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PRECOPULATORY BEHAVIOR AND MATING SUCCESS OF THE EUROPEAN CORN BORER[1] UNDER CONTROLLED CONDITIONS[2]

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ABSTRACT. Biotic factors exhibited little influence on mating success when adult European corn borers, Ostrinia nubilalis (Hübner), were exposed to a simultaneous 16:8 hr photo-thermoperiod. Adult age or crowding did not affect mating frequency. Female multiple matings were few but males will mate with a virgin female every day. Neither sex, however, will mate more than once in 24 hr.

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The results reported here represent part of a continuing program designed to determine the nature of European corn borer, Ostrinia nubilalis (Hübner), population fluctuations. As part of this program, a study was conducted to determine the influence of biotic factors on mating success of the Iowa strain of the corn borer.

GENERAL METHODS AND MATERIALS

Adults used in this study were reared in the laboratory from larvae maintained on an artificial diet (Guthrie et al. 1965). After 20 days, pupae were removed from the diet dishes and placed in individual 0.5-oz plastic jelly cups, which were than capped with paper lids. These pupae were exposed to simultaneous cycles of light and temperature. A daily photophase of 16 hr was used. Light intensity and temperature during the photophase were 175 ft-c and 85°C. During the 8-hr scotophase, the temperature was 65°F. Relative humidity was held at approximately 75% during the 24-hr cycle. Pupae were checked each day to determine the number of adults that had emerged. Pint-sized screen (19-mesh) mating cages were used. The adults were transferred from the 0.5-oz jelly cups to these mating cages in a 60°F walk-in incubator. After the adults were transferred, the cages were watered with a fine spray and then placed in the test incubator. The test incubator could be programmed to automatically control temperature, humidity, and light for 24 hr. Temperature control was accurate to within ± 0.5°F, and relative humidity to within 2%. Light was provided by fluorescent lamps.

[1] Lepidoptera: Pyraustidae

[2] Journal Paper No. J-6773 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa. Project No. 1687. A portion of a dissertation presented in partial fulfillment of the requirements for the Ph. D. degree at Iowa State University. Accepted for publication Dec. 29, 1970.

The criterion for successful mating was the presence of a spermatophore in the bursa copulatrix of the female (Pesho 1961).

RESULTS AND DISCUSSIONS

Crowding

This experiment was designed to determine if crowding under caged conditions had any effect on mating. Combinations of 1, 2, 3, 4, and 5 pairs of adults were placed in pint-sized screen mating cages. The adults were exposed for 24 hr to cycling conditions of 16 hr light at 85 °F and 8 hr darkness at 67 °F. Relative humidity ranged from 75 to 85%.

Table 1. Influence of crowding on mating.[a/]

Adults per cage (pr)	Percent mating	
	Mean	Range
1	75	0-100
2	63	0-100
3	75	66-100
4	56	25- 75
5	75	60- 80

[a/]Experiment performed twice using 2 cages of adults per treatment.

Table 1 shows the percentage of females that mated in this investigation. For the purpose of this experiment, it was concluded that there was no difference in mating due to crowding under these conditions.

Adult age

An experiment was designed to determine if the age of the imagoes is a factor in mating success. To determine this, adult males and females were paired by age to determine how long after emergence adults would be able to mate. Age was established as the number of hours after eclosion of the imago. Age groups studied were 1-6, 24-30, and 48-54 hr old at the beginning of the experiment. Adults of the same age were exposed to cycling conditions of 16 hr light at 85 °F and 8 hr darkness at 67 °F. Relative humidity ranged from 85 to 75%. The experiment was performed 5 times with 5 pair of adults per age group.

The relationship between age and percentage mating is shown in Table 2. The results indicate that there is no difference in the ability of adults, in the age groups tested, to mate successfully.

Mating frequency

An experiment was designed to determine if an adult male or female

will mate more than once during a 24-hr period. Adults were caged in different sex ratios and exposed to cycling conditions of 16 hr light at 85°F and 8 hr darkness at 67°F. Relative humidity ranged from 75 to 85%.

Table 2. Effect of age on mating.

	Age (hr)		
	1-6	24-30	48-54
Females mated	17	18	18
Females unmated	8	7	7

Table 3. Mating frequency in a 24-hr period.

Sex ratio	Spermatophores found
1 male to 5 females[a/]	1
5 males to 1 female[b/]	1

[a/] Experiment performed 3 times.

[b/] Experiment performed 4 times.

Data presented in Table 3 indicate that an individual of either sex mates only once during a 24-hr period.

Multiple mating

In the previous experiment, the paired adults were left together for 24 hr. During this time, neither the male nor the female will mate more than once. This experiment was designed to determine if the female will mate more than once in 48 hr.

Adults of the same age were exposed to a 24-hr cycle of 16 hr light at 85°F and 8 hr darkness at 67°F. Adults were provided water once a day.

Of 41 females examined, none had mated twice. The experiment was repeated, except that the females were examined for spermatophores only after all the females had died. At the end of 11 days, all 17 females had mated, and of these, 2 (11.7%) had mated twice.

To determine how many times a male will mate in a lifetime, a newly emerged male imago was provided with 2 virgin females every 24 hr until the male died. The adults were exposed to a 24-hr cycle of 16 hr light at 85°F and 8 hr darkness at 67°F. Water was provided every day. The male lived 10 days and transferred 9 spermatophores; 1 spermatophore was transferred every 24 hr. On the morning of the 10th day, the

male was dead. Although no measurements were taken, spermatophore size decreased with each successive day past day 3. On days 8 and 9, the spermatophore was observed to be malformed in that it was not of the normal egg shape but, rather, of a dumbbell configuration. The experiment was not repeated because the results have no significance in this study. The observation was included only to serve as a reference to female multiple matings.

Age combination

This experiment was designed to determine if there would be a difference in mating success when adults of different ages were placed together. Adults were mixed in various age combinations ranging from 1-5 days of age. Adult age was the number of days after eclosion of the imago. Adults were exposed to cycling conditions of 16 hr light at 85 °F and 8 hr darkness at 67 °F. The experiment was performed twice with 5 pr of adults per cage.

Results indicate that there is no difference in mating success when adults of different ages are placed together (Table 4).

Female precopulatory behavior

The female, for the most part, plays a passive role in mating. She probably releases a copulatory stimulant or attractant at falling temperatures and decreasing light intensity. This stimulant probably is distributed throughout the environment by the air. In only one observation was a female seen actively moving her wings in what might be considered a dispersal action. The female is sometimes seen to move her abdomen in a pumping action. Usually the female will rest passively with the tip of her abdomen exposed (Fig. 1) as the male tries to copulate with her.

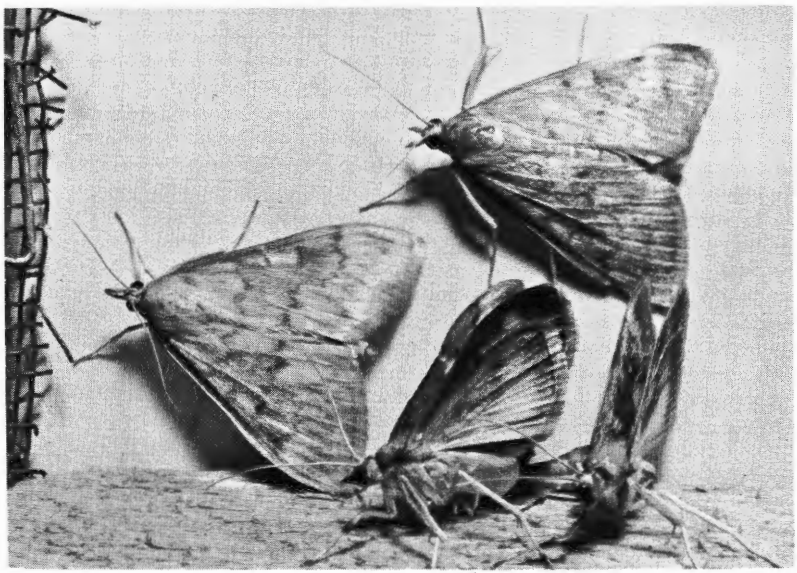

Figure 1. Female with tip of abdomen exposed.

Table 4. Effect of age combinations on mating.

Age combination				
Age (days)	Sex		Rep.	Spermatophores present
1	male		1	3
	X			
1	female		2	4
2	male		1	4
	X			
1	female		2	4
1	male		1	5
	X			
2	female		2	3
2	male		1	4
	X			
2	female		2	3
1	male		1	4
	X			
3	female		2	4
3	male		1	5
	X			
1	female		2	4
1	male		1	4
	X			
5	female		2	4
5	male		1	4
	X			
1	female		2	4

The results of these experiments indicate that biotic factors such as mating age, age preference for a mate, and crowding under the described conditions have no effect on mating success. In this regard, Caffrey and Worthley (1927) reported that the corn borer will mate as soon as 12 hr after eclosion, but no environmental conditions were stated.

The frequency of multiple mating for females was low (11.7%) compared with the 46%(27 of 58) reported by Drecktrah and Brindley (1967). Among feral corn borer adults, Pesho (1961) reported a range of 8 to 43% multiple matings for females. It appears that the current results are close to describing multiple matings under field conditions.

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I wish to thank Dr. Tom A. Brindley for his support and assistance during the conduct of this research.

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STERILIZATION TECHNIQUES FOR SEEDS AND EXCISED EMBRYOS OF CORN (ZEA MAYS L.)[1]

W. J. Dahmen and J. J. Mock[2]

ABSTRACT. Effects of surface-sterilizing treatments on germination, growth, and microbial contamination of seeds and excised embryos of corn (Zea mays L.) were investigated. Treatment sequence, 70% ethanol dip plus a 5-minute exposure to 2.6% sodium hypochlorite, was most effective for both whole seeds and embryos. The procedure should be useful for other monocot species.

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Sterile culture of seeds and excised embryos is becoming a common technique for germination and growth of intergeneric and interspecific hybrid seed. Also, it is used for basic physiological, biochemical, and genetic studies. Use of the technique requires plant material free from microbial contamination; thus, before culture, surface sterilization of potentially infected material is necessary.

Most published procedures give a specific treatment for sterilizing specific material, but there is little data on relative effectiveness of a number of treatments. Smith et al. (4), used a 10-minute exposure to merthiolate (1:2000) for surface-sterilizing peach seeds and a 5-minute exposure to 2.6% sodium hypochlorite for excised peach embryos. Various surface sterilizing procedures for corn seeds have been reported; e.g., 70% ethanol dip (6), washings with "Tide" (1), and dip in 1:1 diluted S. T. 37 (4-hexylresorcinol) (5). Miflin (2) surface-sterilized barley seeds with a 1-hour treatment of 3-5% sodium hypochlorite. He used 0.1% $HgCl_2$ (3 minutes) plus 0.01% H_2O_2 (3 minutes) for barley embryos. Morrison et al. (3), used 1:10 diluted "Javex" for 1 minute to surface-sterilize barley seeds.

This paper compares effectiveness of several surface-sterilizing treatments for corn seeds and excised embryos.

MATERIAL AND METHODS

Agar-sucrose basal medium (A-S basal medium) used in these experiments was originally developed by Dure (1) for seeds and excised embryos of corn and is presented in Table 1.

Surface-sterilization treatments (used individually and in combination) were 70% ethanol, 1:2000 merthiolate (obtained from Eli Lilly and Co.),

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Table 1. Synthetic nutrient medium used in culturing seeds and embryos.

Component	Concentration (mg/l)
Sucrose	20,000.0
Agar	7,500.0
$Ca(NO_3)_2 \cdot 4H_2O$	237.0
KNO_3	85.0
KCL	65.0
$NaH_2PO_4 \cdot H_2O$	16.5
$MgSO_4 \cdot 7H_2O$	36.0
FeCitrate (Ferric)	30.0
$MnSO_4 \cdot 4H_2O$	0.4

2.6% sodium hypochlorite (diluted from commercial bleach), and 2.5% Ferbam in water (carbamate powder obtained from Niagara Chemical Division of FMC Corporation).

Whole corn seeds of the single cross A619 x SD10 were treated (10 seeds per treatment) with the sterilizing solutions, rinsed three times in sterile water, soaked (to soften seeds) for 55 minutes in sterile water, and transferred to 22 x 175 mm culture tubes containing 20 ml A-S basal medium. Tubes were plugged with porous plastic plugs. Excised embryos of A619 x SD10 were allowed to become uniformly contaminated (by handling and air exposure) and then treated similarly, except that they were not soaked. Cultures were incubated in a germination chamber with constant temperature (24°C) and light (700 ft-c). Seedlings were observed after they attained maximum germination and growth (8 and 13 days for whole seeds and excised embryos, respectively) and were evaluated for percentage germination, shoot length, and percentage microbial contamination (subdivided on the basis of colony morphology into bacterial and fungal components). Percentage values were based on number of total cultures per treatment; therefore, only shoot length was replicated and analyzed statistically by student's t test.

RESULTS AND DISCUSSION

In experiment 1, three treatments, 1:2000 merthiolate for 10 minutes, 2.6% sodium hypochlorite for 5 minutes, and 70% ethanol dip plus 2.6% sodium hypochlorite for 5 minutes, resulted in significantly greater shoot growth than did the control (Table 2). Shoot length differences among the three treatments were not statistically different. Combination treatment most effectively removed contamination.

Table 2. Effects of surface-sterilization treatments of whole corn seeds on seed germination, seedling shoot length, and culture contamination.

Treatment	% Germination	Shoot* length(mm)	% Contamination Bact.	Fung.
	Experiment 1			
Control (no treatment)	85	26.4 a	30	100
70% ethanol dip	100	58.8 b	50	5
1:2000 merthiolate (10 min.)	100	79.1 c	35	0
2.6% sodium hypochlorite(5 min.)	100	80.9 c	0	10
2.5% Ferbam dip	70	24.6 a	0	100
70% ethanol + 2.6% sodium hypochlorite	100	83.9 c	0	5
	Experiment 2			
Control (no treatment)	95	62.2 a	15	50
70% ethanol + 2.6% sodium hypochlorite	100	75.4 b	0	5
2.5% Ferbam + 2.6% sodium hypochlorite	100	76.4 b	0	5
	Experiment 3			
Control (no treatment)	90	57.0 b	15	50
70% ethanol + 2.6% sodium hypochlorite	100	75.0 c	0	0
70% ethanol + 1:2000 merthiolate + 2.6% sodium hypochlorite	95	41.7 a	0	0
	Experiment 4			
Control (no treatment)	90	48.5 a	20	67
70% ethanol + 2.6% sodium hypochlorite	100	78.1 b	0	3

* Means within an experiment followed by same letter are not-significant at 5% level of probability.

Experiments 2-4 showed 2.5% Ferbam dip plus 2.6% sodium hypochlorite for 5 minutes and 70% ethanol dip plus 2.6% sodium hypochlorite for 5 minutes resulted in equivalent germination, seedling growth, and contamination control (Table 2). A sequence of three treatments, 70% ethanol, 1:2000 merthiolate, and 2.6% sodium hypochlorite, was an effective sterilant, but it substantially retarded growth and reduced germination (Table 2). For all experiments, low germination percentages were associated with high amounts of microbial contamination. Because of consistent results and handling ease, 70% ethanol dip plus 5-minute exposure to 2.6% sodium hypochlorite is suggested as a reliable surface-sterilizing treatment for whole corn seeds.

If excised embryos are internally contaminated or become contaminated during excision, resterilization is necessary. Thus, four resterilization treatments were compared (Table 3). Shoot length differences for embryos treated with 70% ethanol plus 2.6% sodium hypochlorite and 2.5% Ferbam plus 2.6% sodium hypochlorite were not statistically significant. Growth of embryos receiving these treatments was greater than for other treatments. Although treatments resulted in decreased seedling growth (compared with control), 70% ethanol plus 2.6% sodium

Table 3. Effects of resterilization treatments of excised corn embryos* on embryo germination, seedling shoot length, and culture contamination.

Treatment	% Germination	Shoot† length (mm)	% Contamination Bact.	% Contamination Fung.
Control (no resterilization)	95	59.1 c	25	5
70% ethanol + 1:2000 merthiolate	100	17.6 a	5	0
1:2000 merthiolate + 2.6% sodium hypochlorite	100	14.6 a	10	0
2.5% Ferbam + 2.6% sodium hypochlorite	100	28.9 b	0	10
70% ethanol + 2.6% sodium hypochlorite	100	35.2 b	0	5

* All embryos excised from seeds surface sterilized with 70% ethanol + 2.6% sodium hypochlorite.

† Means followed by same letter are not significant at 5% level of probability.

hypochlorite gave the least inhibition, and these seedlings developed normally after transfer to soil. Also, 70% ethanol plus 2.6% sodium hypochlorite gave the most effective contamination control; therefore, this treatment is recommended for resterilization of excised embryos.

The sterilization procedure recommended in this paper emphasizes flexibility and handling ease. Both whole seeds and excised embryos can be sterilized with identical materials. Constituents used produce no residual effects on subsequent plant growth, yet are of sufficient potency to control microbial contamination. Data presented are for corn seeds and embryos, but preliminary experiments with sorghum show similar results, suggesting the procedure may be applicable to other monocot species.

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VARIATION AND INTERRELATIONSHIPS OF PROTEIN AND OIL CONTENT, AND SEED WEIGHT, IN GRAIN SORGHUM[1]

V. H. Reich and R. E. Atkins

ABSTRACT. Protein and oil percentages and 100-seed weights were determined on parental, F_1, and F_2 hybrid seed of grain sorghum. Variation in oil content within each population was less than 1%. Protein percentage among the F_1 and F_2 hybrids ranged from 8 to 18 and from 10 to 16, respectively. Correlations among the three characters for F_2 seed were positive, indicating no marked barriers to the simultaneous improvement of protein and oil percentage and seed weight in commercial hybrid sorghums. The heritability of each character seemed sufficient for reasonably effective selection within segregating populations.

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Sorghum grain is used in the United States principally as feed for animals. Composition of the grain is similar to that of corn, except for a higher protein and lower oil content. The content and quality of protein in sorghum grain have been studied considerably, but variability for oil content has received little attention. Sorghum grain also is used by the wet-milling industry for the production of starch and its derivatives, with an edible oil as a principal by-product. Lines with strikingly high percentages of grain protein have been identified recently within the world sorghum collection, and efforts to transfer high protein content into desirable agronomic types are underway. Marked differences in seed size also occur among lines in the collection. Little information has been published on the interrelationships among these attributes in grain sorghums. This paper presents the results of determinations for grain protein and oil percentages and 100-seed weight made on 48 sorghum hybrids and their parental varieties.

REVIEW OF LITERATURE

Several investigations have shown that the protein content of sorghum grain may differ appreciably among varieties or hybrids. Marked effects of cultural practices and environmental conditions on protein percentage have also been reported. Protein percentage among 28 varieties ranged from 7.3 to 10.5 in a 2-year study by Heller and Sieglinger (1944). A range of 11.6 to 15.0% protein was obtained at the same location in a different year, but, at another Oklahoma location, the range among the same varieties was from 8.9 to 11.8%. Drouth stress was observed to decrease yields, but increase protein percentages.

[1] Journal Paper No. J-6739 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa. Project 1364.

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Hubbard et al. (1950) found a range of only 11.5 to 13.2% protein in the whole grain of five varieties of sorghum. A range in protein content of 8.7 to 16.8% was reported by Miller (1958), but he did not indicate whether varieties or hybrids were evaluated. Grain protein determinations were made on six varieties and 35 sorghum hybrids by Worker and Ruckman (1968). The varieties and hybrids responded alike to different environmental conditions. Mean grain protein content over a 5-year period was 10.1 and 14.8% from plantings in April and July, respectively. The complete range was 8.5 to 21.5% during this period, depending on variety, year, and planting date. Seed size and protein percentage were correlated significantly (r = 0.55) in their experiments.

Similar ranges in grain protein (6.6 to 12.8% and 5.9 to 12.1%) among the entries in Kansas hybrid sorghum trials in two seasons were reported by Miller et al. (1964). Significant differences among locations and hybrids were found, and fertilizer applications resulted in both increased yields and protein percentages. In tests where check varieties were included, the standard varieties were higher in protein percentage than the hybrids. In other tests in Kansas, Deyoe and Shellenberger (1965) found a range of 8.6 to 12.5% in protein content among 15 sorghum hybrids grown at three locations. Significant differences were noted for the hybrids, locations, and hybrids x location sources of variation.

Analyses of the grain of entries in the world sorghum collection by Pickett (1969a) showed a range of 7 to 26% in crude protein. Values above 20% were obtained mostly with grassy-types, but a range of 8 to 20% protein was obtained among grain types. In a subsequent study by Picket (1969c) with hybrids among some of the entries, positive correlations of seed size with grain yield (r = 0.42) and seed size with protein yield (r = 0.51) were obtained. With hybrids among a different group of lines, Pickett (1969b) found a negative association (r = -0.57) between yield and protein percentage.

Oil content of the whole grain ranged only from 3.2 to 3.9% among five sorghum varieties analyzed by Hubbard et al. (1950). The range in oil percentage among the 28 varieties evaluated by Heller and Sieglinger (1944) at two locations in two years was 1.4 to 3.9. A somewhat greater range (1.2 to 5.7%) was reported by Pickett (1969a) among diverse entries of the world sorghum collection.

Seed protein and oil content are correlated negatively in some crop species. Simultaneous increases of both constituents by plant breeders, therefore, have been difficult with these crops. According to Wilcox (1969), soybeans consistently have shown negative correlations between oil and protein content, ranging from -0.48 to -0.77. Associations of both oil and protein content with seed size in soybeans have been variable. Some studies associate high-oil and high-protein percentage with large seed, but others indicate that high values for both constituents are correlated with small seed. Brown et al. (1966) found significant negative correlations of -0.31 and -0.48 between oil and protein content in spring and winter oats, respectively. Correlations of 0.72 and 0.79 were obtained between oil percentage and 100-seed weight in two experiments with flax by Johnson (1932).

Oil and protein content of the corn kernel were not significantly correlated (r = 0.23) in the experiments of Brunson et al. (1948). They

also observed that kernel size had little influence on composition of the kernel. Hopkins et al. (1903) reported that the correlation between protein and oil content of corn was very low. In two synthetic varieties of corn, previously selected for oil content in the grain, Alexander and Seif (1963) found oil content independent of kernel weight. Miller and Brimhall (1951) found that variation in total-oil percentage was not closely associated with the variation in total-protein percentage of corn kernels. Correlations between these attributes were not significant, ranging from -0.04 to 0.33 in F_2 and backcross populations.

In sorghum, oil and protein content of the grain were significantly correlated ($r = 0.44$) in an experiment reported by Pickett (1969c). The experiment involved six genotypes planted at three population densities. Additional evaluations of associations between these attributes in sorghum were not found in the literature.

EXPERIMENTAL PROCEDURE

Sorghum grain samples of 14 parental varieties, plus the F_1 and F_2 seed of 48 hybrids, were obtained from plantings at Ames, Iowa. The F_1 hybrid seed was produced by pollinating each of six male-steriles (A-lines) with eight different pollen fertility restorers (R-lines). F_2 seed was obtained the same year from an adjacent experiment by bagging heads of F_1 plants of these hybrids. Seed of the parents was obtained from bagged heads of the R-lines and B-lines (fertile, nonrestorer counterparts of each male-sterile).

Samples for determining the oil percentage of each F_2 entry were obtained by bulking seed from three bagged heads from each of two field replicates. For the parental and F_1 seed, three heads of each entry were bulked from controlled self- and cross-pollinations, respectively. Twenty-five grams from each bulked sample were used to determine oil percentage of the whole seed. Oil percentages were determined[3] by wide-line nuclear magnetic resonance (NMR) using a Varian PA-7 Process Analyzer equipped with integrator V4221. Conway and Earle (1963) have shown that oil percentages by NMR and by gravimetric analysis are highly correlated ($r = 0.99$).

Duplicate 100-seed lots were taken from each sample after oil percentages were determined and seed weights in centigrams were recorded. These samples were ground in a Wiley mill (40-mesh screen), and 0.1 gram of the pulverized seed from each sample was used for the crude protein analyses. Nitrogen determined by the micro-Kjeldahl procedure was converted to protein percentage by multiplying by a 6.25 factor. Analyses of variance of the date for each attribute, and correlations among attributes, were calculated in accordance with the methods of Snedecor (1956).

[3] Thanks are extended to Dr. D. E. Alexander, Agronomy Department, University of Illinois, for the oil percentage determinations.

RESULTS AND DISCUSSION

Oil and protein percentages, plus 100-seed weights, of the 14 parental varieties are listed in Table 1. In the development of these lines, selection has been directed largely toward their value as either seed or pollen parents and their combining ability for grain yield in hybrid combinations. Seed size and desirability for other agronomic and disease characteristics also have been considered, but protein and oil content of the grain have received little attention. Significant differences in oil content, within either the male or female parent groups, were not indicated by the analysis of variance. The range among all parents was less than 1%. Protein percentages among the parents differed more than did their oil content, with a range of 11.1 to 14.4% among all parents. Differences in protein percentages among the female parents exceeded the 5% probability level. Similarly, the female parents differed significantly (1% level) for 100-seed weight, but the male parents did not.

Mean oil percentages for F_1 and F_2 seed of the 48 hybrids are given in Table 2. Comparable data for protein percentage are given in Table 3.

Table 1. Mean oil and protein percentage, and 100-seed weight, of parental varieties of grain sorghum.

	Character 1/		
	Oil (%)	Protein (%)	100-seed wt (g)
Male parents			
Norghum	3.38	12.0	2.46
Texas 7078	3.17	12.6	2.85
Texas 04	2.92	12.7	2.65
Texas 07	3.30	12.1	2.13
Texas 74	3.35	11.5	2.55
Redbine 60	2.93	13.3	2.80
Plainsman	3.01	11.1	2.39
Caprock	3.15	11.4	2.66
Mean of male parents	3.15	12.1	2.56
Female parents			
Reliance	3.31	14.4	2.39
Martin	3.45	13.3	3.01
Combine Kafir 60	3.05	11.8	3.02
Westland	3.10	11.3	2.50
Wheatland	3.05	11.9	3.52
Redlan	2.77	11.3	3.14
Mean of female parents	3.12	12.3	2.93
Mean (all parents)	3.14	12.2	2.72

1/ $LSD_{.05}$ (among individual parent means), oil percentage = 0.45, protein percentage = 2.1, 100-seed wt. = 0.58.

Table 2. Mean oil percentage of F_1 and F_2 hybrid seed of grain sorghums.

