{c,d,e}$ | 0.19 | 36.33$^c$ | 3.59 |
| 20$^b$ | 58.01$^{d,e}$ | .61 | 4.77$^{c,d,e}$ | 0.24 | 8.30$^{c,d,e,f}$ | 0.18 | 1.15$^{c,d,e}$ | 0.09 | 39.96$^{c,d}$ | 1.69 |
| 30 | 60.98$^e$ | 1.29 | 6.28 | 0.52 | 8.39$^{c,d,e,f}$ | 0.39 | 1.41$^{c,d,e}$ | 0.19 | 40.58$^{c,d,e}$ | 3.59 |
| 35 | 60.89$^e$ | 1.29 | 4.77$^{c,d,e}$ | 0.52 | 9.38$^f$ | 0.39 | 1.09$^{c,d,e}$ | 0.19 | 42.34$^{c,d,e}$ | 3.59 |

[a]Mean consists of 3 observations.

[b]Mean consists of 18 observations.

e,f,g,h,iValues with same superscript are not significantly different (P<.05).

Table 4.  Effect Of Temperature On Mean Nitrogen Retention, Percent Nitrogen Retained Of Nitrogen Intake, Protein Efficiency And Percent Urinary Nitrogen Of Nitrogen Consumption.

| Temperature (C) | Nitrogen retention (g/day) | S. E. | Nitrogen retained of intake (%) | S. E. | Protein efficiency | S. E. | Urinary nitrogen (% of N intake) | S. E. |
|---|---|---|---|---|---|---|---|---|
| -5 | 6.44[c,d] | 1.21 | 15.84[c] | 3.03 | 0.09[c,d] | 0.05 | 32.39[d,e] | 2.80 |
| 0[a] | 9.05[c,d] | 1.39 | 26.53[c,d,e,f] | 3.49 | 0.12[c,d] | 0.05 | 32.69[d,e] | 3.23 |
| 5 | 6.19[c,d] | 1.21 | 18.62[c,d] | 3.03 | 0.11[c,d] | 0.05 | 34.93 | 2.80 |
| 10 | 5.43[c] | 1.21 | 19.30[c,d,e] | 3.03 | 0.34[e] | 0.05 | 40.06 | 2.80 |
| 15 | 7.07[c,d] | 1.21 | 23.49[c,d,e,f] | 3.03 | 0.31[e] | 0.05 | 28.83[c] | 2.80 |
| 20[b] | 7.70[c,d] | 0.56 | 26.50[c,d,e,f] | 1.43 | 0.24[e] | 0.02 | 31.40[d] | 1.32 |
| 30 | 9.45[c,d] | 1.21 | 34.39 | 3.03 | 0.21[d,e] | 0.05 | 27.38[c] | 2.80 |
| 35 | 1.29 | 1.21 | 6.55 | 3.03 | 0.05 | 0.05 | 57.26 | 2.80 |

[a]Mean consists of 3 observations.

[b]Mean consists of 18 observations.

[c,d,e,f]Values with same superscript are not significantly different (P<.05).

Table 5.  Effect Of Temperature On Mean Daily
          Consumption.

| Temperature (C) | Consumption (W0.75kg) | S. E. |
|---|---|---|
| -5 | $120.51^{e,f,g,h,i}$ | 6.84 |
| 0 | $114.85^{e,f,g,h,i}$ | 7.90 |
| 5 | $102.36^{d,e,f}$ | 6.84 |
| 10 | $82.81^{d}$ | 6.84 |
| 15 | $111.51^{e,f,g}$ | 6.84 |
| 20 | $99.41^{d,e}$ | 3.22 |
| 30 | $112.65^{e,f,g,h}$ | 6.84 |
| 35 | $59.84^{c}$ | 6.84 |

[a] Mean consists of 3 observations.

[b] Mean consists of 18 observations.

