THE EFFECT OF ROXARSONE WITH OR WITHOUT ZINC BACITRACIN ON BODY WEIGHT GAIN, FEED CONVERSION, SHANK COLOR AND LIVABILITY OF BROILER TYPE CHICKS

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
ALSOBAYEL ABDULLAH
1975

ABSTRACT

THE EFFECT OF ROXARSONE WITH OR WITHOUT ZINC BACITRACIN ON BODY WEIGHT GAIN, FEED CONVERSION, SHANK COLOR AND LIVABILITY OF BROILER TYPE CHICKS

by Alsobayel Abdullah

A 2 X 4 factorial experiment was conducted over a period of seven weeks. The experiment consisted of 16 experimental treatments with three replicates in each. In each replicate, there were 40 male and 40 female commercially hatched broiler type one-day-old chicks. The experiment was performed in order to investigate the effect of varying levels of Roxarsone, with or without zinc bacitracin, on final average body weight gains, final average feed conversion, shank color, and livability. The different experimental groups received the same basal diet supplemented with varying levels of Roxarsone with or without zinc bacitracin. At the end of the experimental period, data obtained were subjected to statistical analysis.

Roxarsone, with or without zinc bacitracin, did not significantly improve the final average body weight gains (pen weights) or final average body weight gains (individual birds) or livability. On the other hand, the experimental groups which had received 30 or 45 grams/ton Roxarsone with 50 grams/ton zinc bacitracin in their diets, were significantly improved in their feed conversion over the control. In respect to shank pigmentation, the inclusion of Roxarsone alone in the diet did not significantly improve shank pigmentation. In contrast, zinc bacitracin significantly improved shank pigmentation, when it was added to the diet at the level of 30 grams or more per ton. However, both of the drugs, when they were added together to the diet, zinc bacitracin at the level of 10 grams per ton and Roxarsone at the level of 30 grams/ton or more, did significantly improve the shank pigmentation, which suggests a positive synergistic effect between both upon shank pigmentation, at this level.

THE EFFECT OF ROXARSONE WITH OR WITHOUT ZINC BACITRACIN ON BODY WEIGHT GAIN, FEED CONVERSION, SHANK COLOR AND LIVABILITY OF BROILER TYPE CHICKS

by

Alsobayel Abdullah

A Thesis

Submitted to

Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Poultry Science

1975

ACKNOWLEDGEMENT

To: Dr. T. H. Coleman, whose suggestions were most helpful and whose association will be a pleasant experience of my stay at Michigan State University.

Dr. J. C. Flegal for the guidance and advice that made this work possible.

Michigan State University, Department of Poultry Science for the use of the farm facilities.

Dr. T. H. Coleman, Dr. J. C. Flegal, and Dr. H. C. Zindel for the constructive review of this manuscript.

My friends and the graduate students in the Poultry Science Department for their help on the farm.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (cont'd.)

INTRODUCTION

Organic arsenic compounds widely used as chemical additives in poultry rations are 3-nitro-4-hydroxy-phenylarsonic acid (Roxarsone), p-amino phenyl-arsonic acid (arsanilic acid), and sodium arsanilate.

Evidence is at hand which indicates that certain organic arsenicals have anticoccidial activity and may influence growth, feed conversion, feathering, and pigmentation in poultry and may result in a decrease in mortality and greater uniformity of size of individual birds.

Most investigators have found that the mode of action of active arsenic compounds in promoting growth is similar to that of antibiotics, but only insofar as both influence microorganism population in the intestine. The kinds of microorganisms that are affected is still questionable. However, several other organic compounds are used to prevent or control coccidiosis, blackhead, and other diseases.

The organic arsenic compounds mentioned above have been approved by the U.S. Food and Drug

Administration (Feed Additive Compendium, 1972) for growth promotion, improved feed conversion, and improved pigmentation.

For growth promotion, the usual dietary levels are 90 grams arsanilic acid or sodium arsenilate per ton of feed, or 45 grams of the 3-nitro-4-hydroxy-phenlarsonic acid per ton. Caution is needed when arsenicals are used in the feed because the margin of safety is rather low. Five times the effective level has been shown to reduce growth and to be toxic.

The arsenicals have been found to be highly effective in counteracting the toxicity of selenium; therefore, they have a special value in feeds that contain excessive selenium. When arsenicals are fed, there is likely to be some arsenic deposited in edible tissues. For this reason, a withdrawal period of five days is required before the birds may be slaughtered for human consumption.