Male parents	Female parents: Reliance F_1	Reliance F_2	Martin F_1	Martin F_2	Kafir 60 F_1	Kafir 60 F_2	Westland F_1	Westland F_2	Wheatland F_1	Wheatland F_2	Redlan F_1	Redlan F_2	Means of hybrids F_1	Means of hybrids F_2
Norghum	3.53 1/	3.63	3.64	3.50	3.26	3.27	3.36	3.27	3.37	3.14	3.45	3.19	3.43	3.33
Texas 7078	3.54	3.46	3.64	3.59	3.55	3.35	3.26	3.45	3.27	3.38	3.51	3.41	3.46	3.44
Texas 04	3.32	3.38	3.28	3.60	3.38	3.28	3.44	3.43	3.03	3.59	3.16	3.51	3.27	3.46
Texas 07	3.57	3.53	3.63	3.56	3.38	3.43	3.68	3.56	3.03	3.54	3.25	3.66	3.42	3.55
Texas 74	3.58	3.66	3.76	3.81	3.31	3.44	3.40	3.46	3.13	3.54	3.40	3.45	3.43	3.56
Redbine 60	3.79	3.50	3.76	3.33	3.21	3.18	3.70	3.27	3.19	3.43	3.11	3.26	3.46	3.33
Plainsman	3.39	3.48	3.02	3.52	3.47	3.40	3.30	3.37	3.04	3.38	2.95	3.35	3.19	3.42
Caprock	3.33	3.56	3.55	3.50	3.47	3.49	3.63	3.40	2.92	3.54	3.35	3.23	3.37	3.45
Means of hybrids	3.51	3.53	3.60	3.55	3.38	3.36	3.47	3.40	3.13	3.45	3.27	3.39	3.39	3.45

1/ $LSD_{.05}$ (F_1), individual hybrids = 0.45, means by female groupings = 0.18, means by male groupings = 0.15

$LSD_{.05}$ (F_2), individual hybrids = 0.11, means by female groupings = 0.04, means by male groupings = 0.04

Table 3. Mean protein percentage of F_1 and F_2 hybrid seed of grain sorghums.

Male parents	Female parents: Reliance F_1	Reliance F_2	Martin F_1	Martin F_2	Kafir 60 F_1	Kafir 60 F_2	Westland F_1	Westland F_2	Wheatland F_1	Wheatland F_2	Redlan F_1	Redlan F_2	Means of hybrids F_1	Means of hybrids F_2
Norghum	13.1 1/	13.2	16.7	12.9	13.0	10.4	13.9	10.7	13.6	13.8	14.0	11.5	14.0	12.1
Texas 7078	14.8	11.0	14.0	11.8	12.5	11.2	13.6	13.5	14.6	11.1	13.4	13.5	13.8	12.0
Texas 04	15.3	13.2	13.9	13.6	11.2	12.2	14.1	14.2	13.9	13.7	9.4	13.9	13.0	13.5
Texas 07	16.8	12.3	16.5	13.1	12.7	12.8	14.2	12.8	14.0	13.5	14.1	13.7	14.7	13.1
Texas 74	17.5	16.1	16.7	14.2	10.6	14.3	13.6	13.6	14.9	12.3	7.9	14.6	13.5	14.2
Redbine 60	16.9	13.3	14.8	13.0	11.6	12.1	14.3	11.8	14.8	12.4	12.5	14.2	14.2	12.8
Plainsman	15.4	12.6	14.9	13.1	12.0	13.5	15.7	10.9	14.5	11.7	14.4	13.0	14.5	12.5
Caprock	18.0	11.4	14.7	14.1	14.0	13.4	11.4	12.6	14.7	10.7	14.7	13.7	14.6	12.7
Means of hybrids	16.0	12.9	15.3	13.2	12.2	12.5	13.9	12.5	14.4	12.4	12.6	13.5	14.0	12.8

1/ $LSD_{.05}$ (F_1), individual hybrids = 2.1, means by female groupings = 0.87, means by male groupings = 0.75

$LSD_{.05}$ (F_2), individual hybrids = 2.3, means by female groupings = 0.92, means by male groupings = 0.79

The parental and F_1 seeds were produced in the breeding nursery, but the F_2 seeds were obtained from an adjacent yield trial. Therefore, separate analyses of variance were calculated for the F_2 data and for the F_1 plus parental variety results. Significance at the 5% probability level was shown for the F_1 hybrids vs. parents comparison for oil percentage. Mean oil percentage for the F_1's was 3.39, compared with 3.14 for the parents. The range among the hybrids in oil content of the F_1 seed was small (2.92 to 3.79). The mean and range in oil content of the F_2 seed were similar to those for the F_1 seed. Average mid-parent heterosis for oil content of the F_1 seed was 8%, and the F_2 seed averaged 10% higher than the parental mean.

Data from reciprocal crosses in soybeans by Singh and Hadley (1968) and in corn by Woodworth and Mumm (1935) show a strong maternal effect on oil percentage of the grain. Oil content of the F_1 seed in these studies was much closer to that of selfed seed from the female parent than to that of selfed seed from the male parent. Our study with sorghum did not include reciprocal crosses, but the data generally are not indicative of a strong maternal influence on oil content. Crosses with Redlan serve particularly well to support this conclusion. The Redlan female parent was lower in oil percentage than any of the male parents, but the F_1 seed of all crosses with Redlan exceeded the mid-parent value. Usually, the F_1 seed approached or exceeded the oil content of the male parent. Although less pronounced and consistent, this trend also was evident in many of the crosses involving other female parents. The reverse was true, however, in crosses with the Martin female parent. It was higher in oil content than any of the male parents, and the F_1 seeds of its crosses always exceeded the mid-parent oil percentage.

In the analyses of variance for both the F_1 and F_2 data, a partitioning of the variation among hybrids within each female parent was made. For oil percentage of the F_1 seed, the variation among the eight hybrids involving a given female parent was not significant in any instance. However, for the F_2 seed, the variation among hybrids involving a particular female parent always was significant (1% level). This contrast in variation within the two populations suggests that the oil content of sorghum seed is influenced by the genotype of the seed and is not strictly determined by the genotype of the plant producing the seed. Analyses of the oil content of single F_2 seeds would be necessary to categorize the nature and extent of the genotypic effects.

Protein percentages of the F_1 vs. parental seed differed significantly (1% level) and showed an average mid-parent heterosis of 15%. A few very low and high percentages extended the range from 7.9 to 18.0, but most F_1 hybrid seed had 11 to 14% protein. Variation among F_1's was partitioned into variation among hybrids within each female parent, and variation was significant for all but the Combine Kafir 60 and Wheatland hybrids. For the F_2 seed, variation within the Westland, Combine Kafir 60, and Reliance hybrids was significant, but the hybrids within each of the other female parents did not differ significantly in protein content. Mean protein content of the F_2 seed (12.8) was about 8% less than that of the F_1 seed (14.0), but 5% above the parental mean.

Seed weights for the individual hybrids are not presented, but mean weights per 100 seeds for the parental, F_1, and F_2 seed were 2.72, 3.23,

and 3.07 grams, respectively. Mid-parent heterosis for the F_1 seed averaged 19%. For the F_2 seed, mean seed weight was 13% greater than the average of the parental varieties. In the variance analysis of the F_1 data, only the hybrids involving the Martin female parent differed significantly for seed weight, but for the F_2 seed the variation among hybrids within each female parent was significant.

Correlation coefficients for oil vs. protein percentage, oil content vs. 100-seed weight, and protein content vs. 100-seed weight are presented in Table 4. The association of oil and protein content was positive among the parental varieties and among both the F_1 and F_2 seed of the hybrids. Only the coefficient for the F_2 seed was significant.

Table 4. Correlation coefficients for oil vs. protein percentage, oil content vs. 100-seed weight and protein content vs. 100-seed weight in three types of grain sorghum populations.

	Characters correlated[1]		
Population[2]	Oil vs. protein	Oil vs. seed weight	Protein vs. seed weight
Parental varieties	0.288	-0.304	0.011
F_1 hybrid seed	0.184	0.048	-0.155
F_2 hybrid seed	0.299**	0.197	0.470**

[1] **, Coefficient exceeds the 1% level of probability.

[2] 26 df for parental varieties, 94 df for F_1 and F_2 hybrid populations.

Hybrids are planted on nearly all grain sorghum acres in the United States, and the F_2 seed is used for animal or human food and for processing by the milling industry. Therefore, the associations among attributes in the F_2 seed are especially pertinent. The positive correlations of protein and oil content indicate that selection by plant breeders for high protein grain should not preclude a simultaneous improvement in oil content. The correlation of 0.299 between protein and oil percentage in the F_2 seed, however, transposes to a coefficient of determination (r^2) of less than 0.1. This value would be even smaller for the parental and F_1 seed. Thus, selection for high protein content would not have been highly effective in also improving oil content, but at least, marked impediments to the simultaneous improvement of both attributes (as cited for soybeans) were not indicated within the populations of this study. Whether a similar relationship exists among sorghums more diverse for oil and protein content remains to be determined.

The correlations for both oil and protein content with 100-seed weight of the F_2 seed also were positive. For protein content vs. seed weight, the correlation is significant and fairly strong. Collectively, the correlations for the F_2 seed do not indicate any assocations that would impede the development of hybrids that have large seeds with relatively high protein and oil content. The F_2 seed of several of the hybrids had relatively high values for all three attributes, particularly the Reliance x Texas 74, Martin x Texas 74, and Redlan x Texas 07 hybrids.

Correlations among the three attributes also were calculated for the

F_1 and F_2 seed of the hybrids within each female parent group. The degrees of freedom for testing the significance of the correlations within these groups are small (14 df), thus only the coefficients based on the entire F_1 and F_2 populations are presented. Moderately large coefficients were more frequently obtained for the correlations determined within individual female parents, and most were positive. A few nonsignificant negative associations were noted, but all significant coefficients were positive. The variations among individual group correlations indicate that the strength of the interrelationships among oil and protein content and seed weight may be affected by female parentage of the hybrids.

The F_2 data also were analyzed according to the Design II procedure of Comstock and Robinson (1948). The heritability of each attribute was calculated by determining the proportion of the total variance due to additive gene action. Heritabilities for oil content, protein content, and 100-seed weight were 65%, 32%, and 52%, respectively. These values may overestimate the true heritability of the characters, since the data are from a single experiment, and a separation of genotype x environment interactions from the genetic variance is not possible. Nevertheless, each character seems sufficiently heritable to indicate that selection in these populations should be reasonably effective for the improvement of oil and protein content and seed weight. Also, one should bear in mind that our populations were derived from crosses among a small group of highly selected parental varieties. The highly diverse lines of the world sorghum collection may well differ more widely in their genetic constitution for these characters. Crosses among these lines should provide populations with larger genotypic variances and higher heritabilities. Selection within populations of this type likely would be considerably more effective for improving the protein and oil content and seed size of grain sorghums.

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LIFE HISTORY OF MICROTETRAMERES CENTURI BARUS, 1966 (NEMATODA: TETRAMERIDAE). III. TAXONOMY

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ABSTRACT. The taxonomic status of the genus Microtetrameres is discussed. Arguments are presented for maintaining Tetrameres and Microtetrameres as separate genera and for substantiating their possible future placement in separate families.

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The validity of the nematode family Tetrameridae Travassos, 1914 has been challenged by some but accepted by many (Chabaud 1951, Cram 1927, La Page 1961, Oshmarin 1956, Oshmarin and Parukhin 1963, Petrov and Chertkova 1950, Rasheed 1960, Skrjabin 1916, Skrjabin and Soblev 1963, Sultana 1962, Travassos 1914, Yamaguti 1935, Yorke and Maplestone 1926). On the other hand, Tetrameridae has been listed as a synonym of Spiruridae (Chitwood and Wehr 1934). Still others maintained the latter designation (Lopez-Neyra 1947, Wehr 1934). Whichever familial designation was used, the two genera Microtetrameres and Tetrameres have been included within the same family.

Despite the fact that Yamaguti (1935) placed Tetrameres scolopacis in the family Tetrameridae, he (Yamaguti 1961) recently reverted to the use of Tropisurus instead of Tetrameres. The genus Tropisurus was erected by Diesing in 1835. He indicated in a footnote that this name was constructed from two Greek words, "tropis" (keel) and "ura" (tail). But, he erred (Stiles and Baker 1930, Wiegmann 1835) in constructing this generic name because the genitive case of "tropis" is "tropidos." Hence, the proper masculinized designation should be Tropidurus. This generic name, however, ha been preempted in 1824 by Neuwied to name a reptile genus (Agassiz 1848). Therefore, in 1846, Creplin re-named the genus Tetrameres and general acceptance of this designation is indicated by its almost exclusive usage in nematological literature. Tetrameres, therefore, should be the valid name for this genus despite the acceptance of Tropisurus by others (Barus 1966, Ortlepp 1964, Yamaguti 1961).* Tetrameres is the type genus for the family Tetrameridae which includes Microtetrameres as the only other genus.

The genera Tetrameres and Microtetrameres parasitize birds only, except, doubtfully, Tetrameres bispinosa reported by Molin (1860) from Scincus sp. These genera are classified within Tetrameridae, but Lopez-Neyra (1958) proposed placing the genus Crassicauda in this

* The name Tetrameres Creplin 1846 has been validated by the International Commission on Nomenclature (Opinion 892, October 1969) and Tropisurus Diesing 1835 was suppressed, according to Chitwood (1970, J. Parasit. 56:374).

family also. This suggestion may be inappropriate as the latter genus is found in cetaceans (Baylis 1916, Baylis 1920, Baylis 1922, Joyeux and Baer 1951, Skrjabin and Andreeva 1934) and the other genera are found in birds.

Chabaud (1951) proposed including three subfamilies, Crassicaudinae, Geopetitiinae and Tetramerinae, within the family Tetrameridae, with Crassicauda and Geopetitia as the type genera, respectively, for the first two of the subfamilies. Tetrameres was considered the type genus for Tetramerinae which also included Microtetrameres.

These subfamilies, according to Chabaud (1951), should be grouped together because they are related morphologically to both spirurid and filarial nematodes. The remarkable anatomical resemblance between a first-stage juvenile Microtetrameres and a microfilaria has been reported (Ellis 1969a). Furthermore, Chabaud developed the idea that evolution would link these three genera within one family.

The maintaining of Microtetrameres and Tetrameres as two distinct genera is substantiated by anatomical differences between adults and juveniles of the two genera. For instance, adult female Tetrameres are globose or spindle-shaped; those of Microtetrameres are coiled. The buccal capsules of the females of the two genera are quite different, the latter being more complex. The eggs of the two genera differ in the presence of bosses on eggs of Microtetrameres and their absence in Tetrameres. Presumed and known males of Tetrameres possess longitudinal rows of spines; these are absent on presumed and known males of Microtetrameres (Ellis 1969b). First-stage juveniles of Tetrameres possess caudal spines or papillae (Chabaud 1954, Seurat 1918); third-stage Tetrameres americana, experimentally reared, also exhibit these (Cram 1931). Such structures are absent from third-stage M. centuri juveniles (Ellis 1969a).

Some members of the family Spiruridae, as well as juvenile Tetrameres, also possess spines or papillae on their posterior ends. Some of these spines are on a small terminal "bouton" (Seurat 1915-16); others adorn rounded tail ends (Chabaud 1954). Larger spines occur on the tails of presumed fourth-stage juvenile Tetrameres fissipina (Seurat 1918) and papillae have been seen on T. americana third-stage juveniles experimentally reared (Cram 1929, 1931). However, spines and papillae are absent on the posterior ends of laboratory-reared juveniles of M. centuri (Ellis 1969a). Spines were not reported on the same stage of M. helix (Cram 1934) nor from first-stage Tropidocerca (= Microtetrameres) inermis (Seurat 1913). Juveniles of M. helix, M. inermis, and M. centuri terminate posteriorly in a sharp tail. In third-stage juveniles the tail extends to a tiny, glabrous hemisphere.

Because of the anatomical differences and because known data show that members of the genus Tetrameres parasitize aquatic and semi-aquatic birds and those nematodes included in Microtetrameres are harbored by nonaquatic avian hosts, one might relegate the two genera to separate families, Chabaud (1951) notwithstanding. Such action seems premature, however, because of insufficient experimental and quantitative evidence. Therefore, until more information is available the two genera should be kept in Tetrameridae.

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COMPARATIVE MEASUREMENTS AND HOST AND GEOGRAPHICAL DISTRIBUTION OF SPECIES OF MICROTETRAMERES (NEMATODA: TETRAMERIDAE)

Charles J. Ellis

Females of the nematode genus Microtetrameres are parasites found exclusively in the proventricular glands of birds. Their presence has been reported by authors throughout the world whose investigations concerned only wild birds. However, three reports (Cram 1934, Ellis 1969a, 1969b) dealt with experimental rearing of these parasites. Adult males assumed to be of this genus have been mentioned but only one description of such a male raised from an egg is known (Ellis 1969b). The pathogenicity of this genus has been reported (Ellis 1970). However, this work does not indicate how wide-spread the pathological effects of this parasite might be within the Class Aves. Such information might have little practical value as no species of Microtetrameres has been found in birds of economic importance. Perhaps this fact contributes to the dearth of data concerning its pathology.

A large population of these nematodes in the proventriculus of any bird probably would be quite detrimental. Such a number of parasites probably would block the production of acid and in turn would disrupt the digestive processes of the host. Such a hypothesis has been offered (Ellis 1970). However, it remains to be verified in terms of numbers of nematodes per proventriculus.

Some doubt existed concerning the proper family to which this genus should be assigned. It has been classified variously within the Spiruridae, Tropisuridae, and Tetrameridae. However, arguments favoring the latter familial assignment have been presented (Ellis 1971). The taxonomy of the family Tetrameridae itself has been subjected to some question. With more study, perhaps it will be assigned certain other genera or subgenera.

Many investigators interested in the genus Microtetrameres must know its geographic and host distribution and the comparative anatomical measurements. These data can be determined accurately only by an extensive literature search.

Such a search has been completed and the data so accumulated are presented below. No attempt has been made to change the classificatory work of the various authors. All tabulated entries have been made from current literature or personal communication.

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Table 1. Species of Microtetrameres with their hosts and geograpical distribution.

Microtetrameres species	Avian species	Location	Investigator
accipiter	Accipiter gentilis	Idaho	Schell, 1953
aquila	Aquila chrysaetos	Montana	Schell, 1953
asymmetricus	Lanius cristatus	Russia	Oshmarin, 1956
bubo	Asio flammeus	Russia	Oshmarin, 1956
bubo	Strix uralensis	Russia	Oshmarin, 1956
bubo	Otus bakkamoena	Russia	Oshmarin, 1956
bubo	Nyctea scandiaca	Russia	Oshmarin, 1956
bubo	"long-tailed owl"	Russia	Oshmarin and Parukhin, 1963
bubo	Bubo virginianus	Oregon	Schell, 1953
bucerotidi	Lophoceros flavirostris	Transvaal	Ortlepp, 1964
bucerotidi	Lophoceros erythrorhynchus	Transvaal	Ortlepp, 1964
calabocensis[a]	Buteo magnirostris insidiatrix	Calabozo	Diaz-Ungria, 1965
canadensis	Nyctea scandiaca	Hudson Bay	Mawson, 1956a
canadensis	Ardea herodias	Quebec and Ontario	Mawson, 1956a
centuri	Centurus superciliaris superciliaris	Cuba	Barus, 1966
cephalatus[a]	Turdus merula nigropileus	Hyderabad	Sultana, 1962
cloacitectus[a]	Buteo buteo	Bohemia	Barus, 1966
cloacitectus[a]	Buteo buteo	Russia	Oshmarin, 1956
contorta	Dichocerus bicornis	Tonkin	Hsu, 1935
contorta	Corvus frugilegus	Russia	Skrjabin, Shikhobalova and Sobolev, 1949
contorta	"corvidae"	Gorkii	Spasskii and Oshmarin, 1939

Microtetrameres species	Avian species	Location	Investigator
contorta	*Corvus frugilegus*	Roumania	Stoican, 1960
contorta	*Dichocerus bicornis*[b]	Pennsylvania	Weidman, 1913
corax	*Corvus corone*	Egypt	Myers, Kuntz and Wells, 1962
corax	*Corvus corax*	Idaho	Schell, 1953
corax	*Pica pica hudsonia*	Montana	Todd and Worley, 1967
creplini	*Accipiter nisus*	Russia	Vavilova, 1926
cruzi	*Ammospiza maritima macgillivraii*	North Carolina	Hunter and Quay, 1953
cruzi	*Bucco swainsoni*	Brazil	Travassos, 1914
cruzi	*Melanerpes flavifrons*	Brazil	Travassos, 1914
egretes	*Egretta garzetta*	Hyderabad	Rasheed, 1960
egretes	*Ardeola ibis ibis*	Cuba	Barus, 1966
gubernaculiferens[c,d]	"marsh harrier"	Tashkent	Sultanov, 1945
gubernaculiferens[a]	*Circus aeroginosus*	Central Asia	Sultanov, 1947
helix	*Corvus frugilegus*	Kirgizia	Ablasov and Chibichenko, 1962
helix	*Pica pica*	Kirgizia	Ablasov and Chibichenko, 1962
hilix (sic)	*Corvus levaillantii*	Primorsk	Bashkirova, 1960
helix	*Cyanopica cyana*	Primorsk	Bashkirova, 1960
helix	*Garrulus glandarius*	Primorsk	Bashkirova, 1960
helix	*Sturnus vulgaris*	New England	Boyd, 1951
helix	*Corvus americanus*	Washington, D.C.	Cram, 1927
helix	*Corvus brachyrhynchos brachyrhynchos*	Manitoba	Hodasi, 1963

Microtetrameres species	Avian species	Location	Investigator
helix	*Corvus brachyrhynchos brachyrhynchos*	Quebec	Mawson, 1956b
helix	*Corvus brachyrhynchos brachyrhynchos*	Iowa - Wisconsin	Morgan and Waller, 1941
helix asiaticus	*Pica pica*	Russia	Oshmarin, 1956
helix asiaticus	*Garrulus glandarius*	Russia	Oshmarin, 1956
helix asiaticus	*Cyanopica cyana*	Russia	Oshmarin, 1956
helix asiaticus	*Corvus corone*	Russia	Oshmarin, 1956
helix	*Corvus frugilegus*	Russia	Skrjabin, Shikobalova and Sobolev, 1949
helix	"corvidae"	Gorkii	Spasskii and Oshmarin, 1939
helix	*Corvus frugilegus*	Roumania	Stoican, 1960
helix	*Corvus corone cornix*	Bulgaria	Stoimenov, 1963
helix	*Tockus birostris*	Hyderabad	Sultana, 1962
inermis[e]	*Oenanthe isabelina*	Kirgizia	Ablasov and Chibichenko, 1962
inermis[e]	*Sturnus vulgaris*	Kirgizia	Ablasov and Chibichenko, 1962
inermis[e]	"sparrow-hawk"	Algeria-Russia-Turkestan	Cram, 1927
inermis[e]	*Passer domesticus*	Algeria-Russia-Turkestan	Cram, 1927
inermis[e]	*Astur nisus*	Algeria-Russia-Turkestan	Cram, 1927
inermis[e]	*Lanius* sp.	Algeria-Russia-Turkestan	Cram, 1927

Microtetrameres species	Avian species	Location	Investigator
inermis[e]	Alauda arvensis dulcinx	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Anthus spinoletta blakistani	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Corvus cornix sharpei	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Corvus frugilegus	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Emberiza leucocephalus	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Emberiza schoenichus pallidior	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Parus cinereus	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Parus major	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Phoenicurus erythronotus	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Scotocerca inquietta platyvra	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Turdus atrogularis	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Troglodytes troglodytes	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Sturnus vulgaris poltoratskyi	Tadzhikistan	Dubinina and Serkova, 1951
inermis[e]	Corvus coronae (sic)	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957

Microtetrameres species	Avian species	Location	Investigator
inermis[e]	*Falco subbuteo*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957
inermis[e]	*Sturnus vulgaris*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957
inermis[e]	*Astur palumbarius*	Algeria-Russia-Turkestan	von Linstow, 1879
inermis[e]	*Hypotriorchis subbuteo*[f]	Kirgizia	Petrov and Chertkova, 1950b
inermis[e]	*Corvus frugilegus*	Zelenec u Prahy	Rysavy, 1957
inermis[e]	*Corvus corax tingitanus*	Algeria	Seurat, 1913
inermis[e]	"moineau domestique"	Algeria	Seurat, 1913
inermis[e]	*Temenuchus pagodarum*	Hyderabad	Singh, 1949
inermis[e]	*Brachypternus bengalensis*[g]	Hyderabad	Singh, 1949
inermis[e]	*Corvus corone*	Algeria-Russia-Turkestan	Skrjabin, 1916
inermis[e]	*Corvus frugilegus*	Algeria-Russia-Turkestan	Skrjabin, 1916
inervis (sic)[e]	*Corvus frugilegus*	Roumania	Stoican, 1960
inermis[e]	*Leiopicus mahrattensis blanfordi*	Hyderabad	Sultana, 1962
inermis[e]	*Passer domesticus*	Maryland	Wilson, 1956
inermis[e]	*Corvus frugilegus*	Russia	Zekhnov, 1949
longiovatus	*Glaucidium siju vittatum*	Cuba	Barus, 1969
minima	*Tachyphonus cristatus bruneus*	Brazil	Travassos, 1914
mirzai	*Cerchneis tinnunculus interstinctus*[h]	India	Rasheed, 1960
oriolus	*Oriolus oriolus*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957

Microtetrameres species	Avian species	Location	Investigator
oriolus oriolus	*Oriolus oriolus turkestanicus*	Kirgizia	Petrov and Chertkova, 1950a
oriolus orientalis[a]	*Oriolus chinensis*	Russia	Oshmarin, 1956
oriolus	*Turdus merula*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957
oriolus	*Turdus ruficollis*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957
oriolus rasheedi	*Oriolus oriolus*	Russia	Skrjabin and Sobolev, 1964
oshmarini	*Asio flammeus*	Russia	Skrjabin and Sobolev, 1963
oshmarini	*Nyctea scandiaca*	Russia	Skrjabin and Sobolev, 1963
oshmarini	*Otus bakkamoena*	Russia	Skrjabin and Sobolev, 1963
oshmarini	*Strix uralensis*	Russia	Skrjabin and Sobolev, 1963
osmaniae	*Accipiter nisus nisosimilis*	Hyderabad	Rasheed, 1960
papillocephala[a]	*Butastur indicus*	Russia	Oshmarin, 1956
pelecani	*Pelecanus onocrotalus*	Middle Asia[i]	
pokrowskyi	*Ardea cinerea*	Mongolia	Petrov and Chertkova, 1950a
pusilla	"motley thrush"	Primorsk	Bashkirova, 1960
pusilla	*Turdus dauma*	Primorsk	Bashkirova, 1960
pusilla	*Turdus dauma*	Russia	Oshmarin, 1956
pusilla	*Turdus naumanni*	Primorsk	Bashkirova, 1960
pusilla	*Turdus naumanni*	Russia	Oshmarin, 1956

Microtetrameres species	Avian species	Location	Investigator
pusilla	*Turdus rufiventris*	Brazil	Travassos, 1915
pusilla	*Turdus viscivorus*	Russia	Skrjabin, Shikhobalova and Sobolev, 1949[j]
pusilla	*Platycichla flavipes*	Brazil	Travassos, 1915
rasheedae[a]	*Hierococcyx varius*	Hyderabad	Sultana, 1962
saguei	*Myadestes elisabeth elisabeth*	Cuba	Barus, 1966
saguei	*Myadestes elisabeth elisabeth*	Cuba	Barus and Garrido, 1968
singhi[a]	*Falco jugger*	Hyderabad	Sultana, 1962
spiculata	*Cyanocitta cristata*	New England	Boyd, Diminno and Nesslinger, 1956
spiralis	*Ardeola ibis ibis*	Egypt	Myers, Kuntz and Wells, 1962
spiralis	*Bubulcus coromandus*	India	Maplestone, 1931
spiralis	*Bubulcus ibis*	Alabama	Dismukes and Stuart 1970
spiralis	*Lanner falcon*	North Wales	Threlfall, 1965
spiralis	*Bubulcus lucidus*	Algeria	Seurat, 1915
spiralis	*Falco feldegii*	Wales	Threlfall, 1965
travassosi	*Gracula religiosa*[k]	Hyderabad	Rasheed, 1960
tubocloacis[a,l]	*Aquila clanga*	Russia	Oshmarin, 1956
xiphidiopici	*Xiphidiopicus percussus percussus*	Cuba	Barus, 1966
sp.	*Falco tinnunculus*	Slovakia	Barus, 1966
sp.	*Mimocichla plumbea rubripes*	Cuba	Barus and Garrido, 1968
sp.	*Motacilla alba*	Primorsk	Bashkirova, 1960
sp.	*Motacilla flava*	Primorsk	Bashkirova, 1960