[c,d,e,f,g,h,i] Values with same superscript are not significantly different ($P<.05$).
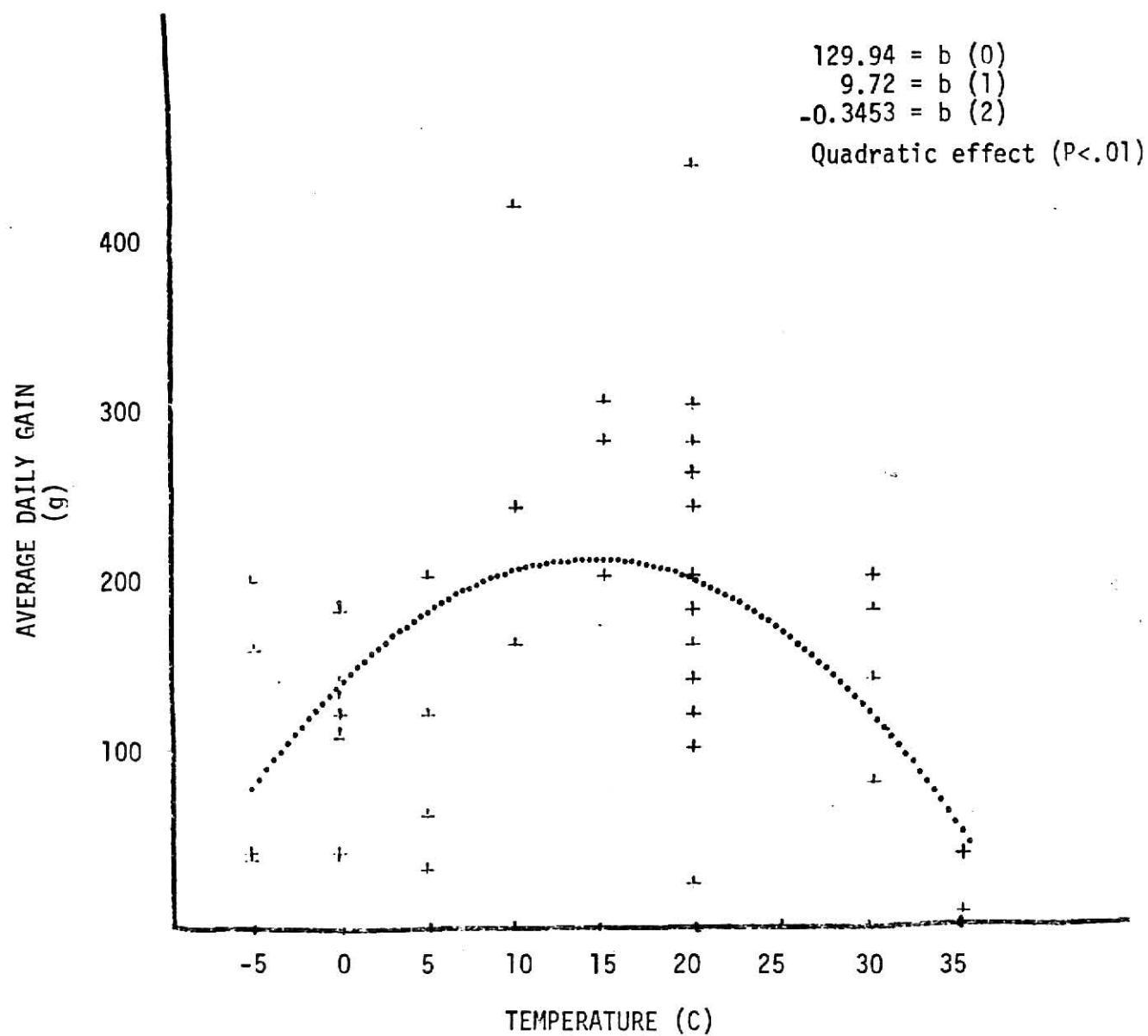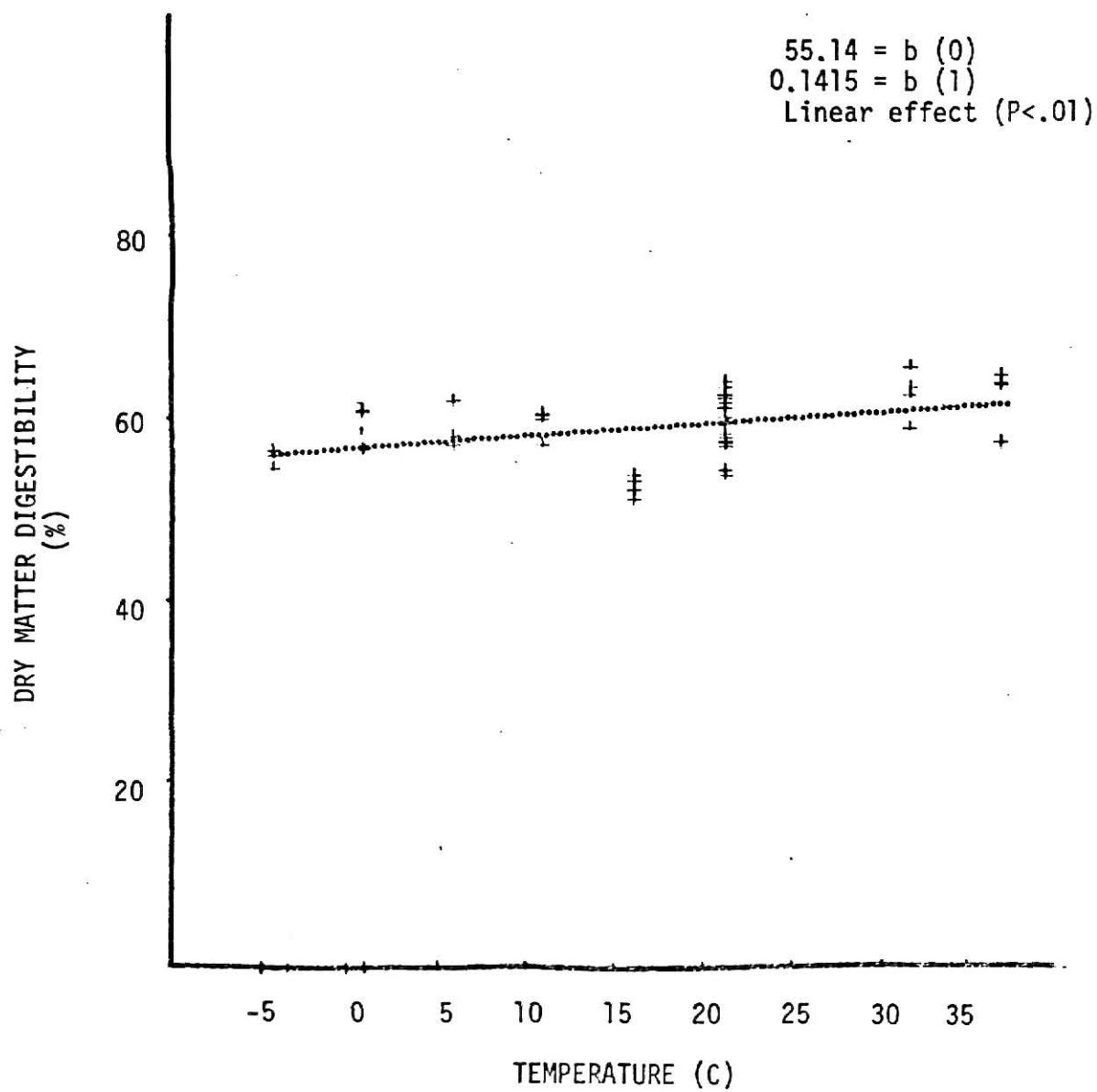
Figure 1.  Actual gain as a function of temperature.