It is claimed that antibioitics and arsenicals might have an additive effect, or synergetic effect in stimulating growth, improving feed conversion, and pigmentation. However, their stimulating properties have been reported when chicks were grown under suboptimal conditions in respect to the ration fed and/or the

environment. When a well-balanced ration was fed and a clean environment was used, there was no positive effect noticed from either one or both.

The purpose of the studies reported herein was to determine the effect of Roxarsone in combination with, or without, Baciferm (zinc bacitracin), and with Amprol Hi-E (Amprolium and Ethopabate), on the average final body weight, final feed conversion, livability, and shank color of groups of broilers and on individual body weight gains of equal numbers of selected individuals from each treatment.

Another goal was to establish efficacy for clearance of Amprol Hi-E in combination with Baciferm (with or without Roxarsone) in broiler feeds. The experiment was performed under conditions which were roughly equivalent to those usually found in commercial broiler production, in respect to square inches/bird floor space, bird numbers, and the type of ration used.

These studies were conducted January 24th through March 13th, 1975 at the Michigan State University Poultry Science Department Research and Teaching Center.

REVIEW OF LITERATURE

Roxarsone (3-nitro-4-hydroxy-phenylarsonic acid) is frequently added to poultry feeds. It has been approved by the U.S. Food and Drug Administration (Feed Additive Compendium, 1972) for growth promotion, improved feed efficiency, and for anticoccidial activity against E. tenella and E. acervulina.

According to Morehouse and Mayfield (1946) Roxarsone had a remarkable growth stimulation property on chickens and turkeys. Bird, Croschke, and Rubin (1948) reported that the growth of chickens fed diets high in soybean meal and deficient in the unknown dietary factor found in fish meal and in cow manure was improved by the addition to the diet of .005 percent Roxarsone. Morehouse (1949) reported that the growth rate of chickens and turkeys receiving 3-nitro-4-hydroxyphenyl-arsonic acid in their feed or drinking water was greater than that of their controls, and he found that the effective concentration limits administered in the feed were 0.00661 to 0.00925 with an optimum concentration of

about 0.009 percent. He also mentioned that the compound was more effective during the early part of the growing period than when the treatment was started during the later part of the growing period. He also reported that feed was utilized more efficiently by turkeys that received 3-nitro-4-hydroxy-phenyl-arsonic acid than by their controls. In the same report, he indicated that pullets which received 3-nitro-4-hydroxy-phenyl-arsonic acid at .0025 percent in their drinking water came into egg production earlier than their controls. Scott and Glista (1950) reported that the arsonic acids at the level of 0.01 percent in the diet produced only a transitory growth increase, lasting for the first few weeks of the chicken's life. In the report of the Chief of the Bureau of Animal Industry (1950), it was stated that the effects of vitamin B_{12}, aureomycin, and arsonic acid appeared to be additive. Combs and Laurent (1953) obtained improved growth and a slight reduction in mortality when arsonic acid or its sodium salt was added to a practical broiler ration which contained animal protein and an atibiotic. Carpenter (1951) stated that 3-nitro-4-hydroxy-phenylarsonic acid had shown a marked growth

stimulating property for swine. Elam et al. (1953) reported that both arsanilic acid and antibiotics stimulated chick growth and lowered the total number of clostridia in the feces. Abbott et al. (1954) stated that arsanilic acid and penicillin stimulated growth of chicks. Combs et al. (1954) suggested that a relationship exists between arsanilic acid and certain unidentified growth factors supplied by fish products. They found that the addition of either fish meal or fish solubles to the ration failed to stimulate growth unless arsanilic acid was included. These authors also suggested that orally administered arsanilic acid increased the dietary requirement for unidentified growth factors present in fish products. Milligan, Wilcke, Marr, and Bethke (1955) obtained an improvement in average final weight, improvement in market grades, and very slight improvement in feed efficiency and pigmentation by supplementation of commercial-type broiler diets that contained effective levels of antibiotics with 0.005 percent arsonic acid. Goates et al. (1955) found that both arsanilic acid and penicillin lowered intestinal weights of chicks reared on infected premises. Pope and Schaible (1958) reported that