Microtetrameres species	Avian species	Location	Investigator
sp.	*Pica pica hudsonia*	Montana	Carney, 1967[m]
sp.	*Coccyzus americanus*	Iowa	Daniell[m]
sp.	*Cyanocitta cristata*	Iowa	Daniell[m]
sp.	*Quiscalus quiscula*	Iowa	Daniell[m]
sp.	*Sturnella magna*	Iowa	Ellis, 1961
sp.	*Quiscalus versicolor*	Iowa	Ellis, 1961
sp.	*Colaptes auratus*	Iowa	Ellis, unpublished
sp.	*Cyanocitta cristata*	Iowa	Ellis, unpublished
sp.	*Melanerpes erythrocephalus*	Iowa	Ellis, unpublished
sp.	*Melospiza georgiana*	Iowa	Ellis, unpublished
sp.	*Myiarchus crinitus*	Iowa	Ellis, unpublished
sp.	*Passerella iliaca*	Iowa	Ellis, unpublished
sp.	*Progne subis*	Iowa	Ellis, unpublished
sp.	*Quiscalus quiscula*	Iowa	Ellis, unpublished
sp.	*Riparia riparia*	Iowa	Ellis, unpublished
sp.	*Stelgidopteryx ruficollis*	Iowa	Ellis, unpublished
sp.	*Toxostoma rufum*	Iowa	Ellis, unpublished
sp.	*Xanthocephalus xanthocephalus*	Iowa	Ellis, unpublished
sp.	*Emberiza bruniceps*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957
sp.	*Oriolus oriolus*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957
sp.	*Pastor roseus*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957

Microtetrameres species	Avian species	Location	Investigator
sp.	*Pica pica*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957
sp.	*Pyrrhocorax graculus*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957
sp.	*Turdus merula*	Kirgizia	Gagarin, Ablasov and Chibichenko, 1957
sp.	*Quiscalus quiscula versicolor*	Manitoba	Hodasi, 1963
sp.	*Accipiter nisus*	Primorskii	Oshmarin, 1956
sp.	*Coccothraustes coccothraustes*	Russia	Oshmarin, 1956
sp.	"goshawk"	Russia	Oshmarin and Parukhin, 1963
sp.	*Turdus merula*	Kirgizia	Petrov and Chertkova, 1950b
sp.	*Oriolus oriolus*	Hyderabad	Rasheed, 1960
sp.	*Athene noctua*	Turkmenistan	Rizhikov and Kozlov, 1959
sp.	"brown owl"	Turkmenistan	Rizhikov and Kozlov, 1959
sp.	*Falco tinnunculus*	Turkmenistan	Rizhikov and Kozlov, 1959
sp.	*Galerida cristata*	Turkmenistan	Rizhikov and Kozlov, 1959
sp.	*Lanius cristatus*	Turkmenistan	Rizhikov and Kozlov, 1959
sp.	*Motacilla alba*	Turkmenistan	Rizhikov and Kozlov, 1959
sp.	*Turdus ruficollis*	Turkmenistan	Rizhikov and Kozlov, 1959

Microtetrameres species	Avian species	Location	Investigator
sp.	Passer domesticus	Moldavia	Sciumilo, 1963
sp.	Turdus mg.	Colorado	Slater, 1967
sp.	Corvus frugilegus	Roumania	Stoican, 1960
sp.	Accipiter cirrohocephalus	Australia	Thomas, 1960[m]
sp.	Anthochoera chrysoptera	Australia	Thomas, 1960[m]
sp.	Cladorhynchus leucocephalus	Australia	Thomas, 1960[m]
sp.	Erolia acuminata	Australia	Thomas, 1960[m]
sp.	Falco berigora	Australia	Thomas, 1960[m]
sp.	Falco peregrinus	Australia	Thomas, 1960[m]
sp.	Gymnorhina hypoleuca	Australia	Thomas, 1960[m]
sp.	Lobibyx novae hollandiae	Australia	Thomas, 1960[m]
sp.	Myzantha melanocephalus	Australia	Thomas, 1960[m]
sp.	Ninox novae zeelandiae	Australia	Thomas, 1960[m]
sp.	Psephotus haemonotus	Australia	Thomas, 1960[m]
sp.	Agelaius phoeniceus	Iowa	Ulmer, 1966[m]

[a] Males only reported.
[b] From a zoon.
[c] No description of new species given, hence, a nomen nudum.
[d] See Sultanov, 1947.
[e] Status of this species is questionable because of variation in descriptions by Seurat (1913) and von Linstow (1879).
[f] This genus is a synonym for Falco (Ripley, 1961).
[g] This genus is a synonym for Dinoplum (Peters, 1948).
[h] Genus is Falco according to Ripley (1961).
[i] See Skrjabin, Shikhobalova and Sobolev (1949, p. 72).
[k] No other information given.
[l] Genus emended to Mainatus by Sharpe (1890).
[m] Transferred to Gubernaculomeres by Oshmarin and Parukhin (1963).
[n] Private communication.

Table 2. Comparative measurements (in millimeters) of Microtetrameres spp. originally described from the western hemisphere.

MALES Species	Lgth.	Width	Buccal capsule lgth.	Buccal capsule width	Spicule length long.	Spicule length short.	Pharynx length musc.	Pharynx length glnd.	Nerve ring to end[d]	Cerv. pap. to end[d]	Exc. pore to end[d]	Cloaca-tail dist.	Cloacal papillae[a]
accipiter													
Schell, 1953	3.6-4.4	.079-.104	.023	--	2.03-2.4	.100-.105	.212-.234	.650-.708	.144-.151	.162-.183	--	.165-.178	4 pre- 4 post-
aquila													
Schell, 1953	3.6-4.3	.090-.100	.025	--	1.48-1.8	.210-.234	.324-.340	.840-.960	.190-.205	.298-.300	.240-.252	.178-.195	4 pre- 4 post-
bubo													
Schell, 1953	3.5-3.9	.079-.081	.023-.025	--	1.8-1.9	.228-.230	.306-.370	.740-.790	.180-.190	.230-.240	.190-.220	.210-.220	4 pre- 6 post-
centuri													
Barus, 1966	3.04-3.78	.064-.076	.015-.019	.010-.012	2.06-2.23	.095-.118	.190-.228	.460-.499	.107-.140	--	.114-.156	.087-.110	4 pre- 4 post-
corax													
Schell, 1953	3.7-4.7	.086-.090	.021-.025	--	3.2-3.8	.120-.140	.244-.266	.620-.780	.151-.187	.194-.237	.154-.194	.160-.207	4 pre- 4 post-
cruzi													
Travassos, 1914	1.17-1.4	.086	.021	.004-.005	.651-.787	.082	.093	.290	--	--	--	.132	2 pre- 6 post-
helix													
Cram, 1927	4.9 (3.9)[b]	.100	.021	--	(3.12)[b]	(.120)[b]	.274	.541	.191	--	--	.183	4 pre- 4 post-
minima													
Travassos, 1914	1.4	--	--	--	.990	.100	--	--	--	--	--	--	--

Table 2. Continued

MALES

Species	Lgth.	Width	Buccal capsule lgth.	Buccal capsule width	Spicule length long.	Spicule length short.	Pharynx length musc.	Pharynx length glnd.	Nerve length to end[d]	Cerv. pap. to end[d]	Exc. pore to end[d]	Cloaca-tail dist.	Cloacal papillae[a]
pusilla[c]													
Travassos, 1915, 1919	3.5-4.0	.100-.120	.017	.007	1.32	.085	.300	.042	--	--	--	.170	4 pre- 1 ad- 4 post-
saguei													
Barus, 1966	1.90-2.35	.076-.087	.015	.010	1.60 2.02	.095 1.030	.181-.219	.380-.460	.129-.152	--	.174-.190	.095 .118	2 pre- 3 post-
spiculata													
Boyd, 1956	2.02-2.242	.079-.095	.020-.024	--	2.312-2.576	.103-.147	.135-.164	.455-.540	.086-.100	.162-.165	.100	.127-.147	4 pre- 4 post-
xiphidiopicl													
Barus, 1966	2.69	.095	.019	.008	1.90	.099	--	.530	.125	--	.144	.114	0 pre- 4 post-

[a] Indicated as pre-cloacal, ad-cloacal and post-cloacal papillae

[b] Dimensions in parentheses from experimental work including immature males (Cram, 1927).

[c] Dimensions taken from the two reports indicated

[d] Anterior end.

Table 3. Comparative measurements (in millimeters) of Microtetrameres spp. originally described from the western hemisphere.

FEMALES Species	Overall size	Buccal capsule lgth.	Buccal capsule width	Egg lgth.	Egg width	Pharynx length musc.	Pharynx length glnd.	Nerve ring to end[d]	Exc. pore to end[d]	Distance Anus-vulva	Distance Anus-tail
accipiter[a]											
Schell, 1953	1.3-1.5 1.0	.018	--	.043	.025	.207- .215	1.56- 2.24	.103	--	.108- .129	.100- .140
aquila											
Schell, 1953	1.3-1.5 1.0	.027 .028	--	.044- .050	.023- .026	.306- .330	1.34- 1.39	.169- .172	.169- .187	.082- .090	.115- .133
bubo											
Schell, 1953	1-1.2 1.0	.021 .022	--	.046	.028	.277- .280	1.43- 1.47	.162- .165	.180- .190	.108- .162	.172- .178
corax											
Schell, 1953	1.2-1.3 1.0-1.2	.024- .025	--	.047	.032	.241- .284	1.36- 1.40	.126- .169	.165- .190	.082- .130	.129- .187
centuri											
Barus, 1966	.83-1.14	.019	.015	.049- .053	.033- .038	.198- .220	.662- .895	.128- .145	.165		.129
cruzi[c]											
Travassos, 1914	1.5- 2.0	.016- .020	.008	.050 .060	.024- .028	.160	.620	--	--	.200- .226	.074 .100
helix											
Cram, 1927	1.2-1.3 1.0-1.3	.0225	--	.042	.033	.225 .230	--	--	--	.075	.141
minima											
Travassos, 1914	.78- .64	.012	.007	.045	.024	.073	.490	--	--	--	.068

Table 3. Continued

FEMALES Species	Overall size	Buccal capsule lgth.	Buccal capsule width	Egg lgth.	Egg width	Pharynx length musc.	Pharynx length glnd.	Nerve ring to end[d]	Exc. pore to end[d]	Distance Anus-vulva	Distance Anus-tail
pusilla[c]											
Travassos, 1915, 1919	2.0-[b] 1.5	.010-.016	.009-.012	.042-.049	.028-.035	.210-.273	.920-.974	--	--	--	.140
saguei											
Barus, 1966	--	.015	.011	--	--	.132-.173	.760-.910	.132	--	--	.103-.132
spiculata											
Boyd, 1956	1.2-1.0	.022-.023	--	.048-.050	.031	.224-.236	1.05-1.08	.109	--	.090-.120	.096-.103
xiphidiopici											
Barus, 1966	--	.021	.011-.012	.049-.055	.033-.038	.152-.185	.870-.901	.102-.125	--	--	.107-.152

[a] Longitudinal flanges present.

[b] Dimensions taken from the two reports indicated.

[c] Longitudinal furrows present.

[d] Anterior end.

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RUMEN LACTIC ACID LEVELS IN CATTLE[1]

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ABSTRACT. Sixteen yearling Holstein steers and heifers were used in three factorial experiments to determine the effect of the following variables on ruminal lactic acid: 1) sex, steers vs. heifers; 2) grain level, low vs. high; 3) antibiotic feeding, none vs. antibiotic mixture; 4) dietary change, low grain to high and vice versa; 5) forage, hay vs. green-chopped alfalfa.

Heifers and steers did not differ in ruminal lactate concentration. Low-grain diets produced significantly ($P < 0.05$) higher lactate concentration than did high-grain diets in Experiment 1, but not in Experiments 2 and 3. Antibiotic feeding caused a slightly depressed appetite in animals receiving the high-grain diet but had no appreciable effect on ruminal lactate concentration. Abrupt increases in dietary grain level caused depressed appetite. Either an abrupt increase or decrease in dietary grain level resulted in a small but significant ($P < 0.05$) decrease in lactate concentration. Substituting green-chopped alfalfa for alfalfa or grass hay significantly ($P < 0.01$) decreased ruminal lactate. Most of the lactate concentrations were very low (1.0 mg or less/100 ml), regardless of treatment.

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High-grain rations are widely used for ruminants to supply sufficient energy for high levels of milk production or rapid feedlot gains. Sometimes, however, animals do not adapt readily to such rations. Transient depressed appetite, diarrhea and general listlessness are reactions commonly observed in ruminants that have ingested large amounts of readily available carbohydrates (Krogh 1959, 1961; Ryan 1964b; Scarisbrick 1954; Uhart and Carroll 1967). Similar reactions have been observed in studies on the prevention of pasture bloat when a combination of antibiotics (streptomycin, tylosin, erythromycin and penicillin) was fed to dairy cattle receiving high-grain rations (Shellenberger 1964; Van Horn et al. 1963).

Reid, Hogan and Briggs (1957) associated high levels of ruminal lactic acid with "indigestion" due to consumption of large amounts of readily available carbohydrates. Uhart and Carroll (1967) associated ruminal lactic acid with an "off-feed" reaction when steers were abruptly shifted from an alfalfa hay ration to a high-grain ration. Further, Mangan, Johns and Bailey (1959) reported an increase in ruminal lactate concentration after administration of penicillin.

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The present experiments were conducted to study the relationship between ruminal lactic acid concentration and the following dietary factors: amount of grain, abrupt changes in amount of grain, antibiotics and green-chopped alfalfa.

EXPERIMENTAL PROCEDURE

Ruminal lactic acid was measured, using 8 Holstein steers and 8 Holstein heifers, under various dietary regimes in three factorial experiments. Five variables and their respective comparisons were used: 1) sex, steers vs. heifers; 2) grain level, 0.91 kg grain/animal daily plus forage ad libitum vs. as near the ad libitum level of grain feeding as could be maintained without feed refusals, plus limited forage; 3) antibiotic feeding, none vs. 206 mg/animal daily of a combination of streptomycin, tylosin, erythromycin and penicillin in the ratio of 7:7:7:4; 4) dietary change, none vs. changing from 0.91 kg grain/head daily to near ad libitum and vice versa; 5) forage, hay vs. green-chopped alfalfa. Six heifers and six steers were housed and fed in pairs in box stalls but were fed individually. All animals had access to fresh water in individual water bowls.

Experiment 1.

Variables 1, 2 and 3 were used in a 2 x 2 x 2 factorial arrangement replicated twice; the four older heifers and four older steers composed one replication, and the eight younger animals composed the second.

All animals were fed their respective diets (high-grain or low-grain) approximately 6 months before antibiotic feeding. The grain mixture consisted of 53.9% ground corn, 32.4% crushed oats, 10.7% soybean meal, 2.0% dicalcium phosphate and 1.0% salt. Each animal receiving the high-grain diet also was fed 0.91 kg alfalfa or grass hay daily, while animals receiving the low-grain diet were fed alfalfa or grass hay ad libitum. The antibiotic mixture was fed with the morning feeding of grain for 28 days.

Rumen fluid was sampled according to the schedule shown in Table 1. Water to the stanchions and stalls was shut off approximately 30 minutes before sampling. Samples were taken with a suction strainer (Raun and Burroughs 1962) and 50-ml syringe connected by a length of Tygon tubing (8 mm inside diameter). The tubing was passed through a 61 cm section of 19 mm inside diameter steam hose used to push the strainer over the animal's tongue and past the epiglottis. After the animal had swallowed the strainer, 20-30 ml of fluid were drawn to flush the line and were discarded. Then a 50-ml sample was drawn and placed in a bottle containing 1.0 ml of a saturated $HgCl_2$ solution. The equipment was thoroughly rinsed after each animal was sampled. Samples from the 16 animals were transported to the laboratory and centrifuged in a Servall Superspeed centrifuge (Model SS-1) for 30 minutes at 18,800 x g. The supernatant fluid from this preparation was frozen and stored in a sample bottle until analyzed for lactic acid by the colorimetric procedure of Barker and Summerson (1941) with the following modifications: The oxidation and color development reactions were conducted in 25 x 150 mm screwcap culture tubes fitted with Teflon-lined caps. The sulfuric acid

TABLE 1. SAMPLING SCHEDULE FOR EXPERIMENTS 1, 2, AND 3.

Experiment 1		Experiment 2		Experiment 3	
Days[a]	Hours[b]	Days[c]	Hours[b]	Days[d]	Hours[b]
-7	3	-1	3	-4	3
-1	3	0	0, 3, 6	0	0, 3, 6
0	0, 3, 6	1	0, 3, 6	1	0, 3, 6
1	0, 3, 6	2	3	2	3
2	3	3	0, 3, 6	3	0, 3, 6
3	0, 3, 6	4	3	4	3
4	3	5	3	5	3
5	3	6	3	6	3
6	3	7	0, 3, 6	7	0, 3, 6
7	0, 3, 6	14	3	14	3
14	0, 3, 6			21	3
27	0, 3, 6				
28	0, 3, 6				
42	0, 3, 6				

[a]Days relative to initiation of antibiotic feeding. Antibiotics were fed first with the morning feeding on day 0 and fed last on the morning of day 27. A minus sign means before antibiotic feeding was begun.

[b]Hours relative to the morning feeding. Zero hour refers to sampling just before feeding, while 3 and 6 refer to that number of hours after feeding.

[c]Days relative to initiation of dietary change. Diets were changed with the morning feeding of day 0 and continued throughout the experiment. A minus sign means before dietary change.

[d]Days relative to the initiation of green-chopped alfalfa feeding. Green material was first fed with the morning feeding of day 0 and continued throughout the experiment. A minus sign means before green-chopped alfalfa was fed.

was placed in the tubes and chilled in an ice bath, after which the sample was overlayed on the acid. The tubes were immediately capped, and the contents were mixed. Protein was precipitated with $Ba(OH)_2$ and $ZnSO_4$. Optical densities of the solutions were determined at a wavelength of 560 mμ as in the original method.

Experiment 2.

Factors 1, 2, 3 and 4 were used in a 2 x 2 x 2 x 2 factorial arrangement. No antibiotics were fed, but the antibiotic factor was retained in the statistical analysis to detect any residual antibiotic effect. This resulted in 16 treatment combinations, one represented by each animal. Replication was not possible; therefore, the higher-order interactions were used to estimate the error terms. Animals changed to the high-grain diet first received grain at the rate of 4.5 kg/animal daily, and the rate was increased as rapidly as the animals would continue to consume all the grain offered.

Rumen fluid was sampled as shown in Table 1. The samples were handled as in Experiment 1 except that meta-phosphoric acid was used to precipitate protein, and optical densities were determined at a wavelength of 565 mμ.

Experiment 3.

Factors 1, 2, 4 and 5 were used in a 2 x 2 x 2 x 2 factorial arrangement of treatments. The animals designated to receive antibiotics in Experiment 1 received green-chopped alfalfa ad libitum in this experiment. Alfalfa was cut with a flail-type forage harvester and fed twice daily. The animals changed to the high-grain diet or to the low-grain diet in Experiment 2 were continued on these diets throughout Experiment 3. Samples were handled similarly to those in Experiment 2. The 16 treatment combinations again necessitated using higher-order interactions to estimate experimental error.

Statistical analysis.

Data from each of the three experiments were analyzed in two groups; one consisted of all data obtained on those days in which 0-, 3- and 6-hr samples were taken, and the second was composed of all data from samples taken 3 hours after feeding. The first group in each experiment was treated statistically as a split-split-plot design in which whole plots were individual animals, subplots were days within the animal's life and sub-subplots were hours within those days. The second group in each experiment was treated as a split-plot design in which whole plots were individual animals and subplots were days within that animal's life. The various responses were compared by the F test as outlined by Steel and Torrie (1960).

RESULTS AND DISCUSSION

Experiment 1.

Grain consumption patterns were erratic before and during antibiotic feeding. During the first 5 days of antibiotic feeding, transient depressed appetite appeared in all animals receiving antibiotic and the high-grain diet. By the sixth day, grain consumption had returned to normal. The animals receiving the high-grain diet with no antibiotic consumed feed at a relatively constant rate through the first week; thereafter, grain con-

sumption was variable in all animals receiving the high-grain diet. One animal receiving the low-grain diet and antibiotic refused a small portion of grain one day after antibiotic was first fed; no other indications of depressed appetite were observed in animals on this diet. This supports the observation that adverse reaction to antibiotic feeding occurs primarily in animals receiving a high-grain diet (Van Horn et al. 1963) but, in this experiment, depressed appetite was the only reaction observed. There was no increase in ruminal lactic acid associated with depressed appetite, indicating that the loss of appetite in this study was not caused by an accumulation of lactic acid in the rumen.

Table 2 shows the analysis of variance of the data of Experiment 1 treated as a split-split-plot design. Of the main effects, only grain level was significant ($P < 0.01$). Animals receiving the low-grain diet averaged 0.89 mg lactic acid/100 ml rumen fluid, while those receiving the high-grain diet averaged 0.44 mg/100 ml. The hours x days interaction is significant at $P = 0.05$ hours x treatments at $P = 0.01$, but the range of the lactic acid values is small. Males receiving antibiotics had higher lactate values than those receiving none, whereas the reverse was true for the females. Moreover, with the low-grain diet, antibiotics increased lactate values for the males and decreased the values for the females. Contrary to expectations (Van Horn et al. 1963), there was little response to antibiotics by either sex when fed the high-grain diets. The data treated as a split-plot design reveal patterns rather similar to those described for the split-split-plot data.

Experiment 2.

Average daily grain consumption of animals abruptly changed from the low-grain diet to the high-grain diet increased rapidly during the first 2 days of dietary change and then continued to increase more gradually to a maximum of 8.2 kg per animal on the sixth day. On the seventh day of dietary change, average consumption dropped to 6.5 kg, after which it gradually returned to near the maximum. Again, consumption was variable in all animals receiving the high-grain diet.

The lactic acid data of this experiment did not greatly differ from those in Experiment 1. Statistical analysis of the split-split-plot data showed significance ($P < 0.05$) only for the main effect of dietary change. Ruminal lactate concentrations in animals changed from the low-grain diet to the high-grain diet were similar to those of animals changed from high grain to low grain. Either change in the dietary grain level, however, caused average ruminal lactic acid concentration to decrease. Conversely, analysis of the split-plot data showed significance ($P < 0.05$) only for the grain level x dietary-change interaction. Changing from high-grain to low-grain diets caused the average ruminal lactic acid concentration to increase from 0.36 mg/100 ml to 0.59 mg/100 ml, but changing from low-grain to high-grain diets brought about a decrease from 1.20 mg/100 ml to 0.43 mg/100 ml. Even though the latter change is nearly three-fold, it represents a range in average lactate concentration of less than 1.0 mg/100 ml.

These results are contrary to those of Ryan (1964a) and Uhart and Carroll (1967) who reported increased ruminal lactic acid when sheep or steers were changed from an all-hay diet to a hay-grain diet. The results

TABLE 2. ANALYSIS OF VARIANCE OF SPLIT-SPLIT-PLOT DATA - EXPERIMENT 1[a]

Source of Variation	Degrees of freedom	Mean square	F
Whole - plot analysis			
Replications	1	0.40	0.44
Treatments	7	6.57	7.30**
A (sex)	(1)	0.89	0.99
B (grain)	(1)	19.99	22.21**
C (antibiotic)	(1)	0.39	0.43
A x B	(1)	0.00	0.00
A x C	(1)	10.59	11.77**
B x C	(1)	0.36	0.40
A x B x C	(1)	13.80	15.33**
Error (a)	7	0.90	
Total	15		
Sub-plot analysis			
Days	7	0.97	1.29
Days x treatments	49	0.77	1.03
Error (b)	56	0.75	
Total	112		
Sub-sub-plot analysis			
Hours	2	0.97	1.24
Hr. x days	14	1.51	1.94*
Hr. x treatments	14	2.02	2.59**
Hr. x A	(2)	2.70	3.46*
Hr. x B	(2)	4.98	6.38**
Hr. x C	(2)	1.83	2.35
Hr. x A x B	(2)	1.94	2.49
Hr. x A x C	(2)	0.31	0.40
Hr. x B x C	(2)	1.24	1.59
Hr. x A x B x C	(2)	1.18	1.51
Hr. x days x treatments	98	0.59	0.76
Error (c)	128	0.78	
Total	256		
Grand Total	383		

[a]Includes all lactic acid data obtained on those days on which samples were taken 0, 3, 6 hr. after feeding.

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

agree, however, with those of Haskins et al. (1969) who found lactic acid concentration in rumen fluid quite low on all treatments, but higher when steers were fed some hay than when an all-grain diet was fed. Furthermore, Eadie, Hobson and Mann (1967) fed barley to steers and young calves and noted that the lactic acid concentration in all samples was low, about 1 mg/100 ml. Mackenzie (1967) noted that several authors reported low or undetectable levels of ruminal lactic acid in animals fed roughage rations, but a range of values from 9 mg/100 ml to over 1350 mg/100 ml was noted in animals fed low-roughage rations. The animals in the present experiment were accustomed to some grain in the diet. Perhaps the microbial population of the rumen had already adjusted to the presence of grain in the diet and could rapidly adapt to the abrupt increase in grain level.

Experiment 3.

In contrast to Experiments 1 and 2, an occasional high ruminal lactic acid value was observed in this experiment. One day after the first feeding of green-chopped alfalfa, one steer receiving the high-grain diet and no green-chopped alfalfa suddenly exhibited ruminal lactic acid concentrations of 223.0 mg/100 ml in the prefeeding sample and 10.4 mg/100 ml in the sample taken 3 hours after feeding. The animal had been on this same diet throughout all three experiments. A heifer receiving the high-grain diet and no green-chopped alfalfa, and whose diet had not been changed, had ruminal lactic acid concentrations of 15.0 mg/100 ml 6 hours after feeding on day three and 12.0 mg/100 ml 3 hours after feeding on day 21. All other values were comparable to those of Experiments 1 and 2. This large range in values caused the higher order interactions (experimental error) to be quite large, resulting in no significant responses in the analysis of the split-split-plot data. Since the two highest values are not among the split-plot data, the interaction terms in the analysis of these data are not so large (Table 3). The main effect of dietary change is similar to that described for Experiment 2. Changing the forage from hay to green-chopped alfalfa caused a decline in average ruminal lactic acid concentration. The mean lactic acid in rumen fluid declined from 1.29 to 0.53 mg/100 ml for diets wherein grain intake was not changed and 0.59 to 0.43 for diets involving a marked change in grain intake (either an increase or a decrease). This agrees with the results of Forenbacher and Srebočan (1963) who found that feeding fresh fodder to cows resulted in lower ruminal lactate concentrations.