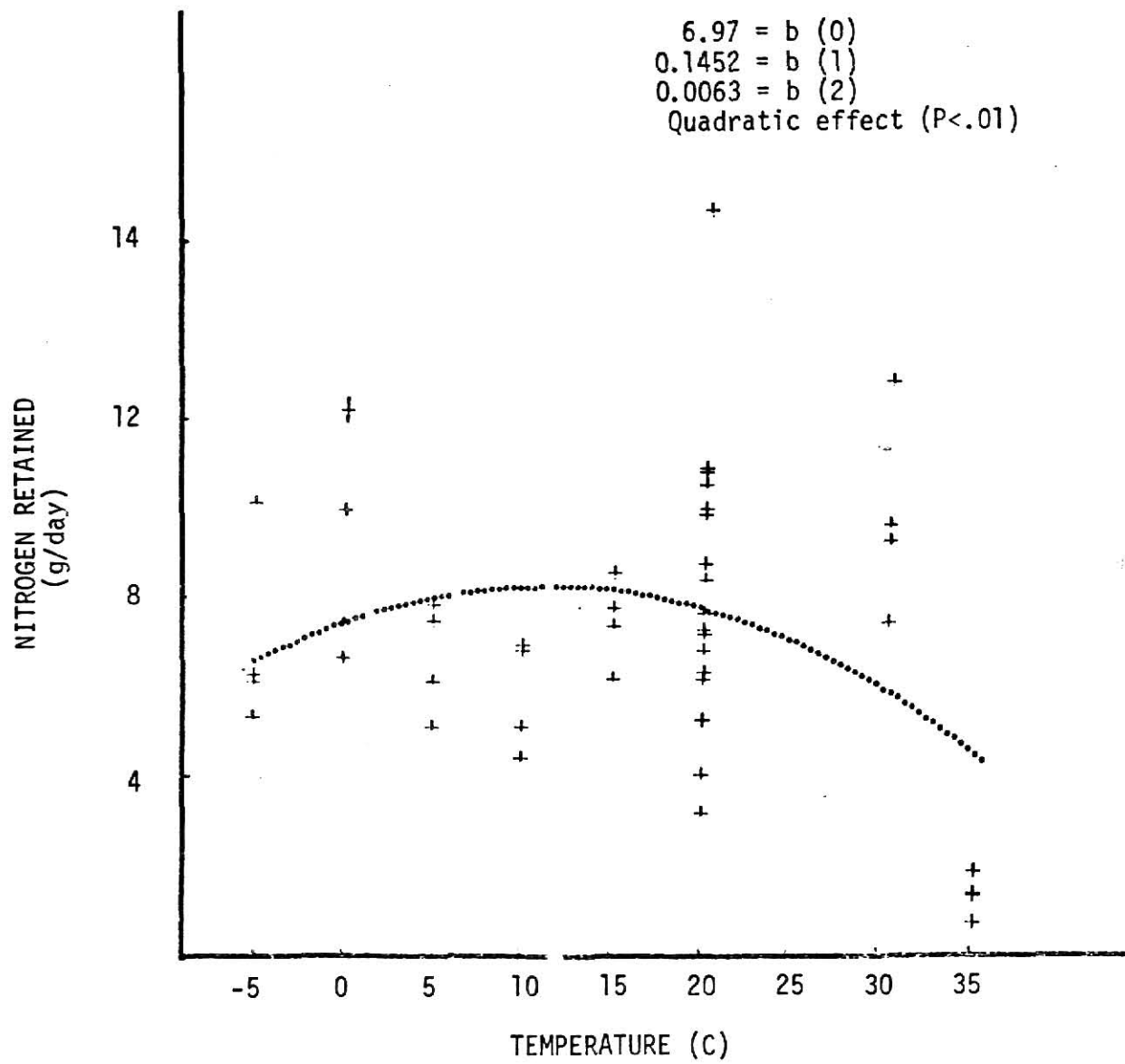Figure 2.  Dry matter digestibility as a function of
temperature.