arsanilic acid increased egg production significantly only when added to a low protein laying ration. Morrison et al. (1954) showed that both penicillin and 3-nitro-4-hydroxy-phenylarsonic acid caused highly significant growth stimulation of chicks in an old environment, but not in a new environment. Wisman (1960) reported that a growth response of chicks to arsanilic acid was dependent upon the presence of fish meal or fish solubles in the ration. Anderson et al. (1952) stated that highly significant increases in the weight of female turkey poults were obtained by inclusion in the diet of magnesium 4-hydroxy-phenylarsonic acid and Roxarsone. He added that, by the addition of terramycin alone or in combination with any phenyl-arsonic derivatives, a highly significant increase in weight gain accompanied by a slight improvement in feed conversion resulted. Kowalski and Reid (1969) stated in a preliminary report that Roxarsone has an anti-coccidial activity against E. brunetti of Roxarsone and they suggested that some production increases obtained, in the field use of Roxarsone, may be due to its anti-coccidial activity against E. brunetti. They also suggested that this efficacy may appear as an

additive effect in coccidiosis prevention, when Roxarsone is used in combination with other anti-coccidial agents.

In contrast to the preceding information, some investigators failed to show any stimulating properties of organic arsenic compounds with or without the combination of antibiotics.

According to Elam et al. (1953), a combination of arsanilic acid and antibiotic was shown to be no more beneficial than either alone. Frost et al. (1953; 1955) were unable to demonstrate any growth stimulation from arsanilic acid in low-vitamin B_{12} rations and pointed out that arsonic acids apparently do not spare vitamin B_{12} as do antibiotics. McDonald (1955) reported that arsanilic acid failed to stimulate growth under conditions where a response to penicillin was obtained. Summers et al. (1959) reported no increased rate of growth from either fish meal or meat meal when added to a ration that contained penicillin and 3-nitro-4-hydroxy-phenylarsonic acid but found a fairly consistent response to fish solubles. Lillie et al. (1957) failed to show any influence of arsanilic acid upon egg production, fertility, or hatchability.

PROCEDURE

A 2 x 4 factorial experiment was conducted with varying levels of Roxarsone with or without varying levels of zinc bacitracin fed for seven weeks. This experiment was composed of 16 experimental groups of sexed chicks, maintained in floor pen units with wood shavings litter. Gas heated brooders were used, and for the first two weeks of the experimental period flat type feeders and jar-waterers were employed, then replaced by hanging feeders and automatic waterers. There were three replicates of each experimental treatment. Each experimental group consisted of 40 male and 40 female Hubbard strain one day old commercially hatched broiler type chicks. Control replicates were offered the basal ration while the experimental groups were given the basal diet to which varying levels of Roxarsone with or without zinc bacitracin had been added. Feed consisted of a commercial broiler ration (Appendix Table 1) fed ad libitum. Feed for each group was mixed at the Michigan State University Poultry Farm and weighed at the beginning and

the end of the experimental period and feed consumption and mortality were recorded.

The basal diet was adequate in all known nutrients required in commercial broiler production, based on calculated analysis (Appendix Table 2). All experimental rations contained Amprolium at 0.0125 percent of the ration and Ethopabate at 0.004 percent of the ration. The different treatments contained varying levels of Roxarsone and zinc bacitracin, as seen in Table 1.

All of the experimental groups were weighed at the beginning and end of the experimental period, and vaccinated twice, on the second and on the fourth week of the experimental period, against Newcastle and Bronchitis. At the end of the fourth week, 5 males and 5 females from each experimental group were individually weighed, leg banded, and reweighed at the end of the experiment, but the number was reduced to 3 males and 3 females from each experimental group and its replicates for statistical reasons, since some of the birds lost their legbands or died before the experiment was completed. The shank color of 5 males and 5 females from each experimental group was measured, using the Roche Color Fan, at the end of the experimental period.

Table 1.--Roxarsone and Zinc Bacitracin levels in the experimental rations

Treatments	Roxarsone g/ton	Zinc Bacitracin g/ton
1	00	00
2	15	00
3	30	00
4	45	00
5	00	10
6	15	10
7	30	10
8	45	10
9	00	30
10	15	30
11	30	30
12	45	30
13	00	50
14	15	50
15	30	50
16	45	50

The collected data were subjected to a Variance analysis (Computer Center of Michigan State University) using "Analysis of Variance Program" from STAT Agricultural Experiment Station Statistical Program, on the Control Data Corporation 6500 at Michigan State University. Through this kind of analysis, the anslysis of variance for the following characteristics was obtained: Final average body weight gain (pen weights) (Table 2); final individual body weight gain (individual birds) (Table 4); final average feed conversion (Table 6); individual shank color (Table 8); and mortality (Table 10). Taken from the computer sheets, Tables 3, 5, 7, 9, and 11 show the final averages of the above mentioned characteristics for the different experimental treatments. Next, Dunnet's test (1955) was employed to determine which treatments were significantly different at the .05 and .01 levels of probability, using the mean square of error.