In Experiments 1 and 2, there was no increase in ruminal lactic acid associated with depressed appetite; in Experiment 3, there was no depressed appetite when high lactic acid concentrations appeared. Dowden and Jacobson (1960) found lactic acid to have no significant effect on appetite when infused intravenously. This suggests that lactic acid, as a metabolic intermediate, may, at least in some instances, not be closely related to depressed appetite. Tremere, Merrill and Loosli (1968) found that ground wheat, as the only ingredient of concentrate fed at a high level, produced high ruminal lactate concentrations but noted no similar increase when the concentrate mixture was composed of only 50% ground wheat. Thus, the carbohydrate components of wheat may be more conducive to lactate production than those of corn. However, a

TABLE 3. ANALYSIS OF VARIANCE OF SPLIT-PLOT DATA - EXPERIMENT 3[a]

Source of Variation	Degrees of freedom	Mean square	F
Whole-plot analysis			
A (sex)	1	0.31	0.63
B (grain)	1	0.16	0.33
C (dietary change)	1	6.92	14.12*
D (green alfalfa)	1	9.41	19.20**
A x B	1	1.06	1.98
A x C	1	0.75	1.53
A x D	1	0.33	0.67
B x C	1	1.82	3.71
B x D	1	0.38	0.78
C x D	1	4.00	8.16*
"Error (a)"[b]	5	0.49	
Total	15		
Sub-plot analysis			
Days	10	1.95	0.78
Days x A	10	0.95	0.38
Days x B	10	1.02	0.41
Days x C	10	2.18	0.88
Days x D	10	2.37	0.95
Days x A x B	10	2.52	1.01
Days x A x C	10	0.86	0.35
Days x A x D	10	1.36	0.55
Days x B x C	10	1.22	0.49
Days x B x D	10	0.77	0.31
Days x C x D	10	2.56	1.03
"Error (b)"[c]	50	2.49	
Total	160		
Grand Total	175		

[a]Includes all 3 hr. samples of Experiment 3.

[b]"Error (a)" includes the A x B x C, A x B x D, A x C x D, B x C x D and A x B x C x D interactions.

[c]"Error (b)" includes all four-, and five-factor interactions.

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

ruminal lactic acid concentration of 223.0 mg/100 ml was obtained in one animal in Experiment 3 of the present study when corn was the major concentrate.

Considerable variability in ruminal lactic acid concentration was observed in the present experiments. This also has been noted by previous workers (Chow and Walker 1964a, 1964b; Ndumbe, Runcie and McDonald 1964; Otterby and Rust 1965; Reid et al. 1957). Reported concentrations of lactic acid have varied from traces (less than 1.0 mg/100 ml) to more than 1800 mg/100 ml (Tremer et al. 1968). Furthermore, high ruminal lactic acid concentrations are not always reproducible (Reid et al. 1957; Scarisbrick 1954).

Of the 1072 observations in the present studies, 98% were less than or equal to 5.0 mg/100 ml, and 89% were less than or equal to 1.0 mg/100 ml. Since most of the values obtained were quite low and since the high values that did appear could not be associated with treatment, conditions other than those in these experiments must be responsible for high concentrations of ruminal lactate.

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MEASUREMENT OF AMBIENT AIR TEMPERATURE WITH ASPIRATED AND UNASPIRATED THERMOCOUPLES IN THE FIELD[1, 2]

Harry C. Vaughan and Clarence Sakamoto[3]

ABSTRACT. A series of measurements was made by using both aspirated and shielded and unshielded copper-constantan thermocouples of various physical sizes. The purpose of this study was to establish the magnitude of the error involved in using unshielded, unaspirated couples. The standard for comparison consisted of a number-16 Brown and Sharp gauge copper-constantan wire welded and then silver-soldered into a 9.5-mm diameter copper cylinder 3.26 cm long and gold-plated. This, in turn, was housed in a coaxial plastic radiation shield covered with gold leaf and painted flat black on the inside. In addition, the couple was aspirated with a 7.3-m-sec^{-1} flow of air. The data show that, depending on the size of the thermocouple, differences of as much as 7 °C can occur if the couples are not shielded and unaspirated.

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INTRODUCTION

It has long been recognized that a measurement of true ambient air temperature is difficult, if not impossible, to obtain (Brunt 1952). It is important that researchers interested in the measurement of ambient air temperature become aware of the potential magnitude of errors present in this aspect of micrometeorological field observations. The magnitude of temperature errors encountered during daytime periods are examined in this paper. These measurements were in the free air over short grass and over a soybean crop, using unshielded thermocouples of various physical sizes. A shielded, asparated thermocouple served as a reference standard.

Middleton et al. (1938) have shown the relationship between the mass of a thermal transducer and its response. A thermal transducer is defined to be any resistance or emf. instrument that responds to temperature changes. In this paper, only thermocouples were considered; the results, however, also are applicable to other thermal transducers. In general, the smaller the wire size, the more nearly it will come to representing the ambient temperature. It has been postulated that, if the wire were sufficiently small, no error from incoming radiation would

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[2] Presented at the Sixth National Conference on Agricultural Meteorology of the American Meteorological Society, Oct. 8-10, 1964, Lincoln, Nebr.
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occur. But this approach is not always practical, because the wire may be too frail to withstand exposure to the free air (Thornthwaite 1949).

If the transducer is unshielded and unaspirated, the data may be erroneous for the following reasons. When the mass of the sensor is increased, its thermal capacity also will increase, and the lag in the response becomes more pronounced; this lag, in itself, is not undesirable, but such a sensor exposed to direct solar radiation will give a positively biased reading. If the free air flow is increased, the transducer will respond as a heat source. Its thermal energy, consequently, will be transferred more effectively with the increased flow of air, and thus, the sensor will be cooled. Unfortunately, the observer has no way of knowing whether the air sample is cooler or if the flow past the transducer has accelerated. The relationship between the mass of the transducer and its response is further influenced in that the instantaneous temperature, as observed by a low-lag thermal transducer, experiences great excursions, which may be of such short duration that most recording systems will be unable to follow them. Figure 1 represents a short record of such a transducer in conjunction with a fast-response recording system.

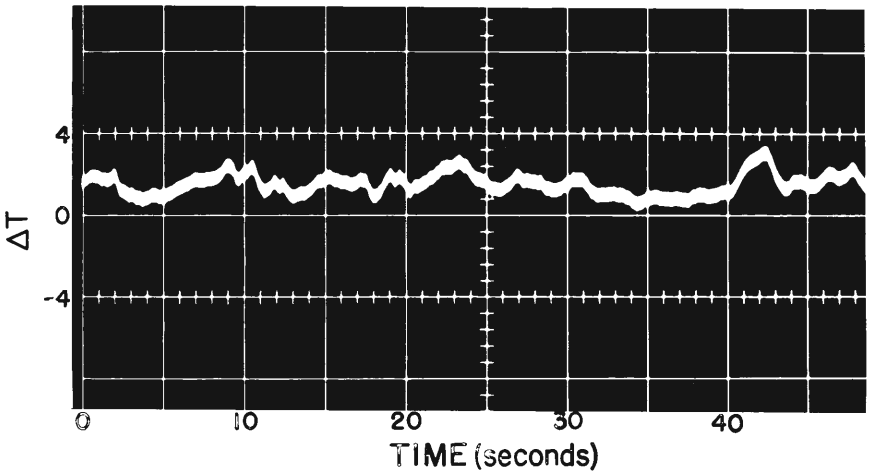


Figure 1. Temperature fluctuations in the free air using an unshielded thermocouple. The abscissa represents time. Each small division equals one second. The ordinate represents a temperature scale with each small division equal to eight-tenths of a centigrade degree.

The purpose of this study is to show the magnitude of some temperature anomalies that may be encountered under normal conditions when using unshielded-unaspirated thermal transducers of various physical size exposed to sunlight.

Theory of radiation error:

The degree of accuracy with which the ambient air temperature may be measured at any given time, is determined by the incremental difference between the temperature of the transducer and that of the medium in which it is immersed. If one assumes a transducer of zero thermal lag and a recording system with infinitesimal intertia, then the only error would be that introduced by ratiation impinging on the transducer. Ideally, a polished metal coating would reflect all radiation impinging on the transducer, thus resulting in a zero radiation error. Several metals have a reflectivity approaching one in portions of the spectrum; no single coating, however, seems to possess the attribute of an ideal white body (Kleinschmidt 1935).

An alternative procedure would be to surround the transducer with a reflector. Because the reflecting surface is less than ideal, however, some energy would be absorbed and reradiated at longer wavelengths. Angstrom (1885) has shown this process follows Lambert's law with good approximation. By increasing the number of reflecting surfaces, each with a good radiator on its inner side, the initial error may be reduced to any desired amount. The disadvantage of this method is that the transducer is no longer exposed to the free air and must be aspirated to assure true fidelity in light winds. It can be further argued that the aspiration results in a gross air sample in place of the discrete sample obtained with an unshielded transducer. If the flow of air past the transducer is constant, an equilibrium condition between its temperature and that of the free air would be maintained. The temperature measured would be between the "true" temperature and the elevated temperature resulting from the remaining radiation.

Geiss (1950) measured differences of 0.5 °C for shaded and unshaded platinum thermocouples with 0.002-cm diameters for average winds of about 1 m-sec. Thornthwaite (1949) used copper-constantan thermocouples of 0.024-cm diameter and observed radiation errors as large as 2 °C under unspecified conditions in March. The experimental results indicate substantial radiation errors. McDonald (1951) calculated values about an order of magnitude smaller and attributed the discrepancy in the theoretical and experimental results to poorly understood dissippation data for transducers.

Description of instrumentation:

Six copper-constantan thermocouples, ranging from number-40 to number-16 Brown and Sharp wire-gauge size, were used in these comparisons. The couples were made by overlapping about 2 mm of wire and then silver-soldering. This resulted in a slight enlargement of the wire at the junction. Table 1 gives a number of physical characteristics of the individual couples. The number-16 gauge wire junction was soft-soldered into a gold-plated copper cylinder 9.5 mm in diameter by 32.6 mm long. A rectangular aluminum rack, 10.16 cm by 30.48 cm was used to support the couples. The thermocouple rack was supported, unshielded, over the grass or soybean crop. The ends of the individual test thermocouples passed through porcelain insulators imbedded in the aluminum support rack. At this point, they were soft-soldered to individual number-14 copper wire on the one end and to number-16 constantan wire on the other (Figure 2).

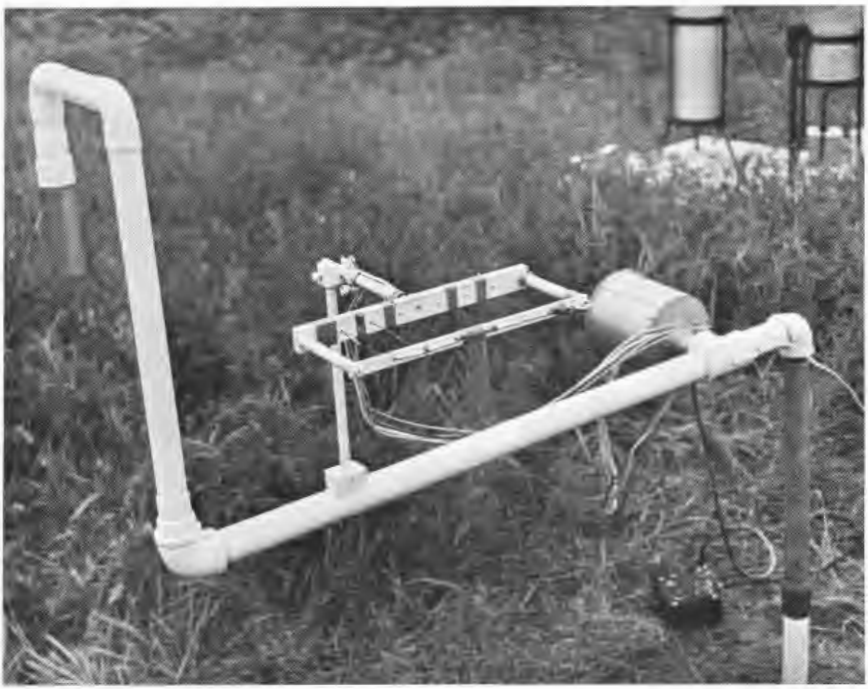


Figure 2. Thermocouple rack and shielded aspirated thermocouple mounted in inverted "J" tube with blower at right hand end of support stand.

To minimize the reference junction error, a common constantan wire was used with the six test couples. This terminated in a silver-soldered junction, which was then soft-soldered into a copper cylinder with identical dimensions to those used with the number-16 wire in the test rack. An independent cold junction of the same size was provided for use with the aspirated, shielded thermocouple. Both cold junctions were painted with General Electric Glyptal enamel to reduce the possibility of extraneous galvanic action between the couples in the ice bath. Distilled water ice was used throughout the work.

The aspirated reference thermojunction was made of number-16 copper-constantan wire silver-soldered into a gold-plated copper cylinder identical to that mounted on the test rack. In this instance, the couple was housed in a coaxial plastic radiation shield covered with gold leaf and painted flat black on the inside (Hewson 1951).

The radiation shield was mounted 1 m above ground on a 1.25-inch pipe in the form of an inverted "J." Air was drawn through the radiation shield and associated pipe at the rate of 7.3 $m \cdot sec^{-1}$ by a small blower which, in turn, exhausted the air downward approximately 1.5 m from the sampling point. Mounted on the horizontal portion of the pipe was an additional support for the six unshielded test thermocouples (Figure 2).

Table 1. Physical properties of thermocouples.

Property	Couple Number 1	2	3	4	5	6
B. and S. Size	16	20	28	30	38	40
Wire Diameter (mm)	1.24	0.80	0.30	0.27	0.10	0.07
Couple Diameter (mm)	9.47	1.65	0.75	0.62	0.35*	0.46*
Calibration Error (°C)+	-	-0.005	-0.004	-0.003	-0.008	-0.007
Lag (Seconds)	114[a]	7.25	3.16	1.52	.34	.72

* Spherical

\+ Average departure from standard

[a] For non-aspirated thermocouple

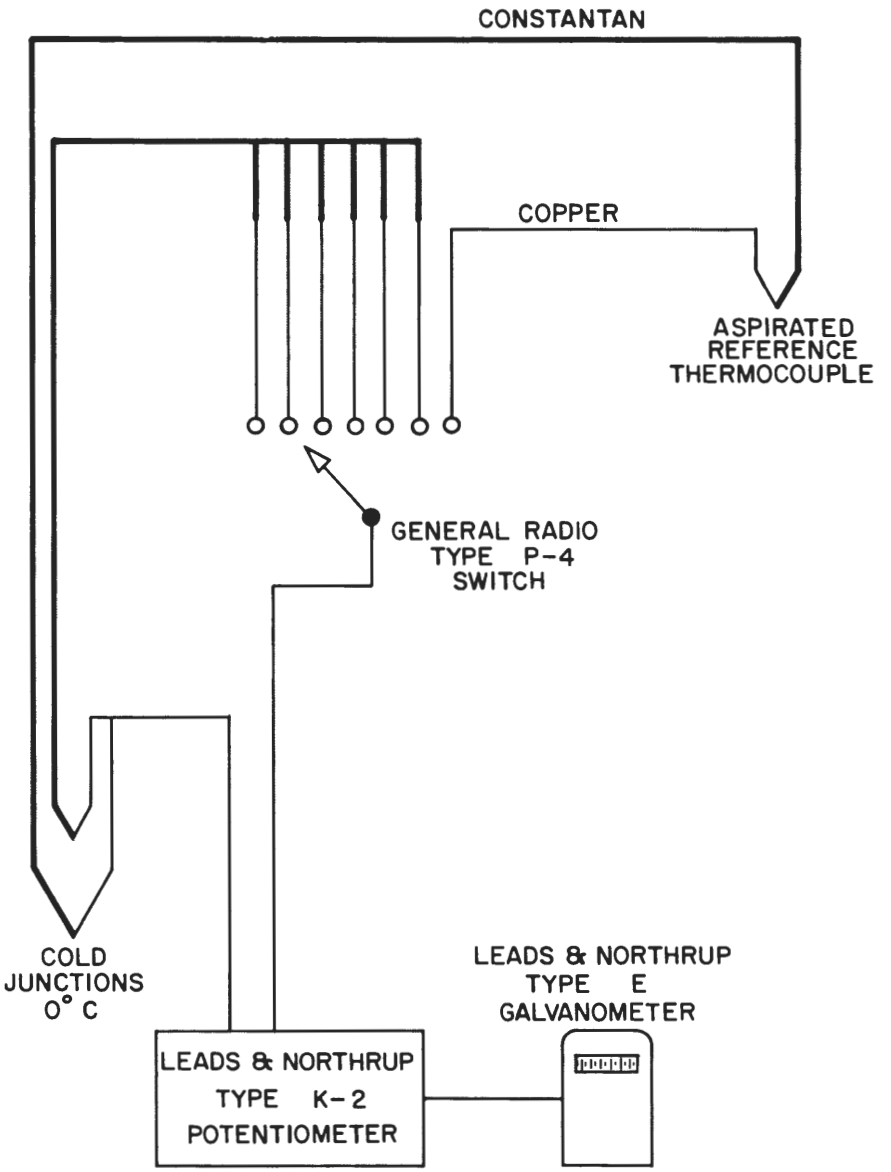
The thermocouple cable extended about 9 m from the test area to a General Radio P-4, low-noise switch and the cold junction. From this point, the thermocouple output was carried over an additional 10 m of shielded cable to the building where the electrical measurements were made. A K-2, Leeds and Northrup potentiometer and an E-2 galvanometer provided the measuring circuit. A schematic diagram is shown in Figure 3. The galvanometer has a natural period of 3.0 sec and was critically damped with a 50-ohm resister.

This equipment was suitable for measuring voltages of 0.5×10^{-6} volts. In terms of temperature, this represents approximately 1×10^{-3}°C. No such claim is made for the over-all precision of the system; from the calibrations, however, it was evident that no systematic errors were present. The system was calibrated by submerging the thermocouple rack in a distilled-water bath, which was continuously agitated, and measuring the water temperature with a previously calibrated mercury-in-glass thermometer graduated to 0.1°C.

To change the water-bath temperature, ice was introduced into the bath. When the water bath came to equilibrium, the thermocouple outputs were measured. During both the measurements and calibrations, the cold junctions were gently agitated. Table 1 shows the mean departure of individual couples from the standard during these calibrations.

Experimental procedure:

Data were collected over pasture land every 15 min. for a number of daylight hours. A similar series of observations was made over a large field of soybeans for 9.5 daylight hours. These observations were made under a variety of sky conditions. During the observations, sky conditions were noted each hour; in addition, solar radiation data were available from an Epply Pyranometer mounted on the roof of the Agronomy Building. This instrument was located approximately 1 mile NNW of the soybean field and 1.5 miles ESE of the pasture site.



Schematic Diagram of Thermocouple Measuring Circuit

Figure 3.

Additional meteorological data were available from a 32-m tower located 25-m south of the pasture site. Wind velocity and temperature data were available 12 min.out of the hour from five levels: 2, 4, 8, 16, and 32 m. In addition, a continuous record of wind direction was available from the 16- and 32-m levels.

The procedure used in the collection of data was: first, the potentiometer was standardized; then, as quickly as possible, the output from each thermocouple was noted. A telephone was used to communicate with the operator who controlled the selector switch and agitated the cold junction bath. The observational procedure was the same for all five observations, starting with the thermocouple number 1 and ending with the aspirated reference junction. A field check was made, much like the calibration described, which assured that no systematic error was present when the system was in the field.

Table 2. Maximum temperature departure (°C) of text thermocouples from aspirated-shielded thermocouple.

	Couple Number						
Date (Aug.)	1	2	3	4	5	6	8[a]
11	1.10	0.71	0.51	0.46	0.46	-0.25	-
13	4.21	3.53	2.06	1.79	1.15	1.36	-
15	3.10	1.42	-3.93	-6.10	-2.18	-0.84	-
19	6.57	5.57	3.77	2.98	2.21	2.68	3.8
26 (unshaded)	2.25	2.16	1.47	1.44	-1.49	1.07	-
26 (shaded)[b]	1.14	1.47	1.62	-1.77	-1.90	1.72	-

[a] Unaspirated, shielded B and S gauge 22 thermocouples.

[b] The term shaded relates to a blocking of direct sunlight by an object placed 1 to 2 m distant from the unshielded thermal transducers. The aspirated, shielded reference-standard is described elsewhere in the text.

Experimental results:

In an effort to show the erratic nature of the midday temperature when observed with a low-lag transducer and recording system, a short series of observations was made by using thermocouple number 5 and a Tektronix 502 oscilloscope. This instrument is well adapted to this type of observation, having a sensitivity of 200 μv cm^{-1} (5.0°C cm^{-1}) and a calibrated sweep of 5 sec cm^{-1}. This provided the single, 50-sec observation shown in Figure 1. Some difficulty was experienced in making these observations because of the superimposed carrier frequency of the university radio station operating at 640 MHz. This, along with some other extraneous noise, was removed by a simple RC filter, which did not affect the relatively low frequency of the thermocouple fluctuations.

TABLE 3

DATE	OBSERVATIONS Start	End	SITE	RANGE OF CLOUD COVER+	TIME OF MAXIMUM ERROR (LOCAL STANDARD TIME) Thermocouple 1	2	3	4	5	6
August 11	1400	1545	Short grass	10/10 Sc	1445	1445	1445	1445	1445	1400
August 13	0900	1515	Short grass	3/10 - 9/10 Cs	1030	1230	1045	1000	0930	1115
August 15	1000	1115	Short grass		1000	1000	1115	1115	1100	1100
August 19	0815	1745	Soybean	1/10 Cs 2/10 Cu	1230	1230	1230	1215	1145	1145
August 26	0800	1600	Short grass	1/10 - 3/10 Ci 3/10 Ac	0900	0945	0845	1015	1015	1015
August 26*			Short grass		0907	1322	1322	1152	1052	1322

+ Cloud type: Sc = stratocumulus, Cu = cumulus, Cs = cirrostratus, Ac = altocumulus, Ci = cirrus

* Observations made with thermocouples shaded from direct sunlight.

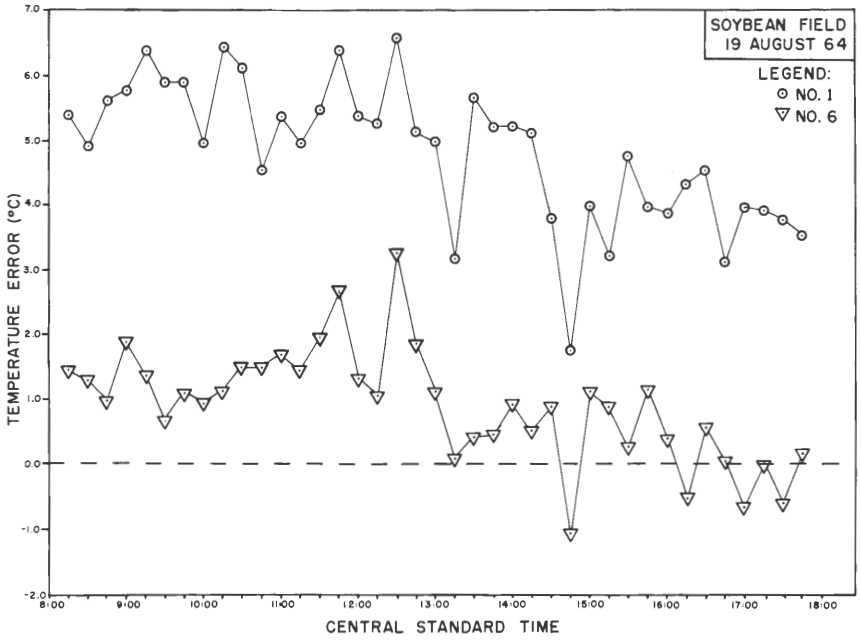


Figure 4. March of the temperature departure of the unshielded B&S 16 (No. 1) and B&S 40 (No. 6) thermocouples from the standard aspirated and shielded thermocouple on August 19, 1964.

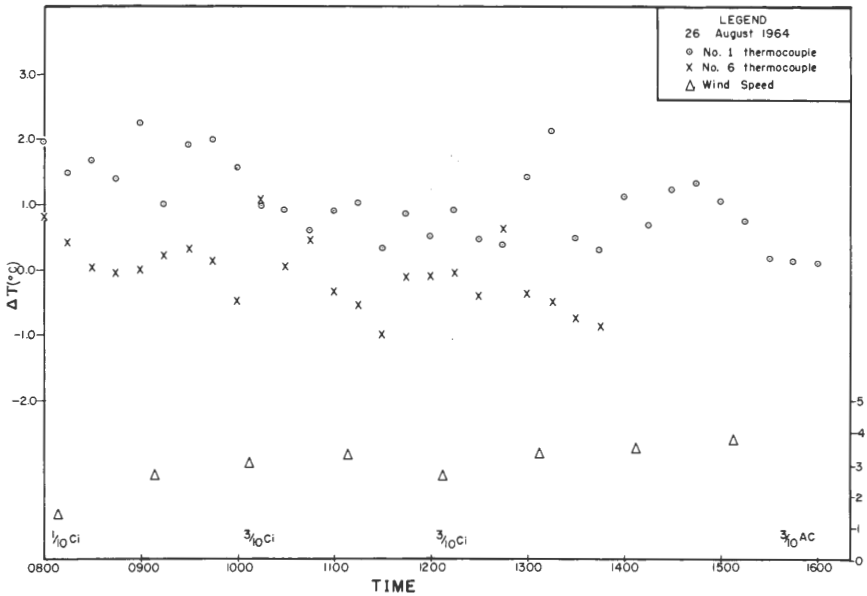


Figure 5. March of the temperature departure of the unshielded B&S 16 (No. 1) and B&S 40 (No. 6) thermocouples from the standard aspirated and shielded thermocouple with wind speed on August 26, 1964.

The five observational periods described in this paper range from 1 hr, 15 min, to 9 hr, 30 min. The maximum temperature anomalies, with reference to the shielded ventilated reference standard, are given in Table 2. A detailed plot of the temperature error associated with the largest (1) and the smallest (6) of the six thermocouples is given in Figure 4. These data were collected at a height of approximately 50 cm over a soybean field on Aug. 19, 1964. There seems to be a slow rise in error readings, which reach a maximum near noon. About this same time, the amplitude of the oscillations increase. After the noon maximum error, there is a tendency toward smaller errors. Whether these violent oscillations and subsequent decrease in the error were related to the passage of fair-weather cumulus clouds during the early afternoon could not be determined from available radiation data. Neither wind speed nor cloud cover suggested a direct relationship to the marked decline in error, particularly with regard to the small couple. These data are presented in Figure 5. Examination of the remaining data suggest that this trend is not unique to the data presented in Figure 4. The times of maximum anomalies are given in Table 2. Two of the observational periods are too short to substantiate this trend, but data taken over short grass also suggest that the maximum error occurs before the time of maximum insulation (Table 3, Aug. 13). Table 3 presents the range of cloud cover during the observational period.

CONCLUSIONS

The foregoing data suggest that temperature errors as great as 6 or 7 °C (i.e., 12 °F) are realistic in unshielded, unaspirated transducers during midday, summer observations. The error is directly related to the physical size of the transducer, as suggested by Middleton et al. (1938). It also seems that highly reflective surfaces without adequate ventilation will not appreciably reduce the potential error. If the observer is unable to provide facilities for an aspirated, shielded instrument, then, the smaller the transducer, the smaller will be the error. Unfortunately, this approach may result in a fast-response transducer being matched with a slow recording instrument, which, to an extent, mechanically integrates the rapidly fluctuating input signal.