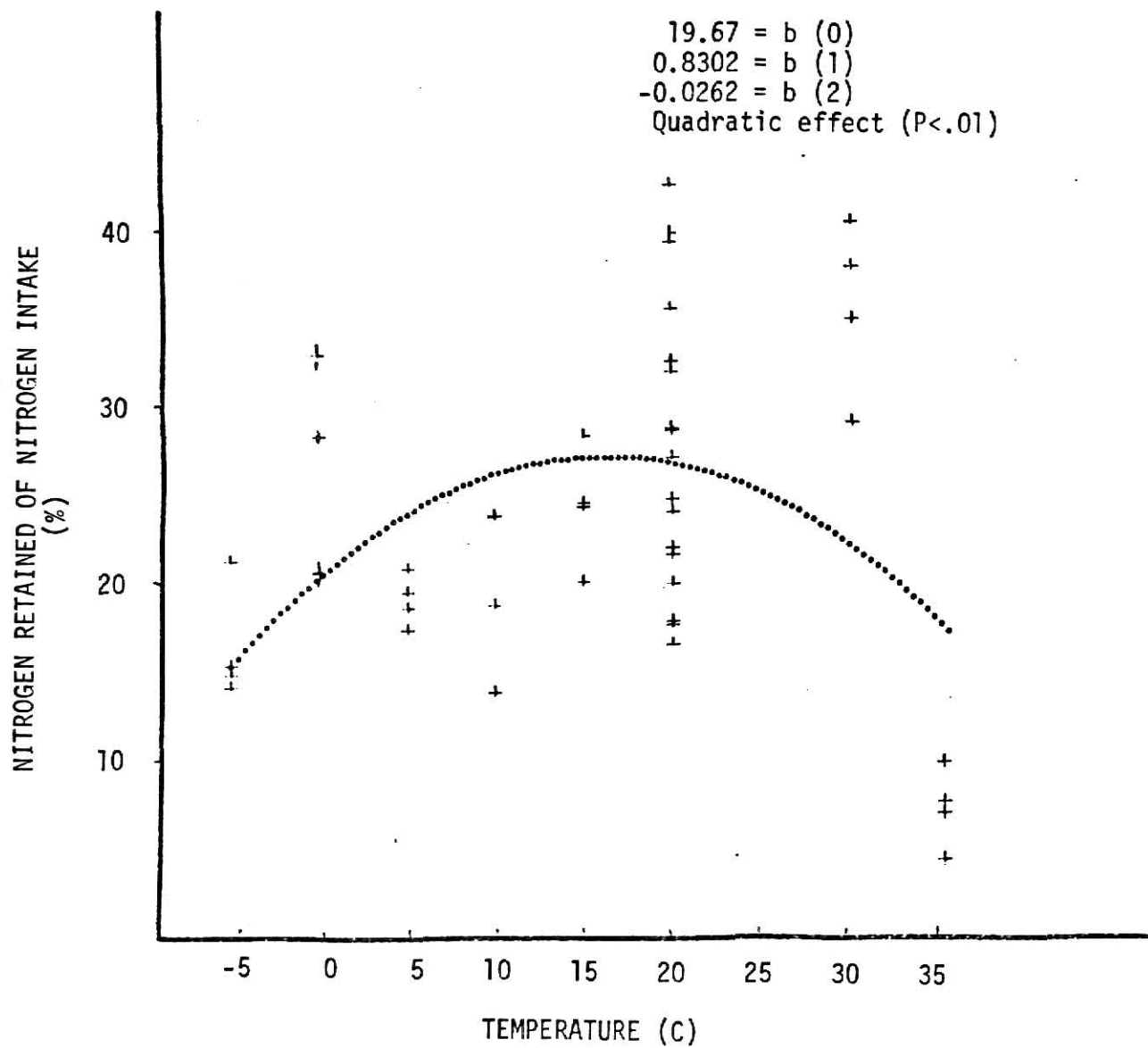Figure 3. Nitrogen retention as a function of temperature.