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SELECTION OF SUITABLE TISSUES FOR USE IN THE RNA-DNA RATIO TECHNIQUE OF ASSESSING RECENT GROWTH RATE OF A FISH[1]

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ABSTRACT. Feeding experiments with bluegills (Lepomis macrochirus) indicated that growth rate, as indicated by changes in length and weight, was reflected in RNA-DNA ratios of liver, stomach, intestine, anterior muscle, and posterior muscle tissue samples. RNA-DNA ratios in bluegill liver were most sensitive to changes in body weight, followed by muscle tissue, stomach, and intestine, respectively.

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INTRODUCTION

Using controlled laboratory studies, Bulow (1970) demonstrated that quantitative determinations of ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) can be used as biochemical indicators of recent growth of fishes. Although DNA concentrations remained fairly constant, RNA concentrations varied and were highest in those undergoing fastest growth and protein synthesis. For example, golden shiners (Notemigonus crysoleucas) deprived of food for 14 days had a mean RNA-DNA ratio of 2.30. When feeding was resumed, ratios averaged 5.73 after 4 days. In other experiments, daily feeding of golden shiners at 0, 2, and 6% body weight for 15 days produced mean weight changes of -16.1, 2.2, and 21.3%. These growth rate differences were reflected by mean RNA-DNA ratios of 2.19, 2.83, and 4.32, respectively. The RNA-DNA ratio thus provides an indication of how well a fish is feeding, synthesizing protein, and presumably growing at the time of sampling.

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Whole, eviscerated fish were used in the golden shiner experiments. For larger species of fishes, it would be necessary to take selected organ or tissue samples rather than to use the entire fish. The present experiment was designed to gain information regarding organs or tissues that best exhibit RNA-DNA differences at various growth rates.

METHODS

Bluegills (Lepomis machrochirus) were held for 10 and 20 days and fed pelleted fish feed at rates of 0, 0.5, and 4.0% of the total body weight of fish per day. Twenty-four 15-gallon tanks, with one fish per tank were used. Thus, there were four fish for each treatment. Fish were fed once daily, with excess feed and waste materials being siphoned from the tanks between feedings. An overflow system provided an entire change of water approximately every 8 hr. Water temperature was held between 22.0 and 24.0°C.

The entire liver, stomach, intestine, anal fin, and pelvic fins were removed from each fish at the termination of each feeding run. Stomach and intestine samples were flushed out to remove possible contaminating materials. In addition, muscle tissue samples were removed from the left side of each fish anteriorly, between the longitudinal axis and dorsal fin, and posteriorly, in the caudal peduncle region.

To inhibit ribonuclease action, samples were immediately quick frozen by immersion in a preparation of dry ice and methanol. Samples were kept in capped vials and stored in a freezer for 4 to 5 days before preparation for RNA and DNA analyses.

Preparation of fish tissue samples, standard solutions, and reagents as well as extraction of nucleic acids and determination of RNA and DNA content were the same as those described by Bulow (1970), with the several exceptions. Total nucleic acid was extracted from dry, fat-free tissue by the methods of Webb and Levy (1955). Twenty-mg samples were used for liver, stomach, and intestine and 50-mg samples for muscle samples. Fin samples proved unsuitable since they contained extremely low nucleic-acid contents. Analysis of RNA-P content followed the orcinal method described by Schneider (1957), with a modification by Lusena (1951). Nucleic-acid aliquots of 0.5 ml were used for stomach, intestine, and muscle extracts, and 0.1 ml was used for liver. DNA-P was again determined by using the Burton modification of the diphenylamine reaction (Burton 1956).

Since orcinol reacts with DNA as well as with RNA, a correction must be made for the fraction of optical density resulting from DNA present in each sample. This was done through use of the DNA-P standards in the orcinol reaction. Calculations were made as described by Schneider (1957).

Results were reported as concentrations of RNA-P and DNA-P. Concentrations of RNA and DNA can be estimated by assuming that the phosphorus content of both RNA and DNA is approximately 10%.

Because unusually high concentrations were found in some bluegill tissues, particularly liver, some interference was suspected by chromogenic substances in the orcinol reaction. Many substances particularly concentrated in liver tissue interfere with the orcinol reaction (Munro

and Fleck 1966b). To determine if such interference may have occurred and influenced results, remaining samples of liver tissue powder from each set of four fish were pooled and extracted twice with cold 5% trichloroacetic acid (TCA) before normal nucleic acid extraction. This was done by adding 3 ml of cold 5% TCA to each tube containing 20 mg of tissue powder, refrigerating for 12 hr, mixing, centrifuging, and drawing off the supernatant fluid. An additional 3 ml of cold TCA was then added, the mixture centrifuged, and the supernatant again discarded. This procedure removed interfering low-molecular-weight compounds (Munro and Fleck 1966b). RNA-P and DNA-P were then extracted and measured in the usual way. Results were compared with samples run simultaneously, but with no cold TCA extraction.

RESULTS

Bluegills held for 10 days at feeding rates of 0, 0.5, and 4.0% of the body weight per day responded with a slight loss, maintenance, and gain in standard length, respectively (Table 1). Corresponding mean weight changes were -3.0, -0.9, and 2.9 gm. Liver samples yielded highest RNA-P values, followed by stomach and intestine, posterior muscle, and anterior muscle samples, respectively. RNA-P increased with higher feeding rate in all tissues except stomach, in which there was a decline at the 0.5% level. DNA-P values were highest in liver and intestine samples, followed by stomach, posterior muscle, and anterior muscle samples. Liver DNA-P declined with higher feeding rate. DNA-P levels for most other tissues were highest in fish not fed and similar at the 0.5 and 4.0% feeding rates. RNA-DNA ratios were highest in liver, followed by anterior muscle, posterior muscle, stomach, and intestine.

Percentage change in body weight was reflected by RNA-DNA ratios in all tissues sampled (Table 1).

Bluegills held for 20 days responded with a loss, gain, and larger gain in standard length and weight at the three feeding rates (Table 2). Liver RNA-P values were very high, followed by intestine, stomach, posterior muscle, and anterior muscle. RNA-P increased with higher feeding rate in all tissues except anterior and posterior muscle, which declined at the 0.5% level. DNA-P values were highest in intestine samples, followed by liver, stomach, posterior muscle, and anterior muscle samples, respectively. Liver DNA-P declined sharply with higher feeding rates. Stomach and posterior muscle DNA-P also declined with feeding rates, but less sharply. DNA-P levels for all tissues were highest in fish not fed. RNA-DNA ratios were highest in liver, followed by anterior muscle, posterior muscle, stomach, and intestine.

Percentage change in body weight was reflected in RNA-DNA ratios for all tissues sampled (Table 2). In all tissues, there was an increase in ratio with higher feeding rate and faster growth. Changes in ratios were greatest in liver, followed by posterior muscle, anterior muscle, stomach, and intestine, respectively.

RNA-P and DNA-P were recorded in μg/100 mg dry, fat-free tissue. Since literature values are often reported in terms of fresh weight, both fresh weight and dry, fat-free weight of the various organ and tissue

Table 1. Changes in standard length (S.L.) and fresh weight (wt.), and nucleic acid response of various organs and tissues of bluegills held for 10 days at three feeding rates[a]

	Days - Feeding rate[b]		
	10 - 0.0	10 - 0.5	10 - 4.0
Number of fish	4	4	4
Initial S.L. (mm)	100.7 ± 2.5	98.5 ± 2.7	97.7 ± 3.7
S.L. change (mm)	-0.5 ± 0.3	0.0 ± 0.0	2.7 ± 0.4
Initial wt. (g)	35.9 ± 2.6	33.1 ± 3.2	33.5 ± 3.8
Wt. change (g)	-3.0 ± 0.3	-0.9 ± 0.6	2.9 ± 0.3
Wt. change (%)	-8.3 ± 0.7	-2.3 ± 2.2	8.6 ± 0.1
Liver RNA-P[c]	3,358.9 ± 142.7	4,256.3 ± 216.2	4,946.5 ± 37.2
Liver DNA-P	225.7 ± 30.8	156.3 ± 11.4	107.9 ± 10.0
RNA-P/DNA-P	15.9 ± 2.4	27.9 ± 3.0	47.8 ± 7.5
Stomach RNA-P	454.4 ± 11.7	431.7 ± 17.8	506.9 ± 9.0
Stomach DNA-P	130.6 ± 5.6	108.0 ± 7.2	111.4 ± 2.9
RNA-P/DNA-P	3.5 ± 0.1	4.0 ± 0.1	4.6 ± 0.1
Intestine RNA-P	439.9 ± 92.0	495.5 ± 63.5	553.7 ± 80.8
Intestine DNA-P	182.8 ± 23.4	197.3 ± 11.7	186.1 ± 17.9
RNA-P/DNA-P	2.4 ± 0.5	2.5 ± 0.2	3.0 ± 0.1
Anterior muscle RNA-P	248.4 ± 13.9	254.3 ± 12.1	302.9 ± 18.3
Anterior muscle DNA-P	15.5 ± 2.7	11.9 ± 1.6	12.9 ± 0.5
RNA-P/DNA-P	16.3 ± 1.8	22.3 ± 2.5	23.5 ± 1.2
Posterior muscle RNA-P	303.1 ± 8.9	301.7 ± 29.3	357.4 ± 31.0
Posterior muscle DNA-P	20.7 ± 1.5	16.7 ± 2.0	17.5 ± 3.4
RNA-P/DNA-P	14.8 ± 0.9	18.8 ± 2.9	21.0 ± 2.6

[a]Values given are mean ± standard deviation of the mean.

[b]Feeding rate in percentage of body weight of fish per day.

[c]RNA-P and DNA-P in ug per 100 mg dry, fat-free tissue.

samples are given in Table 3. Conversion to μg/mg fresh tissue can be made with the formula:

$$\frac{\mu g/100 \text{ mg DFFT} \times \frac{\text{DFFT weight (mg)}}{100}}{\text{Fresh weight (mg)}}$$

Extraction with cold 5% TCA before nucleic-acid extraction had a definite effect in reducing RNA-P values and therefore indicated that there were high concentrations of interfering chromogenic substances in the liver tissue (Table 4). DNA-P values, however, showed considerably less change. The result was a decrease in RNA-DNA ratios; however, the rank of these ratios did not change. Ratios still increased

Table 2. Changes in standard length (S.L.) and fresh weight (wt.), and nucleic acid response of various organs and tissues of bluegills held for 20 days at three feeding rates[a]

	Days - Feeding rate[b]		
	20 - 0.0	20 - 0.5	20 - 4.0
Number of fish	4	4	4
Initial S.L. (mm)	104.5 ± 4.8	106.0 ± 4.7	98.0 ± 1.6
S.L. change (mm)	-0.3 ± 0.2	2.0 ± 0.4	7.5 ± 0.8
Initial wt. (g)	36.1 ± 4.0	45.7 ± 5.0	37.3 ± 4.0
Wt. change (g)	-3.3 ± 0.4	0.5 ± 0.3	7.9 ± 1.1
Wt. change (%)	-9.4 ± 1.1	1.2 ± 0.7	21.1 ± 4.6
Liver RNA-P[c]	3,242.3 ± 256.2	3,493.0 ± 444.8	4,434.5 ± 208.4
Liver DNA-P	210.8 ± 27.7	134.9 ± 19.6	98.0 ± 8.8
RNA-P/DNA-P	16.9 ± 4.1	27.9 ± 6.0	47.1 ± 6.8
Stomach RNA-P	428.7 ± 23.2	467.2 ± 15.2	518.5 ± 17.3
Stomach DNA-P	121.2 ± 4.5	112.5 ± 1.8	102.5 ± 5.9
RNA-P/DNA-P	3.5 ± 0.1	4.2 ± 0.1	5.1 ± 0.3
Intestine RNA-P	502.7 ± 15.9	507.9 ± 24.8	601.1 ± 10.7
Intestine DNA-P	223.4 ± 26.6	191.2 ± 15.3	221.1 ± 9.2
RNA-P/DNA-P	2.4 ± 0.4	2.6 ± 0.3	2.7 ± 0.1
Anterior muscle RNA-P	275.7 ± 22.0	250.0 ± 5.9	314.9 ± 30.2
Anterior muscle DNA-P	15.6 ± 1.9	12.9 ± 0.5	13.5 ± 0.5
RNA-P/DNA-P	18.0 ± 1.1	19.4 ± 0.5	23.5 ± 2.4
Posterior muscle RNA-P	349.2 ± 16.2	325.9 ± 2.3	380.1 ± 7.2
Posterior muscle DNA-P	22.4 ± 1.9	20.9 ± 3.0	18.3 ± 1.2
RNA-P/DNA-P	16.0 ± 1.7	17.0 ± 3.3	23.2 ± 1.7

[a]Values given are mean ± standard deviation of the mean.

[b]Feeding rate in percentage of body weight of fish per day.

[c]RNA-P and DNA-P in ug per 100 mg dry, fat-free tissue.

with higher feeding rate and faster growth rate. For greater accuracy, however, initial cold TCA extraction should be included in the standard procedures.

DISCUSSION

By using values obtained with cold, TCA-extracted liver tissue and converting to similar units of measure, it is possible to make comparisons with values obtained in other studies. RNA concentrations of bluegill liver were slightly lower than those found in mammalian liver (Leslie 1955), but fell within the range of values reported for sockeye salmon liver (Creelman and Tomlinson 1959). Liver DNA concentrations of bluegills fell within ranges reported for mammalian liver by Leslie (1955) and sockeye salmon liver by Creelman and Tomlinson (1959).

Table 3. Fresh weight and dry, fat-free weight of various organs and tissues of bluegills held for 10 and 20 days at three feeding rates

Days - rate[a]	Liver[b]	Stomach	Intestine	Anterior muscle	Posterior muscle
10 - 0.0	337.5 ± 43.9[c] 59.4 ± 7.7[d]	255.0 ± 9.6 34.7 ± 1.3	310.0 ± 23.9 44.0 ± 4.8	1,165.0 ± 80.0 180.6 ± 12.4	575.0 ± 52.1 79.3 ± 7.2
10 - 0.5	427.5 ± 22.9 75.3 ± 4.0	255.0 ± 20.2 34.7 ± 2.8	377.5 ± 63.5 53.6 ± 9.0	1,195.0 ± 47.7 181.3 ± 6.9	612.5 ± 47.5 84.5 ± 6.6
10 - 4.0	632.5 ± 123.7 111.3 ± 21.8	302.5 ± 29.0 41.1 ± 4.0	387.5 ± 38.5 55.0 ± 8.0	1,455.0 ± 115.1 225.5 ± 17.9	685.0 ± 83.9 94.5 ± 11.6
20 - 0.0	280.0 ± 28.0 49.3 ± 4.9	275.0 ± 24.0 37.4 ± 3.3	330.0 ± 41.3 46.9 ± 5.9	870.0 ± 40.6 134.9 ± 6.2	445.0 ± 89.4 61.4 ± 7.2
20 - 0.5	795.0 ± 244.6 139.9 ± 43.1	360.0 ± 27.1 49.0 ± 3.7	420.0 ± 17.8 59.6 ± 2.5	1,177.5 ± 64.2 182.5 ± 10.0	640.0 ± 78.8 88.3 ± 10.9
20 - 4.0	817.5 ± 156.3 143.9 ± 27.5	405.0 ± 23.1 55.1 ± 4.7	482.5 ± 37.5 68.5 ± 5.4	1,307.5 ± 82.6 202.7 ± 12.7	600.0 ± 62.9 82.8 ± 8.7

[a] Feeding rate in percentage of body weight of fish per day.

[b] Mean ± standard deviation of the mean of four samples.

[c] Fresh weight of sample in mg.

[d] Dry, fat-free (DFFT) weight of sample in mg.

Table 4. Comparison of nucleic acid determinations with and without prior extraction of interfering compounds with cold trichloroacetic acid.

	Days - Feeding rate[a]					
	10 - 0	10 - 0.5	10 - 4.0	20 - 0	20 - 0.5	20 - 4.0
			Without Cold TCA Extraction			
RNA-P[b]	1,833.6	2,354.4	2,401.8	2,262.9	2,182.8	2,332.8
DNA-P	180.7	144.4	108.2	273.5	106.7	101.7
RNA-P/DNA-P	10.2	16.3	22.2	8.3	20.5	22.9
			With Cold TCA Extraction			
RNA-P	750.0	1,299.6	1,103.1	445.2	1,050.9	923.4
DNA-P	244.6	170.2	102.6	265.1	124.9	91.4
RNA-P/DNA-P	3.1	7.6	10.7	1.7	8.4	10.1
			Magnitude of Difference[c]			
RNA-P	2.4	1.8	2.1	5.1	2.1	2.5
DNA-P	0.7	0.8	1.1	1.0	0.9	1.1
RNA-P/DNA-P	3.3	2.1	2.1	4.9	2.4	2.3

[a]Feeding rate in percentage of body weight of fish per day.

[b]RNA-P and DNA-P in ug per 100 mg dry, fat-free tissue.

[c]Magnitude of difference between measurements with and without prior cold TCA extraction.

In making such comparisons for other bluegill tissues tested, it is necessary to use values obtained without initial cold TCA extraction.

RNA concentrations of bluegill stomach and intestine are similar to those reported for mammalian small intestine (Leslie 1955), but slightly higher than RNA concentrations found for the alimentary tract of sockeye salmon (Creelman and Tomlinson 1959). DNA concentrations of bluegill stomach and intestine fell within the range reported for sockeye salmon alimentary tract (Creelman and Tomlinson 1959), but were lower than values reported for mammalian small intestine (Leslie 1955).

RNA concentrations of bluegill muscle tissue were similar to those reported for mammalian muscle (Leslie 1955), but considerably higher than concentrations found in sockeye salmon (Creelman and Tomlinson 1959; Bluhm and Tarr 1957). DNA concentrations of bluegill muscle were similar to values reported for sockeye salmon muscle by Creelman and Tomlinson (1959), but higher than levels reported by Bluhm and Tarr (1957). DNA concentrations in bluegill muscle fell within the ranges reported for mammalian skeletal muscle (Leslie 1955).

The validity of such comparisons is questionable since, in each study, different species and different analytical procedures were used. In this area of research, there is a need for standardization of techniques and

methods of reporting results. At present, there seems little agreement among researchers on methods of extraction, estimation of RNA and DNA, and reporting of data. Munro and Fleck (1966a, 1966b) should be consulted for recent reviews on the methods of measuring nucleic acids in biological materials. Even though it is difficult to compare absolute values between studies, comparisons between trends and changes found within various studies should be reliable.

This study substantiated the findings of Bulow (1970), that RNA-DNA ratios can be used as indicators of recent growth rate of fishes. It also demonstrated that large fish can be sampled by removing selected organ or tissue samples. RNA-DNA ratios of bluegill liver were most sensitive to changes in body length and weight. In addition, initial removal of interfering compounds with cold TCA extraction would be a desirable addition to previously described techniques.

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EVALUATION OF STRESS INDICES FOR CORN IN IOWA[1]

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ABSTRACT. Four methods of computing moisture stress indices were correlated with corn yield data to determine the best index. The indices computed for each day were summed over the 66-day period from June 27 through Aug. 31. An index that assumed the yield reduction was the same as the reduction in actual evapotranspiration from potential evapotranspiration expressed as a percentage of potential, gave the highest correlations.

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In many areas, particularly in the western part of the Corn Belt, plant water stress causes significant reductions in crop yields. Over the years, many studies have been conducted on the relationship between weather and yield. No attempt will be made to review this literature in detail.

Rainfall was one of the first meteorological parameters used in studying weather-yield relationships. Soil moisture represents a step closer to the water supply of the plant, but only very limited data are available (Stanhill 1957; Baier 1965; Baier and Robertson 1966, 1967, 1968). It is now generally accepted that water stress in the plant is not necessarily produced by either of these factors alone, but is the result of an imbalance between the available water in the soil profile and the atmospheric demand for water (Philip 1957; Denmead and Shaw 1963). A parameter measuring the internal water status of the plant, which is the result of this imbalance, would be the most desirable parameter to study. Of the indices reported, only one involves computing the internal water status of the plant directly; the others use it only indirectly.

Daily soil moisture was calculated for a selected group of stations in Iowa. An April, gravimetric soil-moisture sample was used as the starting point, and daily rainfall and Class A, evaporation-pan data were used as inputs. Four daily stress indices were computed from these data. These indices were an attempt to evaluate the supply versus demand for soil water for each day and to measure the effect on crop yields. This paper summarizes the results of a study where four moisture-stress indices were related to corn yields at 10 locations in Iowa.

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STRESS INDICES

The use of drought or stress indices is not new. The work reported here is a further development of that reported by Dale and Shaw (1965a, b) in which days without moisture stress per season were correlated with corn yields from experimental plots near Ames. Dale (1968) presented results on the climatology of days without moisture stress in Iowa for four locations.

In the original determination of nonstress days, each day was considered either as a stress or nonstress day, with no intermediate degrees involved. In the present study, several different indices were examined, which assigned a severity of stress for each day considered. The indices compared are:

Index I.

This is the original nonstress day (moisture) as used by Dale (1968) and reported on by Dale and Shaw (1965a, b). When the soil moisture cannot meet the atmospheric demand for water, the plant is considered under stress. Denmead and Shaw (1962) expressed the amount of soil moisture in the corn root zone at the estimated turgor loss (stress) point as a function of the transpiration at field capacity. Dale (1964)[3] defined a stress day as any day in which the combination of evapotraspiration demand and available soil moisture did not permit potential water loss.

Two estimates are necessary to identify the stress condition on each day: (a) the soil moisture available in the root zone, or in the top foot of the profile, expressed as a percentage of field capacity (PAV or PAVI) and (b) the atmospheric evaporative demand expressed as the percentage of available field capacity in the root zone required by existing atmospheric conditions to prevent the corn plant from losing turgor (TH).

In the computer program for estimating soil moisture (Dale and Hartley 1963), the stress condition is given by

$$\text{Ratio} = \text{PAV or PAVI}/\text{TH}$$

where the greater of the two PAV values is used. If the ratio is $\geqslant 1.00$, the day has no moisture stress; if less than 1.00, it is a moisture-stress day; i.e., the index is either 1 (no stress) or 0 (stress).

Index II.

This index uses the Ratio as just computed but the degree of stress on a stress day is given by 1.00 - Ratio. Stress on a given day can have any value between 0 and 1, with greater stress occurring with the greater index; opposite of how it was used in Index I.

Index III.

Another way to evaluate the degree of stress is to examine the relationship between the actual evapotranspiration (ET), as computed by the soil-moisture program, and the potential evapotranspiration (PET). When ET is occurring at the PET rate, no stress is assumed. The

[3] Robert F. Dale. 1964. Weather effects on experimental plot corn yields: Climatology of selected favorable and unfavorable conditions. Ph.D. Thesis. University Microfilm Order No. 64-9258. Iowa State University, Ames.

assumption is made that, for any reduction in actual ET from the PET, a similar yield reduction will occur. The computer program computes the ratio of ET/PET. This is called STRS. If STRS is 1.00, the available moisture is $\geq$ that needed to meet the atmospheric demand, and no stress occurs. If the value is less than 1.00, then 1.00 - STRS gives the stress index for that day. Values can range from 0 to 1, with greater stress occurring with the greater value.

In computing STRS, only the percentage of available soil moisture in the root zone has been considered. In computing soil moisture, adjustments are made for evaporation from the top foot of soil, but these do not affect the value of STRS. Although the effect is expected to be small, subsequent work will examine the effect of considering PAV or PAVI, whichever is greatest, on this index.

Index V.

This index is a modification of what was originally called Index IV. Laing (1966)[4] developed a relationship that predicted the relative water content of the crop canopy at 1400 hours each day from the daily soil moisture in the root zone and Class A, evaporation-pan data. This relative water-content value is then used to estimate a relative photosynthetic index (yield) for each day. This index is thus a function of the relative water content, percentage available soil moisture, and the Class A, evaporation-pan loss. For each day, the index can range from 0 to 1, with the lesser values associated with lesser stress.

Each index was summed over the 66-day period from June 27 through Aug. 31. This period was used in place of Dale's (1968) period of 6 weeks before silking to 3 weeks after silking, more as a matter of convenience than for any other reason. Dates before and after this period were not considered in computing stress.

YIELD DATA USED

When the soil moisture survey was started in 1954, the idea was to select a representative area for the soil-moisture sample. At many locations, an area was not available to set up a specific site for soil moisture sampling; therefore an available "representative" area on the farm was used. Because of this, the soil moisture sites at most of the locations have changed position several times. Yields from the soil-moisture sites have often resulted from a range of management conditions. Of the locations used, nine are on experimental farms that had yield data from crop-rotation experiments. The other location, on a private farm, had field yield data available. Data were used where the starting soil moisture was measured on an area where meadow was grown in the previous year (MC) and where corn was grown in the previous year (CC). The yield data and soil-moisture site descriptions for each location are given in the following text because of their importance in interpreting the results obtained.

[4] Douglas R. Laing. 1966. The water environment of soybeans. Ph.D. Thesis. University Microfilm Order No. 66-6988. Iowa State University, Ames.

Ames (Agronomy Farm). During the period of record, the Agronomy Farm was relocated. The yield data were from a well-fertilized, corn-corn-oats-meadow (CCOM) on Nicollet loam or Webster silty clay loam. These soils are somewhat poorly drained, but have drainage tile installed. Under wet conditions, they will have free water in the subsoil. The soil-moisture data are from similar soils, except for a 5-year period when data were collected from a Colo silty clay loam at a nearby irrigation-research area. This soil is a poorly drained, alluvial soil.

Beaconsfield (Shelby-Grundy Farm). Yield data used were from the soil moisture sites and from a CCOM rotation with good fertilization on a Grundy silty clay loam with a slope of 2-4%. Some plots are imperfectly drained. The soil-moisture sites were in bulk corn areas with widely varying previous management, but having soil characteristics very similar to those of the rotation experiment. In some years the soil moisture site yield was quite different from the rotation yields.

Bloomfield (Southern Iowa Farm). The soil of this farm is an Edina silt loam with high clay content in part of the subsoil and with poor drainage. Moisture samples were taken in a tile-drainage experiment with high fertility and a COM rotation. Yield data are from this experiment for meadow-corn (MC) and from a nearby continuous-corn area for corn-corn (CC), also in the drainage experiment.

Castana (Western Iowa Farm). This area is hilly. The plots were located on an Ida silt loam soil with slopes of up to 15%. This is a deep loess soil, low in organic matter and available phosphorus. The rotation yield data are from an experiment receiving adequate fertilization. The soil moisture site has changed frequently, with individual years having quite different management from that of the rotation experiment.

Doon (Northwest Iowa Moody Farm). The Moody soil is a well drained, silty clay loam with slopes of 2-5%. Yield data come from COMM and CCO rotations in which the soil-moisture samples were taken.

Independence (Carrington-Clyde Farm). The soil at this site in northeastern Iowa has been renamed Kenyon. It is a loam soil, moderately well drained with many sand pockets in the subsoil. Yield data are from an adjacent CCOM rotation.

Kanawha (Northern Iowa Farm). The soil at this site is a Webster silty clay loam, which is naturally poorly drained, but which has tile drainage. The yield data come from a CCOM rotation from which the soil-moisture samples were taken in about half the years. The samples for the remaining years were taken in available areas. In several of these years, meadow areas with poor stands were the only meadow sites available.