Figure 4.  Percent nitrogen retained of nitrogen intake as
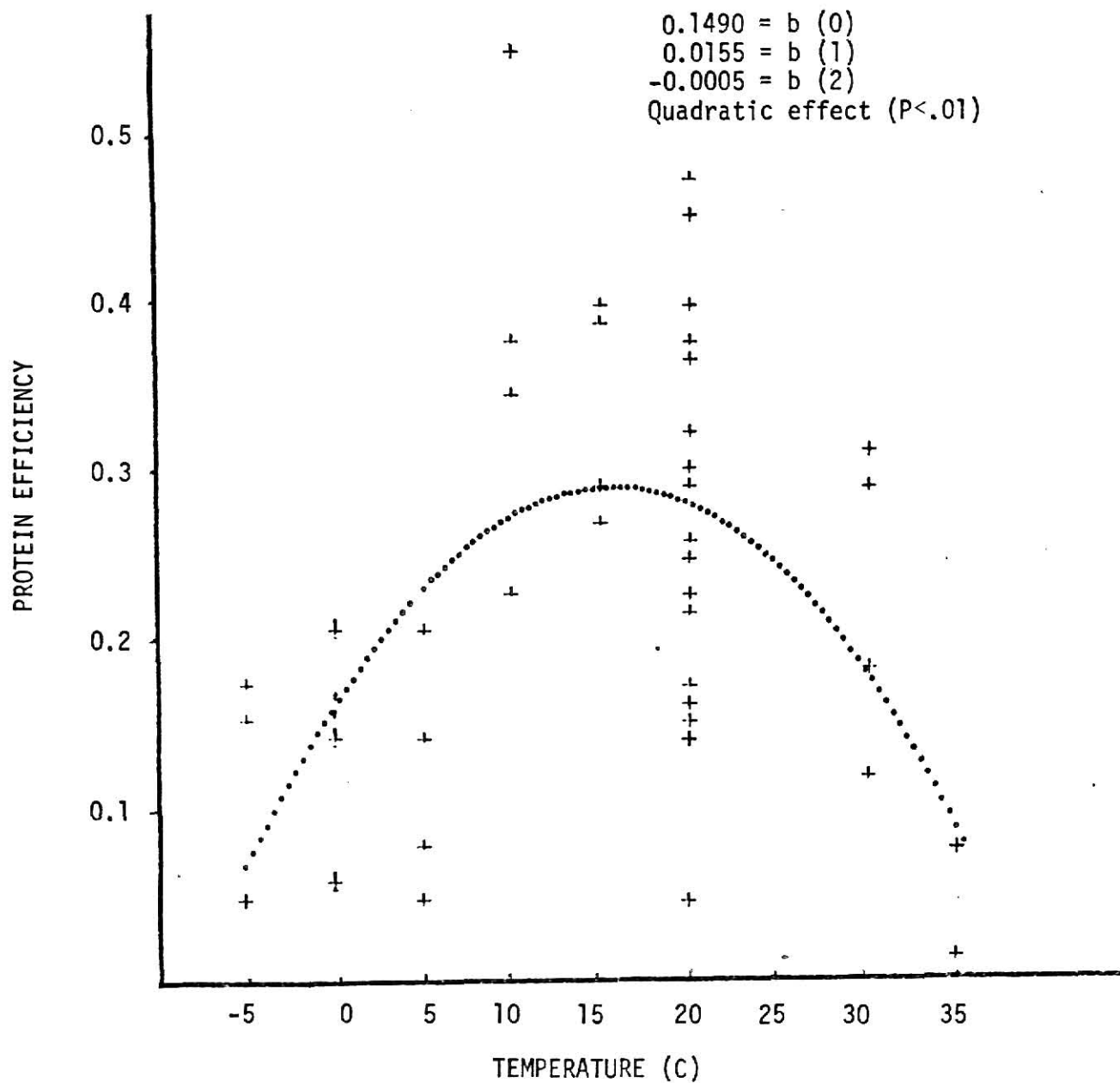a function of temperature.

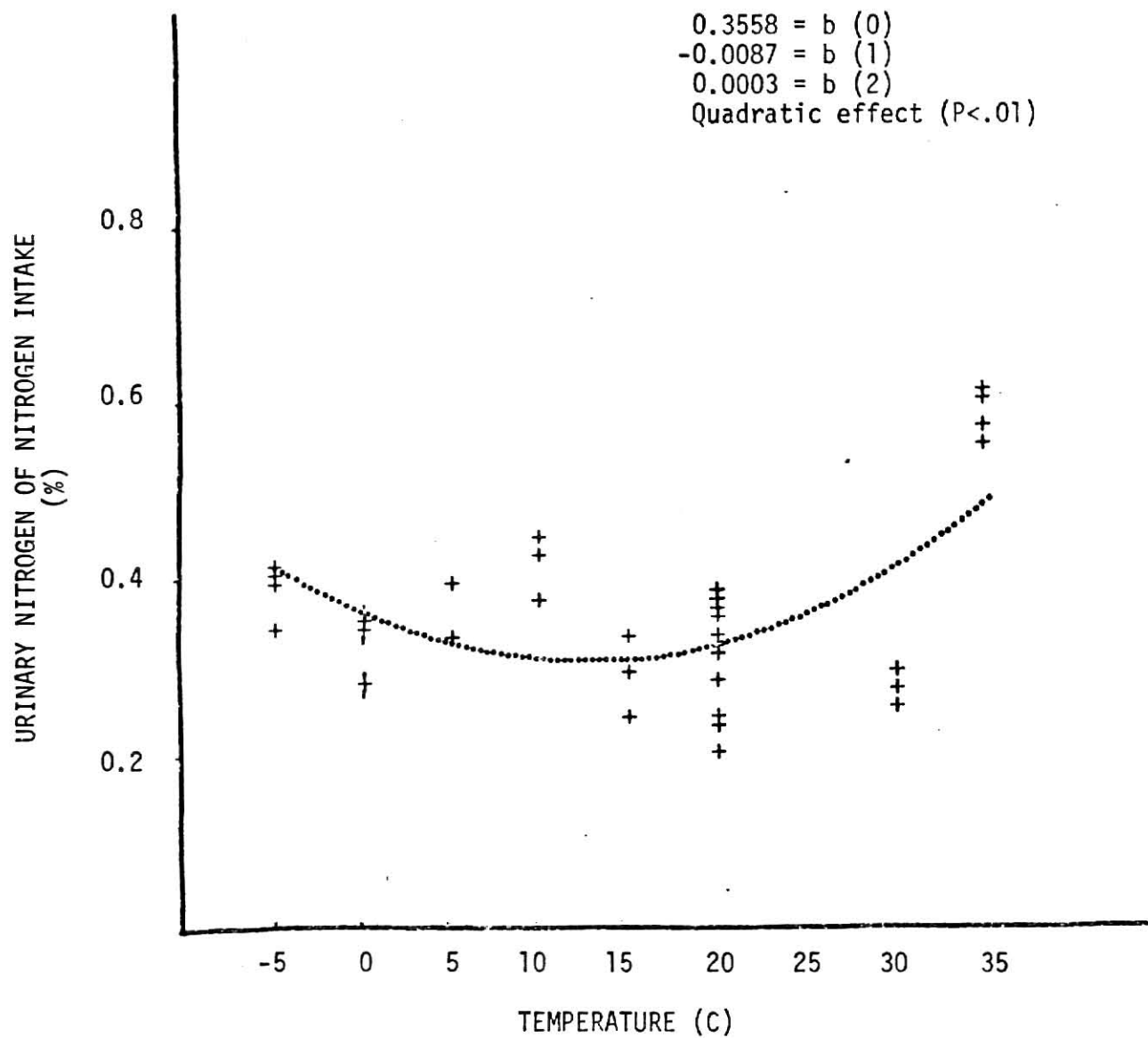Figure 5.  Protein efficiency as a function to temperature.