Marshalltown. This is the only site on a private farm. The soil is a Muscatine silty clay loam with very little slope. This soil is somewhat poorly drained. Yield data are field values for the field within which the soil-moisture samples were taken. Although labeled CC, this has been a Sb-C sequence in some years.

Norwich (Soil Conservation Farm). The soil at this site is a Marshall silty clay loam, moderate to well drained, with slopes of 2-4%. Yield data are from a well-fertilized CCOM rotation. Soil moisture samples were taken from a number of bulk corn areas with widely different management.

Sutherland (Galva-Primghar Farm). The soil of this site is a Galva silty clay loam, well drained, with 2-4% slope. Yield data come from a CCOM rotation and from the nearby soil-moisture-site area.

When different varieties were used during the period of the data and when records of these varieties were available, the yields were adjusted to the last hybrid grown by using data from the Iowa Corn Yield Test (1958-1967). Adjustments were made for Ames, Bloomfield, Doon, Independence, and Sutherland. There were only small ranges in the population levels used at each location; therefore, no stand adjustments were made.

RESULTS AND DISCUSSION

The correlation coefficients between yield and the different indices at each location are given in Table 1. In comparing the indices, index III

Table 1: Correlation coefficient (r) between corn yield and four different indices.

Location and Experiment	Index 1	2	3	5
Ames CC	0.79	-0.90	-0.92	0.82
Ames MC	0.67	-0.86	-0.84	0.72
Beaconsfield CC	0.30	-0.36	-0.47	0.28
Beaconsfield SMS	0.73	-0.81	-0.79	0.78
Bloomfield CC	0.31	-0.28	-0.42	0.25
Bloomfield MC	0.49	-0.45	-0.51	0.40
Castana CC	0.63	-0.75	-0.77	0.70
Castana MC	0.70	-0.80	-0.82	0.73
Castana SMS	0.67	-0.79	-0.92	0.74
Doon CC	0.73	-0.90	-0.92	0.84
Doon MC	0.77	-0.90	-0.93	0.92
Independence CC	0.06	-0.08	-0.13	0.10
Independence MC	0.51	-0.62	-0.61	0.55
Kanawha CC	0.62	-0.79	-0.81	0.71
Kanawha MC	0.53	-0.67	-0.60	0.60
Marshalltown CC	0.64	-0.71	-0.63	0.65
Norwich CC	0.57	-0.74	-0.87	0.68
Norwich MC	0.58	-0.68	-0.90	0.62
Norwich SMS	0.51	-0.60	-0.74	0.53
Sutherland CC	0.62	-0.78	-0.84	0.73
Sutherland MC	0.74	-0.86	-0.89	0.82
Sutherland SMS	0.64	-0.78	-0.85	0.73

r^{05} (14 df) = .50; r^{01} (14 df) = .62

had the highest correlation coefficient 17 of 22 times and, index II, 5 of 22 times. Index III was statistically different (1 or 5% level) from index I 9 times and near the 10% significance level 3 times. Index III was significantly different from index II only once, with 2 values near the 10% level of significance. Index III was significantly greater than index V for

5 values. There seems little to choose between indices II and III, although index III consistently gave the highest correlation. Index III was accepted as the best index, and further discussion will be limited to that index. In interpreting the correlations with yield, the site information given previously should be considered. Also, the general level of stress for different areas needs to be considered because lower correlations were generally found in the wetter parts of the state. The average values of the index for the period used ranged from 7 at Independence to 25 at Doon for MC. Individual yearly values have ranged from 0.1 to 56.

At Ames, the correlations were surprisingly high since the moisture samples for almost a third of the years came from a different soil type than did the yield data. The correlation for the CC site at Beaconsfield was not significant. Management and soil moisture conditions at the moisture site were believed enough different from the rotation experiment to cause this. A good correlation with yield was found for the soil moisture site. Correlations at Bloomfield were low, although significant for the MC site. This soil is characterized more as being too wet rather than too dry. The highest index value for MC was 37, with the next highest 26, indicating no severe stress has occurred. The highest index value for CC was only 28.

At Castana, the soil moisture site showed the highest correlation. The differences in management between this site and the rotation sites are believed to cause this. Both Doon and Sutherland have what are considered excellent data. This, combined with their drier locations, resulted in high correlations.

The correlation for CC at Independence was not significant, although that for MC was significant. No high stress values were measured. Lack of significance for the CC site was due to a small range in the corn yields for most years, with the highest and lowest yields measured under wet conditions. This was not true for MC. Independence had the lowest index of the stations used.

Kanawha had a good correlation for CC, but was considerably lower for MC. The lower correlation for MC was believed due to several years with poor stands of meadow at the soil moisture site. The soil moisture site did not adequately represent the corn-yield site.

Marshalltown had a relatively low correlation. At that location, only 2 years have had an index value greater than 20. This station did show an increase in the yield variation explained by using a quadratic relationship. At Norwich, the soil moisture site had extremely variable management, which affected the yield level; yet, the index calculated was well correlated with the rotation yields.

As far as Iowa is concerned, index III explained a considerable amount of the yield variation measured in the western half of the state, with a much poorer relationship in the wetter, eastern part. Because the period of record has been generally a below-normal stress period (Dale 1968) and because the data used were not from experiments specifically designed to evaluate stress-yield relationships, the results seem very satisfactory.

Future work will evaluate the effect of weighting the stress index at different phenological periods and the effect of consecutive days of stress on the relationship with yield.

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A KEY TO THE SPECIES OF BOLTERIA UHLER WITH DESCRIPTIONS OF SIX NEW SPECIES (HEMIPTERA, MIRIDAE)

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ABSTRACT. A key to 14 species of Bolteria Uhler is provided. New species of Bolteria are B. arizonae from Arizona; B. dakotae from South Dakota; B. nevadensis from Nevada; B. omani from California; B. siouxan from Wyoming; and B. schaffneri from Colorado.

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The genus Bolteria Uhler, type Bolteria amicta Uhler, was described in 1887 from New Mexico. The genus went unrecognized by other workers for many years, or until the writer found type material in the Lugger collection at the University of Minnesota in 1919. In the same year Knight (1919) published concerning the characters of the genus, its position in family Miridae, and noted that Dichrooscytus speciosus Van Duzee really belongs in genus Bolteria. It was also pointed out that Dichrooscytus speciosus var. rubropallidus Knight (1918) is a good species in genus Bolteria. Other species have since been described and are now included in a key which follows. The male genital segment does not offer useful external characters for separating species, hence the lack of illustrations for such purpose. It now appears that species of Bolteria breed only on conifers, particularly the genus Juniperus, where several species have been found.

Key to the Species of Bolteria

1. Antennal segment I not equal to width of vertex. 2
   Antennal segment I in length, greater than width of vertex. . . . . semipicta Blat.

2. Frons pale, transversely marked with red lines. 3
   Frons without distinct transverse lines. 7

3. Rostrum reaching beyond hind coxae. 4
   Rostrum only reaching upon hind coxae. 6

4. Corium chiefly pallid or opaque white. 5
   Corium rather uniformly dark red to fuscous; pronotum reddish to fuscous brown, disk and calli flecked with red; femora dark red, hind pair white on anterior aspect and with two rows of red spots; small ovate form, length 3.7 mm. . . . . nicholi Kngt.

5. Clavus with a pale stripe running lengthwise through the middle; pronotum with blackish spot or ray beginning at outer margin of callus and curving around behind and toward middle of disk; length, 5.1 mm. . . . . amicta Uhler

Clavus dark reddish to black, margin bordering claval suture only, pallid; pronotal disk white, without a blackish ray extending around behind callus, although the basal margin of the disk is black; length 4.3 mm. . . . . rubropallida Kngt.

6. Pronotum opaque white, calli black, a small black ray extending posteriorly from lateral margin of each callus; cuneus white, narrow apex red; length (♀) 4.8 mm. . . . . omani n. sp.

Pronotal disk with a broad submarginal basal band of reddish brown color; calli brownish black; cuneus pallid, central area with a triangular red brown spot, and apex with a small black spot; length (♂) 3.8 mm. . . . . arizonae n. sp.

7(2). Hemelytra with red, sometimes only dusky red, but the cuneus red on outer margin. 8

Hemelytra testaceous, inner half of clavus and apical area of corium darkened with fuscous; outer margin of cuneus fuscous; length (♂) 4.2 mm, (♀) 3.9 mm. . . . . luteifrons Kngt.

8. Scutellum white, usually with a dark mark on median line at base. 9

Scutellum and pronotum reddish, although finely reticulate with paler; propleura and epimera of mesothorax white; clavus uniformly reddish like the corium; length (♀) 4.6 mm. balli Kngt.

9. Pronotum pallid to opaque white, basal margin of disk darker. . 10

Pronotal disk and corium chiefly red; apical fourth of corium, inner half of clavus bordering scutellum, blackish; length 4.8 mm. . . . . speciosa Van D.

10. Corium and clavus with opaque white areas. 11

Corium and clavus rather uniformly light fuscous, subtranslucent, the hypodermis filled with granules of red pigment; length 4.0 mm. . . . . nevadensis n. sp.

11. Cuneus white, outer margin and apical one-third red, or reddish black. 12

Cuneus dark, fuscous to reddish, the inner basal angle opaque white, but with flecks of dark color; length (♀) 3.8 mm. . . . . dakotae n. sp.

12. Epimeron of mesothorax fuscous; legs pallid to dusky. 13

Epimeron of mesothorax white; legs white; length 4.7 mm. . . . . juniperi Kngt.

13. Membrane fuscous, with an opaque spot bordering apex of larger areole; epimeron of the mesothorax fuscous; length (♀) 3.2 mm. . . . . siouxan n. sp.

Membrane without an opaque callus spot bordering apex of larger areole; length (♂) 3.0 mm, (♀) 3.1 mm. schaffneri n. sp.

Bolteria omani new species

In the key this species runs in the couplet with arizonae, but size is larger; pronotal disk without a basal submarginal band; cuneus white, apex only reddish black.

Female. Length 4.8 mm, width 2.2 mm. Head: width 1.2 mm, vertex .50 mm; vertex rather broadly convex, carina not elevated as in most species; white, frons with six transverse red lines each side of middle, in part fused; vertex with a red spot each side set in contact with the eye; clypeus with red each side of middle on basal half, apex fuscous; juga with lower half red. Rostrum, length 1.6 mm, reaching upon apex of hind coxae, yellowish to reddish. Antennae: segment I, length .48 mm, red, dorsal aspect white; II, 1.8 mm, cylindrical, slender, slightly thicker on apical half, yellowish; III, broken. Pronotum, length 1.0 mm, width at base 1.9 mm; disk rugose punctate; white, calli black, with a fuscous ray extending posteriorly from outer margin of each callus. Scutellum convex, smooth and white; mesonotum exposed, black but reddish on median line.

Hemelytra opaque white; clavus narrowly fuscous along inner margin and at base; apical edge of corium and two incomplete marks on middle, reddish to black; apex of embolium with black; cuneus white, narrow apex with reddish black; membrane fuscous, darker within areoles, veins white. Venter white, irregularly marked with reddish. Sternum fuscous to red. Legs pallid to white, femora irregularly marked with red.

Holotype: ♀ June 4, 1935, San Jacinto Mts., California (P. Oman), on Pinon pine. U.S.N.M. Collection. Paratypes: 2 ♀, taken with the type.

Bolteria arizonae new species

In the key this species runs in the couplet with omani, but differs in having a broad, submarginal basal band of reddish brown on disk of pronotum.

Male. Length 3.7 mm, width 1.5 mm. Head: width .98 mm, vertex .35 mm; carina slightly arcuate as viewed from above, vertex with a prominent reddish spot each side next to the eye; frons with a patch of transverse red lines each side, some lines so close they appear to merge; clypeus, bucculae, and lora except basal half, deep red. Rostrum, length 1.4 mm, reaching upon apex of hind coxae, reddish. Antennae: segment I, length .40 mm, pale yellowish; II, 1.9 mm, brownish yellow, cylindrical, slightly more slender near base; III, .67 mm, slender, brownish; IV, broken. Pronotum, length .68 mm, width at base 1.28 mm; propleura and central area of disk, pallid to white; transversely across calli, lateral margins of disk, and a broad, transverse subbasal band reddish brown, the narrow basal edge and central area of disk, opaque white. Scutellum moderately convex, white; mesonotum dark brownish black. Hemelytra, lateral margins only slightly arcuate; clavus white, with two longitudinal dark reddish brown lines, the inner line wider on middle and reaching edge by scutellum; corium white but with dark brown along inner side of radius, widening to take in much of apical half of corium; embolium dark brown, paler just beyond middle, but broadly reddish brown on apical area and confluent with apex of corium. Cuneus reddish brown, the margins white except narrow apex which is brownish black. Membrane fuscous, veins white.

Sternum dark brown, epimera with brown but margins white. Legs white and in part brown; femora dark brown, apical half more or less white, hind pair with a row of red dots along median line; tibia white, spines dark brown; tarsi fuscous. Venter white, marked laterally with brown; basal half of genital segment dark reddish brown. Male claspers typical of the genus.

Female. Length 3.7 mm, width 1.7 mm. Head: width 1.02 mm, vertex .49 mm; color and markings similar to the male. Rostrum reaching upon apex of hind coxae. Antennae: segment I, length .38 mm; segment II, 1.6 mm, color and form similar to that of the male. Pronotum, length .72 mm, width at base 1.3 mm; coloration similar to that of the male.

Holotype: ♂ August 18, 1927, Coconino County, Arizona (R.H. Beamer); Kansas University Collection. Allotype: same data as the holotype. Paratypes: 2♂, 2♀, taken with the types (R.H. Beamer). 7♂♀ (P.A. Readio); 4 ♂♀ (L.D. Anderson), taken with the types.

Bolteria nevadensis new species

Allied to speciosa Van D., but differs in color of the hemelytra; corium and clavus shaded with light fuscous, subtranslucent, the hypodermis filled with granules of red pigment.

Male. Length 4.0 mm, width 1.5 mm. Head: width 1.21 mm, vertex .60 mm; yellowish to pale fuscous, frons uniformly dusky yellow. Rostrum, length 2.1 mm, reaching upon base of genital segment, dark red. Antennae: segment I, length .26 mm, pallid to pale fuscous; II, broken. Pronotum, length .69 mm, width at base 1.3 mm; reddish yellow, collar black, calli pale fuscous, basal margin of disk fuscous; propleura pallid to dusky yellow. Scutellum white, disk moderately convex; mesonotum yellowish to fuscous. Hemelytra except cuneus, dusky, subtranslucent, hypodermis filled with light red granules of pigment. Cuneus opaque white, lateral margin and apical half dark red. Membrane light fuscous, veins red. Venter brownish black, genital segment dusky brown. Sternum brownish black, epimera white. Legs white, no marks, tips of tarsi fuscous.

Female. Length 4.1 mm, width 1.6 mm. Head: width 1.31 mm, vertex .64 mm; form similar to the male; frons yellow, clypeus fuscous, lora and juga light fuscous. Rostrum, length 2 mm, reaching upon ovipositor to just short of middle. Antennae broken. Form and coloration very similar to the male.

Holotype: ♂ June 24, 1966, White Pine County, Nevada, 6 miles southwest of Ely, altitude 6500 ft. (W. Gagné), taken on Juniperus. Knight Collection. Allotype: ♀, taken with the type.

Bolteria dakotae new species

In the key to species dakotae runs nearest to juniperi Kngt., but differs in having the cuneus fuscous to reddish, also by other color distinctions.

Female. Length 3.8 mm, width 1.4 mm. Head: width 1.0 mm, vertex .56 mm; pale to yellowish without marks, clypeus fuscous, juga reddish yellow. Rostrum, length 1.7 mm, reaching upon middle of venter, reddish. Antennae: segment I, length .40 mm, pallid; II, 1.4 mm, nearly cylindrical, but more slender on basal one-fourth, yellowish

to pale fuscous, with short, fine pale pubescence; III, broken. Pronotum, length .56 mm, width at base 1.2 mm; pale yellowish brown, collar and calli dark brown, propleura pale to yellowish. Scutellum moderately convex, with transverse striae evident, pallid to white, shaded brownish at middle of base; mesonotum dark brown. Hemelytra clothed with fine, recumbent, pale to yellowish pubescence; clavus dark brown, outer margin pallid; corium brown to dark brown, pallid bordering clavus; embolium brown to dark brown. Cuneus brown to dark brown, inner basal angle somewhat pallid. Membrane pale fuscous, veins dusky to reddish. Venter dark brown, genital segment paler on apical half. Sternum reddish brown; epimera dusky to fuscous. Legs pallid to pale fuscous; femora pale fuscous, tibiae dusky, tarsi fuscous.

Holotype: ♂ July 20, 1928, Englewood, South Dakota (H. C. Severin); Knight Collection.

Bolteria siouxan new species

Allied to schaffneri, but distinguished by having a callus spot in membrane bordering apex of larger areole.

Female. Length 4.2 mm, width 1.5 mm. Head: width 1.2 mm, vertex .59 mm; yellowish brown, lower half of head medium brown color. Rostrum, length 1.9 mm, reaching upon first genital segment, color reddish brown. Antennae: segment I, length .38 mm, pallid; II, 1.40 mm, cylindrical, slender, thicker on apical half, dusky yellow; III, .70 mm, slender, dusky; IV, .48 mm, fuscous. Pronotum, length .68 mm, width at base 1.34 mm, yellow brown over opaque white hypodermis, calli more brown, collar brownish black, basal margin of disk dark fuscous. Mesonotum dark brown. Scutellum moderately convex, yellowish white. Corium and embolium reddish brown, inner margin of corium opaque yellowish white and flecked with brown; clavus dark brown, margin bordering claval suture opaque yellowish white but basal one-third all brown. Cuneus opaque dull white, narrow outer margin red, apex dark brownish red. Membrane light fuscous, veins red, a callus spot bordering apex of larger areole. Clavus and corium clothed with appressed, fine short pubescence, color matching that of the subsurface. Ventral surface light brown, or dusky brown; venter medium brown to reddish brown. Legs pallid to opaque white, tibial spines pale to light brown, tips of tarsi infuscated.

Holotype: ♀ July 29, 1931. Medicine Bow Mts., Wyoming (H. H. Knight); Knight Collection.

Bolteria schaffneri new species

Allied to siouxan but smaller and more slender; without the callus spots in wing membrane.

Male. Length 3.0 mm, width 1.5 mm. Head: width 1.14 mm, vertex .56 mm; medium brown, without marks on frons, the clypeus only slightly darker brown; eyes a different shade of brown. Rostrum, length 1.92 mm, reaching to base of genital segment, brown, apex black. Antennae: segment I, length .35 mm, pallid to light brown; II, 1.5 mm, cylindrical, slender, somewhat thicker on apical half; III, .75 mm, slender, pale to dusky; IV, .38 mm, fuscous. Pronotum, length .67 mm, width at base 1.28 mm; collar black, calli brown; central area of disk opaque white in the hypodermis, chitin surface shaded with light brown,

basal margin fuscous to black, but not sharply defined. Mesonotum dark brown. Scutellum moderately convex, white with a yellow tinge on surface. Clavus brownish black, opaque yellowish along suture margin; embolium reddish brown, corium reddish brown to brownish black, opaque yellowish along margin by clavus. Clothed with short, appressed pubescence, but more sparsely set than in siouxan. Membrane rather evenly shaded with fuscous, veins red, without a callus spot by apex of larger areole. Ventral surface fuscous brown, genital segment somewhat paler. Legs opaque white, tips of tarsi fuscous; tibial spines yellowish to brown.

Female. Length 3.1 mm, width 1.5 mm. Head: width 1.23 mm, vertex .64 mm; the eyes curve slightly to posterior position. Rostrum reaches back to middle of first genital segment. Antennae: segment I, length .40 mm; II, 1.14 mm; III, .75 mm, pale; IV, .48 mm, fuscous. Pronotum, length .70 mm, width at base 1.31 mm. Color and pubescence very similar to the male.

Holotype: ♂ August 11-14, 1969, Gould, Jackson County, Colorado (J.C. Schaffner); U.S.N.M. Collection. Allotype: same data as the type. Paratypes: 1♂, 3♀, taken with the types. 1♀ August 19, 1969, North Pass, Saguache County, Colorado (J.C. Schaffner). Named in honor of the collector, Dr. Joe C. Schaffner, Texas A and M University, who has been very active with the Miridae, and of great help to the author.

Bolteria amicta Uhler

Bolteria amicta Uhler, 1887, p. 33
Bolteria amicta Knight, 1919, p. 127

The original specimens were collected in New Mexico by Dr. Bolter.

Records: NEW MEXICO: ♀ June 1913, Silver City (J.B. Wallis). ARIZONA: ♂♀ June 22, 1929 (A.A. Nichol); ♂ May 5, 1933, Chiricahua Mts. (E.D. Ball). UTAH: ♀ May 21, 1909, West Wats (E.D. Ball).

Bolteria speciosa (Van Duzee)

Dichrooscytus speciosus Van Duzee, 1916, p. 236
Bolteria speciosa: Knight, 1920, p. 127 (1919)
Bolteria speciosa: Knight, 1928, p. 131, key.
Bolteria speciosa: Knight, 1968, p. 203

The types came from G. Alpine Creek, Tahoe, California (E.P. Van Duzee), taken on Juniperus. NEVADA: ♂♀ June 23, 1965, Nevada Test Site (H.H. Knight and Joe Merino), taken on Juniperus.

Bolteria juniperi Knight

Bolteria juniperi Knight, 1968, p. 202, fig. 252

Several specimens were collected on Juniperus osteosperma, which is the host plant. All specimens of this species were taken only on young trees, five to seven feet in height. NEVADA: ♂♀ June 23, Nevada Test Site (H.H. Knight and Joe Merino). ARIZONA: ♂ June 16, altitude 8000 ft., Grand Canyon. UTAH: 1♂, 6♀ June 29, 1965, Scipio (H.H. Knight).

Bolteria rubropallidus Knight

Dichrooscytus speciosa var. rubropallidus Knight, 1918, p. 11
Bolteria rubropallidus Knight, 1928, p. 132

Described from NEW MEXICO: ♂♀ June 7-17, 1916, Jemez Spring,

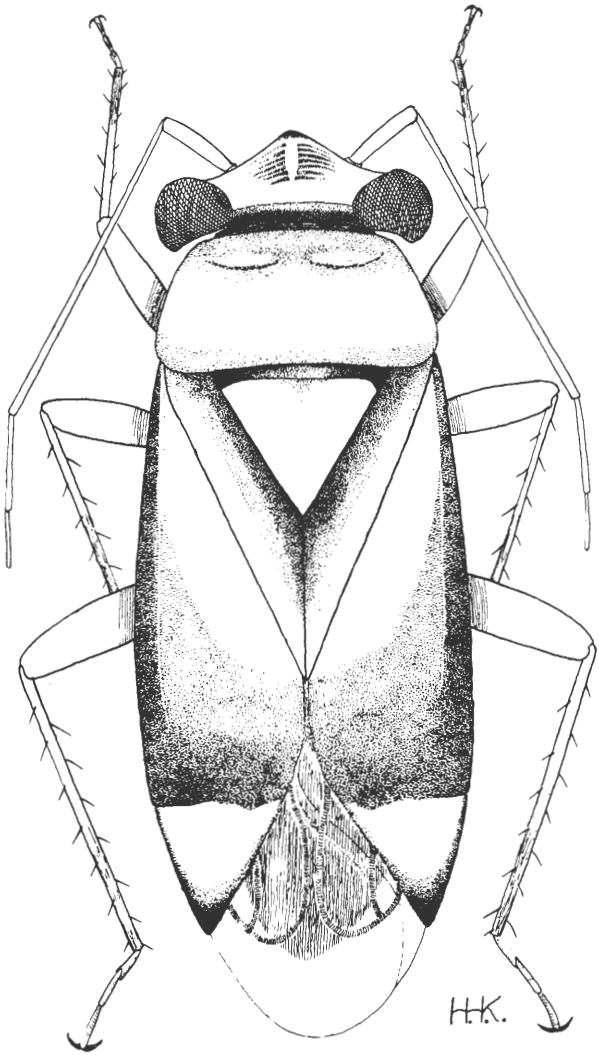

Figure 1. Bolteria juniperi, ♂.

Bolteria nicholi Knight

Bolteria nicholi Knight, 1928, p. 129.

Described from Williams, Arizona, June 18, 1925, where 10 ♂♀ were collected on Pinus edulis (A. A. Nichol). NEVADA: ♂♀ June 24, 1966, Pine County, Ely, alt. 6500 ft. (W. Gagné)

Bolteria luteifrons Knight

Bolteria luteifrons Knight, 1921, p. 73

This species was described from a single specimen, ♂ April 17, 1908, Raleigh, North Carolina (E. P. Van Duzee). The next specimens came from MAINE: ♂♀ July 8, 1938, Bar Harbor (A. E. Brower). MISSOURI: ♂♀ April, 1939, Roaring River State Park (R. C. Froeschner); ♂♀ May 24, 1942, Gray Summit (R. C. Froeschner). Next, the species was found in IOWA: ♂♀ June 3, 1953, Ames (H. H. Knight) where it was found breeding on Juniperus virginiana. Specimens were taken each year up to 1969, but it disappeared from the Juniper trees after that year. It has failed to show since and we believe the species was exterminated around Ames by the mosquito control program which used a DDT spray for a few years. ARKANSAS: ♂♀ May 13, 1963, Washington County; received for identification.

Bolteria balli Knight

Bolteria balli Knight, 1928, 130.

Described from a single specimen, ♀ June 23, 1913, Kanab, UTAH (E. D. Ball), a specimen received in an exchange many years ago.

Bolteria semipicta Blatchley

Bolteria semipicta Blatchley, 1926, p. 743

This species was described from Dunedin, Florida; 1♂ April 23, taken "at porch electric light." The very long first antennal segment distinguishes this species from all others, and may indicate another genus.

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1 A circulating copy of each thesis is available in the Iowa State University Library. A microfilm or a photostatic copy of a thesis may be purchased from the Iowa State University Library, Ames, Iowa.

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Veterinary Surgery

MC DANIEL, CONNIE DAVENPORT
Home economics instruction in modular scheduled schools in Iowa
Home Economics Education

MC KEOWN, BRADLEY KENT
A simulation analysis of a dynamic system
Industrial Engineering

MC WHORTER, GEORGE MICHAEL
Control of the European corn borer with two varieties of Bacillus thuringiensis
Entomology

MEDH, DEVALKUMAR U.
A precision solid state proportional temperature controller
Electrical Engineering

MENDEL, RAYMOND MAX
The motivational determinants of task performance in a non-industrial milieu: A modification and extension of Vroom's model
Psychology

MENTZER, MAUREEN O'BRIEN
A case study of an off-campus quarter of study in family environment
Family Environment

MILLER, JEAN MAGEE
Retention of learning two years after an experimental training program for food service personnel
Institution Management

MINAKUCHI, SATOSHI
Analysis of Indium and Cadmium activated to Metastable States with cobalt - 60 Gamma-Rays
Nuclear Engineering

MINEAR, LANCE ROLLIN
The protein requirement of turkey breeder hens as influenced by strain and supplemental biotin, lysin and a histomoniastat
Poultry Science (Nutrition)

MITCHELL, ALICE JEAN
Dietary protein and serum lipids in refed rats
Nutrition

MOLINS, RICARDO A.
Effect of liquid nitrogen freezing on bacterial flora of beef
Food Technology

MORRISON, DAVID JOHN
Glucoamylase kinetics and recycle
Chemical Engineering

MORROW, CHARLES K.
Competencies needed by seed production and distribution company employees
Agricultural Education

MOSTAFA, BADRIA S.
Neutralization and delinquency, an empirical test of the Sykes-Matza theory
Sociology

MYERS, SHIRLEY EVELYN
The impact of paraprofessionals on home economics extension personnel and programs
Family Environment

NANDI, SHANTANU
Modified simulation of synchronous machine
Electrical Engineering

NELSEN, BURNELL EMERY
Investment analysis by analog computer
Industrial Engineering

NELSON, DALE R.
Infectious bovine rhinotracheitis (Herpesvirus bovis) infection in swine
Veterinary Microbiology

NELSON, DONNA CHRISTINE
Motor ability and motor activity in young children
Child Development

NELSON, GARY MELVIN
Relationships among scores derived from Stanford Achievement test, Otis-Lennon Mental Ability test, Teacher Rating and Hear, See and Mark Test
Child Development

NIEMANN, DAVID ARTHUR
Classification and ordination of the vegetation of Woodman Hollow, Iowa
Botany (Plant Ecology)

NNADI, LAMBERT AKPARU
The influence of organic marbles on the availability of phosphorus to soybean plants
Soil Fertility

NORDSTRUM, DOUGLAS EDWIN
Managing finances of industrial arts departments
Education (Industrial Education)

NOURY, MOSTAFA MOSTAFA
The adjustment of selected foreign students at Iowa State University
Sociology

NWOBODO, CHRISTOPHER IKECHUKWU
A study of audience responses to black actors in television dramas and commercials
Journalism and Mass Communication

OAKLAND, MARY JANE
Quality of fresh whole hams as affected by boning
Food and Nutrition (Food Science)

O'BRIEN, WILLIAM GEORGE
Torque-Knudsen measurement of the vapor pressure of the platinum dihalides
Chemical Engineering

OGUNLANA, MICHAEL OGUNLEKE
Inhibition of salivary carbohydrases of Empoasca fabae (Homoptera: Cicadellidae) by selected solanum alkaloids
Entomology

OLAWOYE, OLUMAYOKUN OMOTAYO
A model of labor mobility and capital growth for Nigeria
Agricultural Economics

ONTHUAM, YUPHA SIRIKIATE
Comparing clusters formed by two cluster analysis techniques
Statistics

OTTO, DONALD PHILIP
Effect of maternal age and calcium on longevity and fecundity of the rotifer (Philodina citrina)
Zoology (Physiology)

PALMER, JANE RAE
The role of enterococci in Cheddar cheese curing
Food Technology

PANDA, DURGA PRASAD
Interfacing a pattern processor with an all-purpose digital computer
Electrical Engineering

PAREKH, HARSHAD
The determination of first coefficient of ionization by electron impact
Electrical Engineering

PARKER, THOMAS MASON
Fracture of Type 347 stainless steel
Nuclear Engineering

PASSERI, DAVID
An adaptive digital frequency discriminator
Electrical Engineering

PATANOTHAI, ARAN
Heterotic response for vegetative growth and fruiting development in grain sorghum
Agronomy (Plant Breeding)

PATANOTHAI, SOONTREE
A comparison of different field designs for evaluating tolerance of oats to crown rust
Plant Pathology

PATTEN, JIM D.
Nebraska daily newspaper executives: A profile
Journalism and Mass Communication

PATTON, JAMES EDWARD
Visual distractibility in children diagnosed as having a learning disability
Psychology

PECORARO, JOSEPH MICHAEL
The chemistry of p-nitrobenzyl sulfides, sulfoxides and sulfones
Chemistry

PECORARO, THERESA NEMETH
Far infrared studies of transition metal-polycyclic phosphite complexes
Chemistry

PERETTI, MARTA CRISTINA
A study on anomie in selected age-segregated and age-integrated communities
Sociology

PETERS, JOHN WILLIAM
Glycolic acid metabolism in lactating and non-lactating goats
Nutrition

PETERSEN, ALLEN DUANE
Experimental evaluation of the effectiveness of audio-tutorial instruction techniques in teaching small gas engines
Agricultural Education

PEYTON, HAROLD L.
The effect of demonstration group size and skill procedure sheets on the development of manipulative skills
Agricultural Education

PHOORATA, PONGSIRI
Availability of native and added phosphorus in Iowa soils
Soil Fertility

PITZEN, DANIEL FREDERICK
Influence of physical form of corn grain on ration digestibility and nutritional performance in finishing beef cattle
Animal Nutrition

PODUSKA, ERVIN LOUIS
Piezoresistance effects in N-type magnesium germanide
Solid State Physics

POITEVIN, HOWARD L.
Factors related to occupational status of male graduates of West Union, North High School
Agricultural Education

POOLE, JAMES CARL, JR.
Envelopes of minimum velocity increment for near-earth orbital transfer and rendezvous
Aerospace Engineering

PROVOOST, HELEN DOROTHEA
Production of a secondary producer (Glyptotendipes barbipes) in a tertiary treatment pond
Zoology (Limnology)

PRYSE, GEORGIA ANN
Relationship of age and performance of food service personnel participating in a training experiment
Institution Management

PURICH, CAROL HOUTS
The relationship between expectation-perception similarity and satisfaction in a simulated counseling session
Psychology

PYNE, DAVID ALBERT
Relationships between sets of variables found by several model building procedures
Statistics

QUINIONES, ADELAIDA CORTEZ
Effect of age and flight on indirect flight muscles of the mosquito, Culex Tarsalis
Entomology

RAMACHANDRAN, GOPAL
A survey of pulse width modulation
Electrical Engineering

REDDY, MALIREDDY SRINIVASULU
Development of cultural techniques for the study of starter streptococci
Food Technology

REIDEL, WALLACE F., JR.
Competencies needed by livestock salebarn employees
Agricultural Education

REISS, EDITH ANN
Home economics programs offered in the Iowa Area Community Colleges and Vocational-Technical Schools
Home Economics Education

ROBINSON, PHILIP WAYNE
Progressive eradication of Ustilago striiformis by Benomyl in perennially infected stolens of Agrostis palustris
Horticulture

ROSSMAN, MARY HONTS
Employment status of women: Patterns of interests and attitudes
Psychology

ROY, SUJIT KUMAR
Sensitivity analysis of a Kalman filter using hybrid simulation
Electrical Engineering

RUEHR, THOMAS A.
Some effects of nitrogen fertilizers on saturation extracts of Nicollet and Muscatine Soils
Agronomy

RUKTANONCHAI, SUNEE
The effect of B chromosomes on a chromosome translocation during endosperm development in maize
Cytogenetics and Plant Breeding

RYEN, ALLEN HARRY
The development of attitudes toward own and other group
Psychology

SALADINO, KATHLEEN BUZICKY
Fit of women's slacks in relation to body shape
Textiles and Clothing

SALEM, AHMED SHAWKI
Investigation of alternative estimators of the parameters of autoregressive processes
Statistics

SAMPAIO, IVAN BARBOSA MACHADO
A comparison of the Cp statistic and the ridge trace method in building nonorthogonal linear models
Statistics

SANCHEZ, BRAULIO VALENTIN
A numerical investigation of Sun-perturbed motion in the vicinity of the Earth-Moon equilateral libration points
Aerospace Engineering

SARGENT, JEAN VIETH
Adaptation of space and equipment for the performance of food preparation processes by elderly arthritic homemakers
Family Environment

SCHELLE, RONALD FRANCIS
Phase relationships in the copper-niobium alloy system
Metallurgy

SCHMIDT, SHERYL ANN
Kinetic studies on the reduction of cobalt (III) complexes by copper (I)
Chemistry (Inorganic)

SEEMANN, RICHARD CHARLES
Droplet separation in a liquid-liquid system
Chemical Engineering

SEXTON, JOSEPH WEST
The effects of high levels of solids in water on the fecundity of mice
Veterinary Pathology

SHARMA, RAJINDER MOHAN
Effects of chronic lead exposure on pregnant sheep and their progeny
Veterinary Pathology

SHARMA, SATINDER M.
Corporate earnings and optimal debt ratio
Industrial Engineering

SHAW, BERTHA JEAN
A guide for placement in university clothing construction courses based on students' knowledge
Textiles and Clothing

SHOBER, STEPHEN FREDERICK
Bond strength on compression bars
Structural Engineering

SHOVER, NANCY HEATH
A method for estimating the variance in nonlinear estimation
Statistics

SHRIVER, BURGESS HALE
Chemical results of the Beta decay of Tellurium-131 and Tellurium-131m in hydrocarbon solutions of Alkyl Tellurides
Chemistry

SHRIVER, CYNTHIA NIEZGODA
Studies on glucagon fibrils
Biochemistry

SKIFF, DONALD ELLSWORTH
Television and cultural change: Marshall McLuhan's "Global Village"
Journalism and Mass Communication

SKOGEN, LOUIS OLE
Capsulation of Propionibacterium
Food Technology

SLACK, ROBERT WILLIAM
Rapid determination of Al, Co, Cr, Cu, Mn, Ni, and V in low and high alloy steels by flame emission spectroscopy
Chemistry (Analytical)

SMITH, BARBARA JEAN
Effect of dietary protein source on carotene and vitamin A utilization
Nutrition

SMITH, JOYCE ANN
Consumption of household textiles by twelve Iowa families
Textiles and Clothing

SMITH, KENNETH EDMUND
A study of the silica in some Iowa diatoms
Geology

SMITH, THOMAS ANDREW
A seismic refraction investigation of the Manson disturbed area
Geology

SNIDER, NANCY RUTH
McLuhan: An experimental test of propositions related to the environment of media use
Journalism and Mass Communication

SPANIER, GRAHAM BASIL
A study of the relationship between and social correlates of romanticism and marital adjustment
Sociology

STANEK, JACQUELINE WENDT
Flow diagrams generated and printed by computer
Computer Science

STEWART, RONALD KENT
Stabilization of the polymorphic transformation of zirconium dioxide using erbium oxide
Ceramic Engineering

STIELER, CAROL MAE
Location of the velvet coat mutant of the laboratory mouse in Linkage Group VI
Genetics

STOFFER, TERRY JAMES
The effects of a self-enhancing appeal, personalized salutation, and handwritten postscript on response to a mail solicitation of funds
Journalism and Mass Communication

STONE, JAY D.
Life history and bioeconomic investigations of Plathypena scabra (Fab.) on soybeans (Lepidoptera: Noctuidae)
Entomology

STRANDBERG, KRISTIN
Effect of sulfhydryl reagents on post-mortem changes in rabbit skeletal muscle Myosin B
Food Technology

STRETZ, LAWRENCE ALBERT
Emissivity studies on selected rare earth metals
Chemical Engineering

STRONGE, JOYCE ELAINE
Age and sex differences in the color preferences of nursery school children and their mothers
Child Development

SULEIMAN, SULEIMAN AHMAD
Effect of salicyclic acid and thyroxine on the early development of chick lim buds
Zoology (Embryology)

SYMALLA, DENNIS MATHEW
Semidiones of cyclohept-2-en-1, 4-dione and derivatives
Organic Chemistry

TANHEHCO, BENITO L.
Graphic recorder for ultrasoundscope
Biomedical Engineering

TANG, CHIN-TZA
Interfacial stability of an embedded plate
Engineering Mechanics

TAS, MEHMET
Effects of variety, planting date, and maturity on dry matter and digestible dry matter yields of pearlmillet
Agronomy (Crop Production)

TAYLOR, JOHN COLIN
An evaluation of the universal soil loss equation for predicting watershed sediment yield
Agricultural Engineering

THOMAS, COLLEEN
An exploratory study of the involvement of family members in the selection of the family dwelling
Family Environment

THOMAS, GAIL BOTTOMLEY
Comparison of the growth of Bacillus Subtillis L forms in sodium chloride or sodium succinate containing medium at minimal agar concentrations
Bacteriology

THOMAS, WILLIAM DEAN
Computer controlled CRT display with character and vector generators
Electrical Engineering

THORNBURG, DENNIS DEAN
Flock behavior of diving ducks on Keokuk Pool, Mississippi River
Zoology (Animal Ecology)

TICE, THOMAS EVERT
Selection systems and performance appraisal in the fire service: A study of criteria development and test validation
Psychology

TOTH, PAUL JOSEPH
A study of refraction error correction in an integrated Inertial/Satellite Navigation System
Electrical Engineering

TOWNSEND, JOE DAVID
Use of speakers and resource persons in young and adult farmer classes in Iowa and Texas
Agricultural Education

TRAMPE, ANN ELYSE
Visual responses to color combinations with application to clothing selection students
Textiles and Clothing

VAN DER PLOEG, RIENK R.
Well flow theory for a confined elliptical aquifer
Agronomy (Soil Physics)

VOIGTS, DAVID KENNETH
Comparative food habits of two Iowa marsh Icterids
Zoology (Animal Ecology)

WALLACE, DONNA
Evolution of the drainage in a portion of the Bighorn Basin near Shell, Wyoming
Geology

WEATHERS, PHILIP WAYNE
Internal flow patterns of forming liquid drops
Chemical Engineering

WEBER, DALE WILLIAM
Studies on the utilization of corn plant by-products by beef cows
Animal Science (Nutrition)

WHIGHAM, MYRNA ANN
Quantitative evaluation of factors affecting vascular regeneration in isolated coleus internodes
Plant Physiology

WIENERT, ROBERT JOHN
Growth of zinc single crystals at a controlled rate from the melt
Chemical Engineering

WILSON, DONALD GARY
Relationships among porcine blood and muscle characteristics
Meat Science

WINBORN, PHILLIP EVERETT
Relationships of specific leaf weight and leaf thickness with net photosynthesis in diverse soybean varieties
Crop Production and Physiology

WINSLOW, DOROTHY JEANNE
Elementary programmed unit on fibers and finishes: their influence on clothing selection and recommended care practices
Home Economics Education

WINTERBOER, RONALD DEAN
A producer orientated model for programming crop production
Economics

WITT, GARY GEORGE
The effect of oxygen on the stability of uranium-carbon compounds
Metallurgy

WOODRUFF, KENNETH ALLEN
Evaluation of header height control mechanisms
Agricultural Engineering

WU, WEI-WHONG
Extraction of copper
Chemical Engineering

YAMAGUCHI, ANN M.
Home and family roles assumed by young Iowa men
Home Economics Education

YETLEY, ELIZABETH ANN
Availability of iron from four foods, fed separately and in mixtures
Food and Nutrition (Nutrition)

YÜCEL, VEFA
Regionalization of reservoir storage requirements for selected streams in Iowa
Water Resources (Civil Engineering)

YUNG, SUZANNA KIT-WING
Chromatographic study of urinary flavins
Biochemistry

ACACIO, FLORECITA BARSANA
Self-instructional program of training for food service personnel compared with group training
Institution Managemand and Home Economics Education

ADAMS, NORMAN ROYCE
Physical and biological characterization of the agent of transmissible enteritis of turkeys
Veterinary Microbiology and Preventive Medicine

ADEYANJU, SUNDAY ADEPOJU OYENIYI
Studies on growth of progeny from rats subjected to dietary restrictions during gestation and lactation
Animal Nutrition

AHRENS, DONALD L.
Experimental evaluation of prepared lesson plans on instruction in vocational agriculture
Agricultural Education

AKHAVI, MANOUCHEHR SADAT
Occurrence, movement and evaluation of shallow groundwater in the Ames, Iowa area
Water Resources

ALDABAGH, ABDUL SATAR YOUNIS
Effect of tile drainage on trafficability for agricultural equipment
Agricultural Engineering - Civil Eng.

ALLISON, DAVID ALBERT
Metal carbonyl complexes of a nonchelating phosphite-phospine ligand
Inorganic Chemistry

ALLISON, JUANITA WILLIAMS
Equilibrium studies of N-methyl and N-ethyl substituted diethylenetriamine complexes of copper (II) with amino acids
Inorganic Chemistry

ANDERSEN, JOHN RICHARD
Comparative study of spontaneous lesions in the hearts and arteries of some Iowa wild animals and birds
Veterinary Pathology

ANDRADE, FRANCISCO JACINTO
Some normative aspects of planning in the Maule Region, Chile
Economics

ARBOLEDA, CECILIO ROCES
Economic feasibility of measuring feed consumption in a poultry breeding operation
Poultry Breeding

ASKALANI, MOHAMED HASSAN
Economic analysis and alternative procedures for estimating broiler production functions
Agricultural Economics

AYANRU, DAFE KPIGERE GBORIAVHIEN
The effects of heterogeneous oat population on the epiphytotic development of Victoria Blight
Botany (Plant Pathology)

BAILEY, FRANK RONALD
A study of finite amplitude disturbances in plane Poiseuille flow by finite-difference methods
Aerospace Engineering - Engineering Mechanics

BARTLETT, ROGER JAMES
Optical studies of Cadmium
Physics (Solid State)

BATAL, KHEIREDDIN MOHAMMED
Influences of certain growth regulators upon fruit cracking and mechanical properties of the tomato fruit skin
Horticulture

BECKER, DONALD ARTHUR
Chemical interferences and ionization in high temperature flames
Analytical Chemistry

BENNETT, ROY
Student achievement in Biology 101 at Iowa State University
Education

BLANKESPOOR, HARVEY DALE
Host-parasite relationships of an avian trematode Plagiorchis noblei Park, 1936
Zoology (Parasitology)

BOAST, CHARLES WARREN
Potential flow and drawdown for a well in a partially confined porous medium
Agronomy (Soil Physics)

BONDARI, KHORSAND
A study of genetic maternal effects in a designed experiment using Tribolium
Animal Breeding

BORCHER, SIDNEY DEAN
Experimental evaluation of demonstrations in teaching vocational agriculture
Agricultural Education

BOWERS, RAYMOND HAROLD
A structural investigation of the hydrogen bonding in copper (II), nickel (II), and palladium (II) complexes of some vic-dioximes
Analytical Chemistry

BRAMMER, GARY LEE
Structure of glycogen
Biochemistry

BREDAHL, RUSSELL L.
Beef-dairy crossbreeding: A study of birth traits
Animal Breeding

BRIDGES, HAROLD RAY
Design requirements of precoat filters for water filtration
Civil Engineering (Sanitary)

BRIGGS, DINUS MARSHALL
Influence of sex chromosomes and maternal effects on production traits in the fowl
Poultry Breeding

BROM, JOSEPH MARCH, JR.
Spectroscopy of matrix isolated high temperature Species I. Thallous Halides II. Thallous Oxide
Chemistry (Physical)

BRUN, JUDY KAY KALBFLEISCH
An observational method for studying classroom cognitive processes
Home Economics Education

BRUN, TORBEN OTTO
Magnetic form factor of thulium and terbium metals
Physics (Solid State)

BRYANT, WILLIAM F.
Mass spectroscopy of organometallic compounds
Organic Chemistry

BULL, JAMES ROBERT
Simulation of heated effluent dispersion in an open channel
Nuclear Engineering

BUREN, LAWRENCE LAMONT
Plant characteristics associated with barrenness in maize
Crop Production and Physiology; Plant Physiology

BURNS, ROBERT ARTHUR
Surface studies of simple hydrocarbons on Iridium by flash desorption
Chemistry (Physical)

BUSCH, NEAL EDWARD
Investigations into the primary structure of feather keratin
Biochemistry

BUSS, PAUL ADELBERT, JR.
A survey of tapetal types and tapetal characteristics in the Leguminosae
Plant Morphology

BYERLY, RICHARD L.
The use of multiple regression and path analysis in analyzing success in Journalism at Iowa State University
Education

CARPENTER, PHILIP DAVID
Part I. Tropone-acetylene cycloadducts: The chemistry of bicyclo-[3.2.2]-nonatrienones. Part II. The reactions of nitrosobenzene with cyclic polyolefins
Organic Chemistry

CASEY, DENNIS WAYNE
Estimation of performance efficiency in the laying hen
Poultry Science (Poultry Breeding)

CETAS, THOMAS CHARLES
Magnetic thermometry from 1 to 30 K
Physics

CHAO, JULIE YE-O
Maltodextrin phosphorylase in Escherichia coli: Mechanism and regulation of synthesis
Biochemistry

CHASE, JAY BENTON
Electron energy loss to surface excitations in thin films
Physics

CHILDS, WILLIAM HENRY
Traveling wave energy conversion in piezoelectric media
Electrical Engineering

CHOUDHURY, NABENDU SEKHAR
Study of the mass and charge transport in thoria
Metallurgy

CHRISTOPHER, JOHN ALLEN
The effect of pH on the biological and chemical characteristics of Salmonella typhimurium
Bacteriology

CHUANG, PI-CHUN
Description and error analysis of a rapidly converging norm reduction method for eigenvectors
Applied Mathematics

CLAASSEN, MARK M.
Effect of agricultural limestone on nutrient composition and yield of corn and on soil chemical properties
Soil Fertility

COLEMAN, THOMAS PATRICK
Model analyses of elementary particle scattering amplitudes
Physics

CONTARIO, JOHN JOSEPH
An oxidation-reduction system with chelating properties
Analytical Chemistry

CORIA, MANUEL F.
Immune response to chickens to live and inactivated avian infectious bronchitis virus
Veterinary Microbiology

CORNICK, DOUGLAS EDWARD
The numerical optimization of distributed parameter systems by gradient methods
Aerospace Engineering and Electrical Engineering

CRAMER, DEAN WESLEY
Factors affecting transfer of students entering the Arts and Sciences Division of Iowa Central Community College during the years 1963, 1964, and 1965
Education

CRISWELL, JEROME GLENN
Physiological basis for variation of net photosynthesis in oat (Avena spp.) leaves as affected by genotype and sink-source ratios
Agronomy (Crop Production and Physiology)

CUTLIP, RANDALL CURRY
Cytopathologic alterations induced by the agent of ovine chlamydial polyarthritis
Veterinary Pathology

DARRAH, LARRY LYNN
Genetic parameters estimated from generation means in four diallel sets of maize inbreds
Plant Breeding

DAS, LAKSHMINARAYANA
Quantitative and histomorphological studies on age-correlated changes in canine and porcine hypophysis
Veterinary Anatomy

DA SILVA, SONIA
Food practices of families in a Brazilian City
Home Economics Education

DEBOER, KENNETH FRANK
The uterine environment and the fate of transferred embryos in the rat
Animal Science (Animal Reproduction)

DEYOE, BILLY L.
Studies on the pathogenesis of a canine abortion agent (Brucella canis) in dogs and other domestic animals
Veterinary Pathology

DIEDRICK, WALTER EMIL, JR.
Evaluation of the industrial-education program at Iowa State University, 1959-1969
Education (Industrial Education)

DIXON, SAMUEL LEE
The relationship of counselor defense mechanisms to counseling outcome
(Counseling and Guidance)

DORNHOFF, GARY MARVIN
Net photosynthesis of soybean leaves as influenced by anatomy, respiration, and variety
Crop Production and Physiology

DOUGLAS, LYLE ANGUS
Inhibition of urease activity in soils
Soil Chemistry

DROST, JIM L.
Job characteristics of automotive mechanics in selected Iowa dealerships and garages
Education

DURAND, BERNICE BLACK
A point and local position operator
High Energy Physics

DUVEN, DENNIS JAMES
Convergence of the difference equation for the error covariance matrix arising in Kalman filter theory
Electrical Engineering

EL-LAKANY, MOHAMED ALI
Characterization of maize inbreds in testcrosses for plant and ear characters and yield at varying plant densities and effectiveness of selection in successive generations of inbred progenies for improvement of hybrid yields
Plant Breeding

EL-TABLAWY, TALAAT AHMED
Digital optimization of long-range power system planning using the dynamic programming technique
Electrical Engineering

ELTZE, ERVIN MARVIN
Some properties of integration
Mathematics

EMIOLA, LATEEF OYEBAMIJI
Production, purification and properties of Bacillus macerans amylase
Biochemistry

ENGARDT, RALPH DUANE
Nuclear magnetic resonance determination of the activation volume for self-diffusion in aluminum
Physics (Solid State)

EYVINDSON, ROGER KARTON
A model of interregional competition in agriculture incorporating consuming regions, producing areas, farm size groups and land classes
Agricultural Economics

FELCH, RICHARD ELROY
Some physical and physiological aspects of evapotranspiration from a soybean canopy
Agricultural Climatology

FERELL, RAYMOND SMITH
Forest management flexibility: A definition and some measures
Forestry (Forest Economics)

FIGHT, ROGER DEAN
The crucial decisions in obtaining "demand" information for outdoor recreation planning
Forest Economics

FINCH, ROBERT BRUCE
Smoothing for delayed state model with applications to aided inertial navigation systems
Electrical Engineering

FIORINO, JOHN A.
Molecular absorption and light scattering in flames employed for atomic absorption spectroscopy
Chemistry (Analytical)

FISCHER, DARYL ROBERT
Dendritic spaces and order relations
Mathematics

FISHER, TOM LYONS
Simulation of the active site of vitamin B_6-dependent enzymes
Biochemistry

FLASH, PATRICK JOHN
Rate and product studies on the oxidative cleavage of some bicyclic alcohols with ceric ammonium nitrate
Chemistry (Organic)

FLEMING, RICHARD WILLIAM
Characterization of organic nutritional requirements for Clostridium Thermocellum
Bacteriology

FODA, ESAM A.
The role of fat in the flavor of Cheddar cheese
Food Technology

FRENCH, HOWARD LINCOLN, JR.
Importance of major gene effects on quantitative traits in the fowl
Poultry Breeding

FRIEDMAN, ROBERT MARK
A study of the preparation, structure and properties of compounds containing polynuclear cations of bismuth. An investigation of anion effects
Inorganic Chemistry

FRIEDRICH, DOUGLAS DUANE
Developmental analysis of short-term memory capacity and information encoding strategy
Psychology

FUGATE, ROBERT Q.
Measurement of the volume dependence of the heat capacity of solid neon
Solid State Physics

GALLANT, A. RONALD
Statistical inference for nonlinear regression models
Statistics

GANFIELD, DAVID JUDD
Characterization of an immunizing antigen with endotoxin-like properties isolated from Pasteurella multocida
Biochemistry

GANFIELD, MONG CHING WONG
Isolation and characterization of sphingolipid from Ochromonas danica
Biochemistry

GEADELMANN, JON LEE
Estimation of mass selection parameters from a heterogeneous oat population
Plant Breeding

GIL-TURNES, JULIO BENJAMIN
An analysis of the one and two year vocational and technical programs in agriculture
Education

GIROLO, JACK EMILE
Fixed point theorems for non-continuous functions
Mathematics

GOOD, CARL MUNGER, III
Temperature sensitive-salt remedial mutants of Staphylococcus aureus
Genetics

GOODALE, THOMAS GORDON
Survey and analysis of student personnel programs for transfer students in four-year institutions
Administration of Higher Education

GUINAN, JOSEPH FRANCIS
Estimation of egg production functions from experimental data with economic applications
Agricultural Economics

GUSTAFSON, LEONARD LEROY
Changes effected by North Central Association visitations to Iowa high schools, 1967-1968
Educational Administration

GUTMAN, EDWARD JOSEPH
A study of the Fermi surfaces of antiferromagnetic chromium-rich alloys using the de Haas-van Alphen effect
Physics

HABENSCHUSS, MICHAEL
Structural, magnetic, and spectroscopic study of nickel squarate dihydrate
Physical Chemistry