Figure 6.  Percent urinary nitrogen of nitrogen intake as a
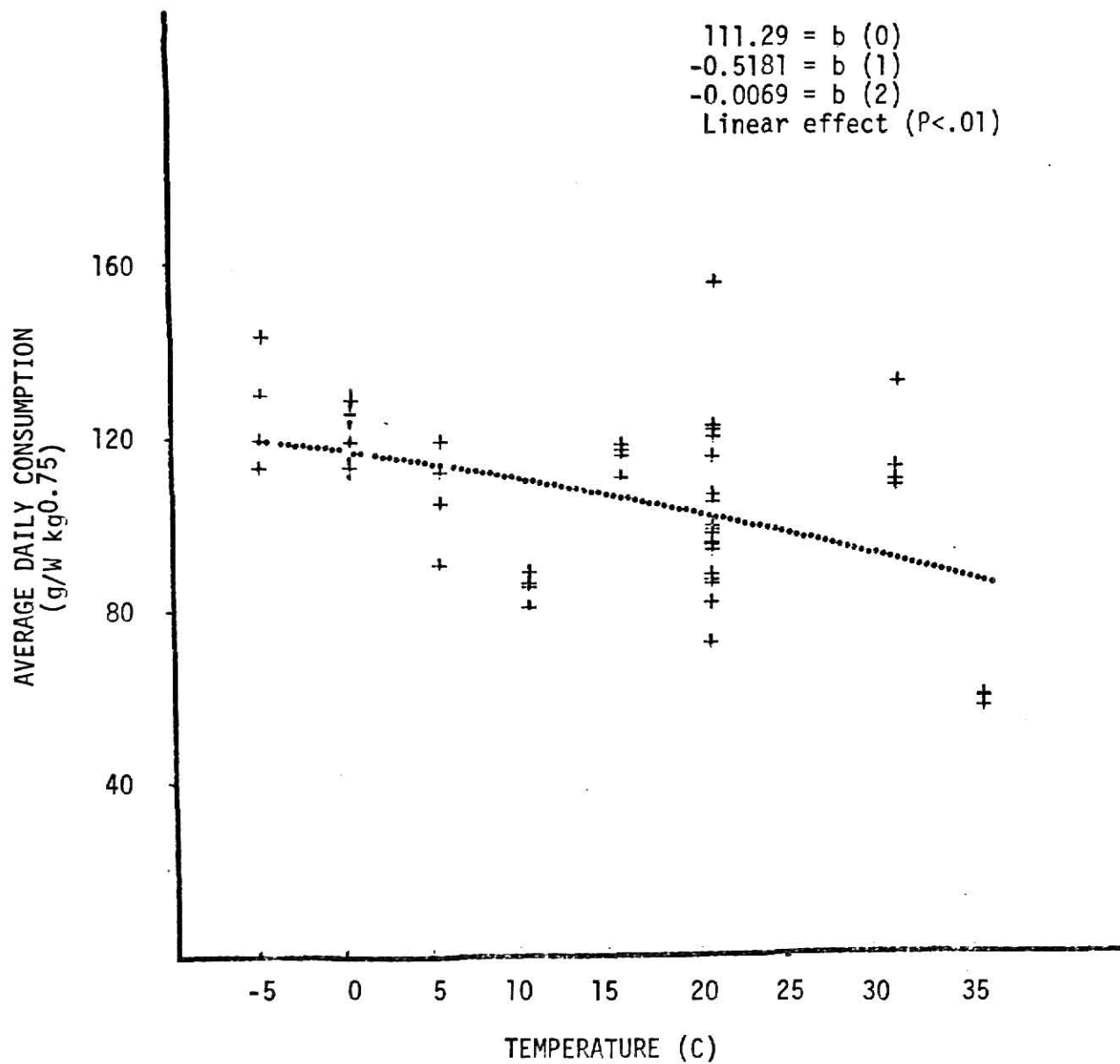function of temperature.

Figure 7. Consumption per unit metabolic body size as a function of temperature.

## SUMMARY

Average daily gain, predicted gain, daily feed consumption, nitrogen balance, dry matter digestibility and protein efficiency were determined for growing lambs reared at ambient temperatures of -5, 0, 5, 10, 15, 20, 30 and 35 C. Temperature significantly affected average daily gain, deviation of actual from predicted gain, feed consumption and protein efficiency, which indicate that protein may be decreased during thermal stress without affecting animal performance.

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EFFECT OF AMBIENT TEMPERATURE ON
LAMB PERFORMANCE

by

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B. S., Kansas State University, 1971

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of

the requirements for the degree

Master of Science

Department of Animal Science

Kansas State University

Manhattan, Kansas

1975

ABSTRACT

Twelve growing lambs averaging 25 kg were housed at -5, 0, 5, 10, 15, 20, 30 and 35 C to measure effect of temperature on daily feed intake, average daily gain, deviation of measured gain from gain predicted by net energy equations, nitrogen retention, percent of consumed nitrogen retained, protein efficiency (gram of gain/gram of protein consumed) and dry matter digestibility. Four sheared lambs per treatment were randomly selected then placed in digestion crates in a temperature controlled room. Temperature treatments were randomly assigned to an experimental order before the experiment began. Lambs were allowed feed for one hour twice daily for 12 days. Urine and feces were collected on days 8 through 12. Three days separated treatments and lambs were not used in consecutive trials. Average daily consumption per unit metabolic body weight and dry matter digestibility were linearly (P<.01) affected by temperature. Average daily gain, deviation from predicted gain, nitrogen balance, and percent of nitrogen intake retained were quadratically (P<.01) affected by temperature. Thermal stress increased $NE_m$ at expense of $NE_p$, consequently, utilization of dietary protein for growth was less efficient. To increase efficiency, protein and energy levels should be adjusted to match the thermal environment.