HACKERT, MARVIN LEROY
The crystal structure determinations of tetraethylamonium hexabromoantimonate (V), 4-enthylpyridinium tetrabromoferrate (III) and D-glucono-(1,5)-lactone, and a method for partial structure evaluation
Chemistry (Physical)

HAESSEL, WALTER WERNER
A theoretical analysis of intersectoral relationships in a five-sector, optimizing model of a dual economy
Economics

HAMILTON, DAVID ALEXANDER, JR.
Precision requirements for some information in timber management decisions
Forestry

HAMMOND, HOWARD RAY
Selected characteristics of new trade and industrial teachers in the nineteen member states of the North Central Association
Education

HANDY, CHARLES B.
The accounting for convertible debt
Economics

HANSEN, HERBERT EUGENE
Experimental evaluation of videotape on instruction in vocational agriculture
Agricultural Education

HARRIS, DELBERT L.
Resistance to Bordetella bronchiseptica infection in swine
Veterinary Microbiology

HARTER, GARY DEAN
Estimates of a dairy cow milk production function
Agricultural Economics

HASKELL, BRENT ALAN
Electron tunneling measurements on pure bulk thorium
Physics

HEIN, WARREN WALTER
Decay of ^{95}Ru and ^{103}Tc
Physics

HEINER, TERRY CHARLES
Competitive ability of five populations of Amaranthus retroflexus L.
Botany (Plant Ecology)

HENDERSON, DAVID COURTLAND
The preparation and some high temperature properties of the rare earth trifluorides
Chemistry (Physical)

HEROLD, EDWARD STEPHEN
Dating adjustment and dating satisfaction: An application of exchange theory
Sociology

HEXEM, ROGER WAYNE
Factors affecting the economic and social well-being of agriculturalists in less-developed countries and agriculture's contribution to general economic expansion
Agricultural Economics

HILLS, THOMAS M.
Comparative factors affecting chemical control of Western corn rootworm larvae
Entomology

HIRNING, HARVEY JAMES
The design of environmental control systems for livestock
Agricultural Engineering

HOCHHAUS, LARRY
Editing processes in memory
Psychology

HOLDEN, PALMER JOSEPH
The sulfur-amino acid requirement for reproducing gilts
Animal Science (Nutrition)

HOPKINS, WALTER ALAN
The impact of anomie and perceived blockage upon adolescent anti-social behavior
Sociology

HOPPER, NORMAN WAYNE
The evaluation of upright leaves and the use of sucrose glutamate in increasing the yield of corn
Agronomy (Crop Production and Physiology)

HUANG, RODNEY JAU-WEI
Mechanism of vapors sorption on Fiberglass-E
Soil Engineering

HULETT, JOE RICHARD
A theory of jointness and infeasibility of exclusion
Economics

HUNTER, LEROY DEAN
Polarized absorption electronic spectra for single crystals of dichloro (ethylenediamine) platinum (II)
Physical Chemistry

HUNTINGTON, ROBERT WARREN
A comparison of student attitudes in selected Iowa high schools
Education (Educational Administration)

HUNTLEY, THOMAS EDWARD
Physicochemical studies on the active site of glutamic acid decarboxylase
Biochemistry

HYBERTSON, RONALD LEE
Biochemical and cytological aspects of in vitro metabolism of parathion by rat liver cell fractions
Zoology

IOANNOU, TOM KYRIACOU
Prediction of equilibrium data for the solvent extraction system Sm Cl_3-Nd Cl_3 $CeCl_3$-HCl-H_2O with the extraction DI-(2-Ethylhexyl) phosporic acid in Amsco
Chemical Engineering

ISAKI, CARY TSUGUO
Survey designs utilizing prior information
Statistics

JAMLANG, EVAMONICA MERCEDITA
Thermal inactivation of staphylococcal enterotoxin with changing pH, protein concentration and ionic strength
Food Technology

JENSEN, LOUIS
Mathematical models for the growth of diploid populations with overlapping generations
Statistics

JENSON, EARL ANGUS
Programming models of irrigation development
Agricultural Economics

JOHNSON, DOUGLAS KIESTER
Stabilities of some rare-earth malonato chelate species in aqueous and methyl alcohol solution
Inorganic Chemistry

JOHNSON, GARY DEAN
Neogene molasse sedimentation in a portion of the Punjab-Himachal Pradesh Tertiary re-entrant, Himalayan foothill belt, India: A vertical profile of Siwalik deposition
Geology

JOHNSON, ROBERT JOEL
Computer methods for analyzing electronic absorption spectra of vitamin B_6 analogs and enzymes
Biochemistry

JOHNSON, RONALD GORDON
The photoneutron cross section in the giant resonance region for several 82 neutron isotones
Nuclear Physics

JOHNSON, VERNON SCOTT
The behavior therapy controversy: A study on observer bias, reliability, and information
Psychology

JOHNSTONE, JAMES KEITH
The Erbia-Hafnia System
Ceramic Engineering

JOLLY, FRANK H.
An experimental approach to class lecture and demonstration techniques in teaching industrial arts
Education

JONES, WILLIAM EDWARD
Surface modes of vibration and optical properties of an ionic crystal slab
Solid State Physics

JOSHI, RAMESH CHANDRA
Pozzolanic reactions in synthetic fly ashes
Soil Engineering

JUNGK, ROBERT ARTHUR
Post-mortem physiochemical changes in turkey muscle
Food Technology

KAMALU, THEODORE NKIRE
Nutritional regulation of insulin and glucagon secretion in sheep
Animal Science (Nutrition)

KAMINSKI, EDWARD EUGENE, JR.
Anion exchange separation of metal ions in Thiocyanate Media
Chemistry (Analytical)

KAWAL, DONALD EDMUND
A systems model of a construction firm
Engineering Valuation

KELLER, DAVID ANTHONY
Electronic heat capacity of R_eO_3
Chemistry (Physical)

KENT, MICHAEL ALLEN
Effects of Ventromedial Hypothalamic lesions on hunger motivated behavior in rats
Psychology

KESKE, ROBERT GUSTAV
The conformations of Cycloheptanesemidione and related systems
Chemistry (Organic)

KLINGENSMITH, JOHN EDWARD
Patterns of change in academic performance in college and their correlates with pre-college variables
Psychology

KOLLMAN, GERALD EUGENE
Germination-domancy and promotor-inhibitor relationships in Setaria lutescens seeds
Plant Physiology

KNOWLTON, TED MERRILL
Components of interelectrode resistance in an electrofluid bed reactor
Chemical Engineering

KRAMER, MAURICE STEPHEN
Relationship of marital status to selected characteristics and activities of male undergraduate students at Iowa State University
Education

KROHN, HOWARD EMIL
Large, multi-layer, high density, nondestructive readout film memories
Electrical Engineering

LACASA-GOMAR, JAIME
The Serder-Linker-Receiver communication model
Sociology and Anthropology (Rural Sociology

LASSAHN, GORDON DENNIS
Exiton oscillator strengths in silver chloride
Physics (Solid State)

LAUER, GEORGE NICHOLAS, II
Power of Cochran's test in Behrens-Fisher problems
Statistics

LAWSON, DAVID FRANCIS
Some phenomena of semidiones in solution
Organic Chemistry

LAZO, EVARISTO
Effect of TIBA on the action of 2,4-D on plants
Crop Production and Physiology

LEVY, LARRY JAMES
Adaptive estimation algorithms
Electrical Engineering

LINDVALL, RONALD NEAL
Genotypic and phenotypic relationships between gain, feed efficiency and backfat probe in swine
Animal Science (Breeding)

LOUGHNER, GEORGE EMMANUEL
Factors influencing mating of the European Corn Borer, Ostrinia Nubilalis
Entomology

LOUP, ROLAND JOSEPH
A generalization of the mean square successive difference statistic with applications
Statistics

LOWE, REX LOREN
Taxonomic and ecological analyses of diatom communities in drainage ditches
Botany (Phycology)

LUGTU, RENATO
Transient stability analysis of power systems using Liapunov's second method
Electrical Engineering

LURA, RICHARD DEAN
Mechanism of the photocycloaddition of stilbene to olefins
Organic Chemistry

LYNDE, RICHARD ARTHUR
A spectrophotometric study of the equilibrium formation of the gaseous species Bismuth (I) Tetrachloroaluminate and Tellurium (II) chloride
Chemistry (Inorganic)

MAC EACHERN, ALEXANDER
A generalized projection method for systems on nonlinear equations
Computer Science

MANNING, WILLIAM ROGER
Anomalous elastic behavior of polycrystalline Nb_2O_5
Ceramic Engineering

MARANGU, JOHN PAUL
Allografting as a biological measure of inbreeding in chickens
Poultry Science (Breeding)

MARTIN, LESLIE LEON
The crystal and molecular structures of selected organometallic compounds and some direct methods
Chemistry (Physical)

MARTINEZ-GARZA, ANGEL
Estimators for the erros in variables model
Statistics

MASTERSON, PAUL BRUCE
Hydrogenation of ethylene on iridium thin films
Physical Chemistry

MAZE, ROBERT CRAIG
An ultrahigh vacuum study of wetting in liquid metal -- solid metal systems
Chemical Engineering

MC ATEE, JOHN WAYNE
Metabolic regulation of somatotropin and prolactin secretion in ruminants
Animal Nutrition

MC ATEE, JOYCE WOOD
Dietary protein and lipid metabolism in refed rats
Nutrition

MC CASLIN, NORVAL L.
Experimental evaluation of field trips on instruction in vocational agriculture
Agricultural Education

MC CLAIN, DONALD HENRY
Development of a computer-assisted instruction unit in probability
Education

MC CLUSKY, JAMES KEITH
Preparation of uranium metal and dense UO_2 shapes by the carbon reduction of U_3O_8
Nuclear Engineering

MC DOWELL, TERENCE LEE
Mechanism of the photoconversion of 5,5-dimethylbicyclo (4.1.0)-hept-3-en-2-one to 2,3,5-trimethylphenol and 3,4,5-trimethylphenol
Organic Chemistry

MC ELHONE, DONALD HUGHES
Estimation of the mean of skewed distributions using systematic statistics
Statistics

MC ELHONE, JOSEPHINE MATILDA
Free gold as a constraint on monetary policy during the early stages of the great depression
Economics

MC EWEN, GERALD KENT
Part I. Structural studies of cyclic phosphorus compounds. Part II. Low-valent transition metal complexes of phosphorus ligands
Inorganic Chemistry

MC GEE, DUBOIS PHILLIP
Construct validation of a measure of alienation in Black adolescents
Psychology

MC VEY, GARY C.
Experimental evaluation of the effectiveness of an audio-tutorial method in teaching vocational agriculture
Agricultural Education

MELLON, DONALD WILLIAMS
Transport properties of Gd-Th, Gd-Mg, and Y-Th Alloys
Physics (Solid State)

MEYER, JOHN LOUIS
A study of some hexanuclear mixed-metal cluster compounds containing tantalum and molybdenum
Chemistry (Inorganic)

MILLARD, JOSEPH EUGENE
Organizational factors which contribute to the development of successful team teaching programs
Educational Administration

MORAGHAN, BRIAN JOSEPH
Plant characters related to yield response of unselected lines of soybeans in various row widths and plant populations
Agronomy (Plant Breeding-Crop Physiology

MORRIS, FLOYD EVERETT
Photoelastic waves
Engineering Mechanics

MOSSHOLDER, NELSON VANCE
Spectroscopic properties and analytical applications of premixed oxygen-hydrogen flames
Analytical Chemistry

MYERS, RICHARD W.
Effects of motivational incentives on GATB "F" and "M" subtest performance with hospitalized neuropsychiatric patients
Education (Guidance and Counseling)

NAITO, HERBERT KUNIO
Interrelationship of thyroxine, exercise, and feed intake on serum and hepatic cholesterol levels
Zoology (Physiology)

NANDA, BHUPINDER SINGH
Extrinsic and intrinsic blood supply and histomorphological changes associated with age in the cerebral arteries and brain nuclei in dog (Canis familiaris) and pig (Sus scrofa domestica)
Veterinary Anatomy

NEARHOOF, EDWARD ORRIN
An examination of teacher-pupil interaction in third-year French classes
Education

NICHOLAS, DAVID COLE
Source codes for the output of a delta modulator operating on speech
Electrical Engineering

NORD, DENNIS LYNN
A study of the effects of demand characteristics on college students' study behavior
Psychology

NOURI, ESMAT MOUSTAFA
The mathematical and statistical theory of culling selection
Statistics - Agronomy

OAKLAND, DAVID OLIVER
Order relations and Boolean methods in general set theory
Mathematics

OBENG, HENRY BENJAMIN
Characterization and classification of some ironpan soils of Ghana
Soil Genesis and Classification

O'BRIEN, PETER CHARLES
Procedures for selecting the best of several populations
Statistics

OLESON, GARY K.
Computational aspects of geometric programming
Economics-Computer Science

OLSON, CLIFFORD GERALD
Infrared spectra of substitutional H^- and D^- impurities (U-centers) in CsBr and CsI
Physics (Solid State)

OLSON, DAVID LAMOYNE
A photomechanics system for non-destructive three-dimensional stress analysis
Agricultural Engineering

OLSON, LARRY ALLAN
Corn rootworm influences on corn varieties at selected plant population and soil fertility levels
Entomology

OLSON, NORMAN JAMES
The effect of precipitation on the mechanical properties of the Cu-1.9% Co and the Cu-2% Co-6% Zn systems
Metallurgy

OPENSHAW, MARTIN DAVID
The effect of ammonia on germination and development of seedlings in soil
Agronomy (Soil Fertility)

OWENS, JOHN CHARLES
Selection for corn rootworm tolerance in maize
Entomology

PANLASIGUI, ROGELIO ANDRES
Kinetics of copper dissolution
Chemical Engineering

PANOUSIS, NICHOLAS THEODORE
Low temperature specific heat of cerium and cerium-yttrium alloys
Metallurgy

PARSONS, GERALD E.
Needs and interest of Iowa State University alumni in continuing education
Education

PATZWALD, JOHN B.
Determining teacher values to improve school communications
Education Administration

PAXSON, JOHN RALPH
Ligand substitution reactions of platinum (II) complexes. Chloro (diethylenetriamine) platinum (II) - chloride exchange
Inorganic Chemistry

PEARSON, JOANNE MILLER
Interrelationship of home environment and industrial employment including methodological study of family food practices
Home Economics Education

PEARSON, RONALD EARL
The effect of age distribution and female culling on the profitability of the dairy herd
Animal Breeding

PETERS, GALEN ROGER
Extension of algebraic theories
Mathematics

POLO, RICHARD JOSEPH
Optimum synthesis of three-dimensional structures
Structural Engineering

PRASSE, KEITH WILLIAM
Granulocyte kinetics in cats
Veterinary Pathology

PREDEBON, WILLIAM WALTER
Shock waves in solids
Engineering Mechanics

RAFFENETTI, RICHARD CHARLES
Even-tempered atomic orbitals in quantum chemical ab initio calculations: Light atoms, heavy atoms, triatomic alkali ions
Physical Chemistry

RASER, GLEN ALVIN
Encoding processes in recognition memory
Psychology

RASMUSON, JAMES ORLEY
An experimental and theoretical evaluation of the nitrous oxide-acetylene flame as an atomization cell for flame spectroscopy
Analytical Chemistry

REEVES, ROBERT DONALD
Influence of feeding frequency on lipid metabolism in adult rats recovering from malnutrition
Nutrition

REIERSON, ROBERT LEE
Thermal rearrangements of 1-methoxybicyclo [3.2.0] hepta-3, 6-dien-2-one and exo-1-methoxybiclo [3.2.0] hepta-3,6-dien-2-ol
Organic Chemistry

REIF, LICENCIADO, ISAAC
Spectroscopic temperature measurements of flames and their physical significance
Physical Chemistry

RHOADES, KEITH RAY
Pathologic responses of turkeys to Mycoplasma meleagridis infection
Veterinary Pathology

RICHEY, JACK ATHA
A comparison of ratios and deviations for expressing weaning weights and grades in beef cattle records
Animal Breeding

RICHARDS, KENNETH EDGAR, JR.
A plane thermoelastic crack problem
Engineering Mechanics

RIPLEY, GERALD DAVID
The use of man-computer interaction in root-finding and numerical problem-solving
Computer Science

ROBBINS, MEDFORD DWIGHT
Reactions of ceric ammonium nitrate I. With substituted cycloheptatrienes II. With diazoalkanes III. With sodium azide and olefins
Organic Chemistry

ROBINSON, WILLIAM H.
A revision of the Nearctic species of Groups I and II of Megaselia (Diptera: Phoridae)
Entomology

ROGERS, KEITH DANIEL
Theory and application of food aid in economic development
Economics

ROSENBERRY, PAUL EUGENE
A proposal for improving the U.S. Department of Agriculture's cost and return studies
Agricultural Economics

ROST, DUANE FOSTER
Laboratory investigation into evaluation of aperture-to-medium coupling loss
Electrical Engineering

ROST, THOMAS LOWELL
Structural and histochemical investigations of dormant and non-dormant caryopses of Setaria lutescens (Gramineae)
Plant Morphology

ROUSE, GENE HENRY
Effect of strain, slaughter weight and protein level on performance and carcass characteristics of swine
Animal Science

RUDOLPH, FREDERICK BYRON
Purification, properties, and kinetics of adenylosuccinate synthetase from Escherichia coli
Biochemistry

RULF, DONALD CLARENCE
Heat capacities of four rare earth trichloride hexahydrates from 5 to 300°K
Chemistry (Physical)

RYAN, JON MICHAEL
The role of histone during aging in Vitro
Cell Biology

SAEGROVE, MARCUS JOHN
On bitophological spaces
Mathematics

SALADINO, CHARLES F., JR.
Age changes in the canine pancreas: Histomorphological, electron microscopic, and biochemical study
Cell Biology

SALMON, LYDIA SUSAN
Molecular integrals using the bipolar expansion and comments on localized orbitals in diatomic molecules
Physical Chemistry

SALMON, WILLIAM IRWIN
Permutational symmetry in electronic systems
Physical Chemistry

SANFORD, JEANNE JOEHLMANN
Graduates of Hospital Dietetic Internships: Their employment and their perceptions of internship experiences in selected areas of administration
Institution Management - Home Economics Education

SAWYERS, BETTY A.
Money management practices of home economics units in colleges and universities
Home Economics Education

SCHMITT, DONALD PETER
Vertical distribution of Xiphinema americanum in minimal and medial developed loess soil in southwest Iowa
Plant Pathology

SCHOBERT, HAROLD HARRIS
The preparation and characterization of some alkanethiolatoosmium compounds
Chemistry

SCHULTZ, RICHARD CARL
The effect of soil moisture and day temperature on photosynthesis, growth and needle anatomy of Scotch pine seedlings
Forest Biology

SCHUMACHER, GARY MICHAEL
The development of encoding processes in memory
Psychology

SCHUSTER, REINHOLD MICHAEL
Strength and behavior of cold-rolled steel-deck-reinforced concrete floor slabs
Civil Engineering (Structural)

SCOTT, DAVID ALLEN
Computer simulation of pattern recognition using statistical decision functions
Psychology

SEAY, EDMOND EGGLESTON, JR.
Minimizing abatement costs of water pollutants from agriculture: A parametric linear programming approach
Agricultural Economics

SEIGLER, CLAUDE IRBY
Knowledge and skill requirements of consumer electronics service technicians with implications for curriculum development
Education

SELIM, HUSSEIN MAGD ELDIN
Transient and steady two-dimensional flow of water in unsaturated soils
Soil Physics

SHEN, I-MING
Acceleration of the projection method for solving systems of linear equations
Computer Science

SHOWERS, WILLIAM BROZE
Ecological effects on F_1 progenies from reciprocal matings of three biotypes of the European corn borer, Ostrinia nubilalis (Hübner)
Entomology

SIECK, ROBERT FREDERICK
Gas chromatography of mixed-ligand complexes of the lanthanides and related elements
Chemistry (Analytical)

SIMMONS, S. OLIVER
The construction of a three crystal spectrometer and a study of the decay of ^{90}Nb
Physics (Nuclear)

SKARDA, PAUL JAMES
The common law of schools in Iowa
Educational Administration

SKRDLANT, HAROLD BERNHARDT
Pathways of triglyceride synthesis by bovine small intestine
Biochemistry

SLABAUGH, MICHAEL RAY
The structures and reactions of four new 5,10b-Ethanophenanthridine Alkaloids
Chemistry (Organic)

SMITH, DAVID WILLIAM
The effect of soil texture and soil moisture on photosynthesis, growth and nitrogen uptake of Scotch pine seedlings
Forest Biology

SMITH, FRED BAXTER, JR.
Dynamic absorption of propane and propylese on activated carbon
Chemical Engineering

SOLOMON, VASANTHA BALAN
Some contributions to the mathematical theory of epidemics and related problems
Statistics

SPECKER, STEVEN ROBERT
Applications of optimal control theory to space-time reactor kinetics
Nuclear Engineering

STACY, DENZIL WAYNE
An X-ray diffraction study of the yttria-hafnia system
Ceramic Engineering

STAMP, DAVID LEE
Soybean response to nitrogen fertility, photoperiod, root pruning, kinetin and shoot apex removal
Agronomy

STARRETT, RICHMOND MULLINS
Synthetic approaches to the eremophilane sesquiterpenes
Organic Chemistry

STRACHAN, DENIS MICHAEL
Knight shift and spin-lattice relaxation measurements in the phosphides with the Ti_3P structure and in the $Vs_{1\pm x}$ system
Physical Chemistry

STOCK, WILLIAM ALBERT
Suprasentential organization in language
Psychology

STOECKER, BARBARA SYMNS
Biosynthesis of retinol as affected by dietary protein and feeding patterns in carotene-fed rats
Food and Nutrition

STONE, RANDOLPH
Hydrogeology of the Nishnabotna River Basin
Water Resources

STRISSEL, JERRY FRED
Bacteria-free soybean plants
Botany (Plant Pathology)

TANG, VICTOR KUANG-TAO
Allocation in stratified sampling based on preliminary tests of significance
Statistics

THAXTON, CHARLES BURTON
A technique for cooling single crystals below 90°K for X-ray diffraction, and the crystal structures of $H_2T_{a6}Cl_{18}6H_{2o}$ and the photo dimer of 1-1-dimethyl-2, 5-diphenyl-1-silacyclopentadiene
Chemistry (Physical)

TONNIES, JAMES JOHN
Part I: Preparation of lanthanide single crystals Part II: Elastic moduli and thermal expansion of lutetium single crystals from 4.2 to 300°K
Metallurgy

TREADWELL, GEORGE EDWARD, JR.
Isolation and partial characterization of flavins from plants
Biochemistry and Biophysics - Botany (Biochemistry - Plant Physiology)

TRENK, HUGH LESLIE
Genetic studies of amylase formation in Bacillus subtilis
Bacteriology

TU, CHANG-CHU LIN
Biosynthesis of a benzoxazinone in maize
Biochemistry

TUCKER, ROBERT HENRY
A quantum electrodynamics for vector mesons
Physics

TURNER, CHARLES EDWARD
Lifetimes of the first excited states in Tm^{169}, Tm^{171}, and Cs^{134}
Physics (Nuclear)

TURPIN, FRANK THOMAS
A mathematical model for rootworm damage to corn in Iowa
Entomology

ULRICHSON, DEAN LEROY
Effect of random experimental error in vapor-liquid equilibrium data on thermodynamic consistency
Chemical Engineering

VAUGHT, RUSSELL SCOTT
Construction and validation of a modified algorithm for the cluster analysis of prose
Psychology

VILLEGAS, CESAR TOLENTINO
Recurrent selection for high self-fertility in Vernal alfalfa (Medicago sativa L.)
Agronomy (Plant Breeding)

VINT, LARRY FRANCIS
Evaluation of selection practices used in a swine herd
Animal Breeding

VOSS, DAVID ALBERT
A spline shooting technique for two point boundary value problems
Applied Mathematics

WAMPFLER, GENE LEROY
Photochemical studies of some 2-cyclohexenones
Organic Chemistry

WANGSNESS, PAUL JEROME
Evaluation of a direct method for measuring absorption from the gut
Animal Nutrition, Physiology

WARD, RONALD W.
Some theoretical considerations for futures trading in commodities requiring transformation services: The case for live beef futures
Economics

WEAVER, RICHARD WAYNE
Populations of Rhizovium japonicum in Iowa soils and inoculum level needed for nodulation of Glycine max (L.) Merrill
Agronomy - Immunobiology (Soil Microbiology - Immunobiology

WEIGAND, EDGAR
The extent of metabolism of propionate and butyrate during absorption from the bovine rumino-reticulum
Animal Nutrition

WEINER, RONALD MARTIN
Determination of intramolecular heterogeneity of microbial DNA by spectral analysis
Bacteriology

WEST, ERIC NEIL
Some aspects of inference, with particular reference to goodness of fit
Statistics

WHIGHAM, DAVID KEITH
Leaf orientation and its effect on Zea mays L.
Crop Production

WIDDOWSON, JOHN PEARSON
Available sulfur in some Iowa soils
Agronomy

WIEDMANN, JEROME LEE
Application of the autoxidation of phenolic compounds to the analysis of cations
Analytical Chemistry

WIGGERS, KENNETH DALE
Atherosclerosis in ruminants
Animal Nutrition and Physiology

WILKINSON, JACK D.
Using a laboratory method to teach geometry in selected sixth grade mathematics classes
Education

WILSON, RICHARD LEE
A search of plant introductions as a source of corn rootworm resistance
Entomology

WINGER, DONLEY JAMES
Error analysis of an integrated inertial/Doppler-satellite navigation system with continuous and multiple satellite coverage
Electrical Engineering

WISNIESKI, GERALD J.
Development and evaluation of self-instructional mathematics materials designed for students in educational statistics
Education

WITT, HENRY FREDERICK
An interpersonal profile of area school instructors
Educational Administration

WITTE, DAVID LAVERN
Cooperative interactions in glutamic acid decarboxylase
Biochemistry

WITZEL, DONALD A.
Suppression of insulin secretion during spontaneous and induced hypoclacemic states
Veterinary Physiology

WOLF, FRANKLIN KREAMER
Markovian decision processes with uncertain rewards
Industrial Engineering - Statistics
Engineering Valuation - Statistics

WOLFF, PHILIP RUSSELL
Size distributions in multistage crystallization
Chemical Engineering

WOOD, RICHARD LEE
Isolation and characterization of Erysipelothrix rhusiopathiae from swine-raising premises and its survival in soil
Veterinary Microbiology

WOLLAN, JOHN JEROME
Superconductivity and magnetic order in La-Ce alloys
Physics

WORDEN, GAYLORD EDSEL
An interfirm competition model for deriving empirical estimates of supply response
Agricultural Economics

YOO, SUN-HO
The mixing of solutions of different densities and viscosities in soil
Soil Physics

ZAVADOSKI, ROGER W.
Analysis of convection effects in capillary-reservoir diffusion measurements
Chemical Engineering - Nuclear Eng.

ZERWEKH, ROBERT PAUL
The mechanical properties of some nickel-copper and nickel-copper-carbon alloys below 0.35 T_m
Metallurgy

ZIMMERMAN, KAREN WRIGHT
Verbal classroom interaction and characteristics including self-actualization of home economics teachers
Home Economics Education and Family Environment

ZIPRIN, RICHARD LEW
Reactions to Tenebrio Molitor and Galleria Mellonella to MS2 bacteriophage and Pseudomonas Aeruginosa
Bacteriology