Final average body weight, and individual body weight gains are expressed in kilos. Feed conversion is expressed as the ratio of feed intake to the body weight gain, the shank color is expressed in Roche Color Fan units, and mortality is expressed as a percent of the total housed chicks in each pen.

Table 2.--Analysis of Variance of Final Average Body Weight Gain of Broilers Used in the Experiment

Source of variation	Degree of freedom	Sum of square	Mean square	F statistic	Approx. significance probability of F statistic
Roxarsone	3	.00335833	.00111944	.36086860	.782
Zinc bacitracin	3	.03524167	.01174722	3.78688200	.020*
Roxarsone X Zinc bacitracin	9	.11425833	.01269537	4.092530	.001**
Residual error	32	.09926667	.00310208		
Total	47	.25212500			

*significant
**highly significant

Table 3.--Final Average Body Weight Gain in Kilos of the Different Experimental Groups Indicating Also the Levels of Roxarsone and Zinc Bacitracin Added to the Basal Diet Used in the Experiment

Roxarsone g/ton	Zinc bacitracin g/ton			
	00	10	30	50
00	1.56	1.57	1.51	1.56
15	1.54	1.57	1.54	1.59
30	1.56	1.56	1.53	1.57
45	1.59	1.57	1.57	1.53

Table 4.--Analysis of Variance of Individual Body Weight Gain of Broilers Used in the Experiment for the Last Three Weeks of the Experimental Period

Source of variation	Degree of freedom	Sum of square	Mean square	F statistic	Approx. significance probability of F statistic
R[1]	3	53103.51	17701.1700	4.82554500	.0070**
Z[2]	3	110975.32	36991.7700	10.08438700	<.0005**
R X Z	9	190931.70	21214.6300	5.78335500	<.0005**
Error	32	117383.11	3668.2222		
S[3]	1	1950148.00	1950148.0000	200.99320000	<.0005**
R X S	3	42490.23	14163.4100	1.45976000	.2270
Z X S	3	6424.04	2141.3461	.22069910	.8820
R X Z X S	9	48213.86	5357.0961	.55213228	.8350
Pen X S X R Pen X S X Z Pen X R X Z X S Z X Pen X S	32	205918.44	6434.9514	.66322080	.9160
Residual error	192	1862891.00	9702.5590		

Footnote: ** highly significant
(1) Roxarsone
(2) Zinc bacitracin
(3) Sex

Table 5.--Final Average Body Weight Gain in Kilos of the Individual Birds Weighed at 4 Weeks of Age Taken from the Different Experimental Treatments Indicating the Levels of Roxarsone and Zinc Bacitracin in their Diets

Roxarsone g/ton	Zinc bacitracin g/ton			
	00	10	30	50
00	0.80	0.84	0.84	0.70**
15	0.83	0.83	0.78	0.79
30	0.76	0.82	0.77	0.78
50	0.78	0.82	0.82	0.78

**highly significant

Table 6.--Analysis of Variance of Final Average Feed Conversion of Broilers Used in the Experiment

Source of variation	Degree of freedom	Sum of square	Mean square	F statistic	Approx. significance probability of F statistic
Roxarsone	3	.01975000	.00658333	3.163163	.038*
Zinc bacitracin	3	.01571667	.00523889	2.517184	.076
Roxarsone X Zinc bacitracin	9	.02560000	.00284444	1.366700	.244
Residual error	32	.06660000	.00288125		
Total	47	.12766667			

*significant

Table 7.--Final Average Feed Conversion of the Different Experimental Groups Indicating the Levels of Roxarsone and Zinc Bacitracin Added to the Basal Diet Used in the Experiment (expressed as the ratio of feed intake to body weight gain)

Roxarsone g/ton	Zinc bacitracin g/ton			
	00	10	30	50
00	2.09	2.01	2.03	2.05
15	2.08	1.98	2.01	2.01
30	1.99	2.02	2.03	1.96*
45	2.01	2.00	2.01	1.95**

*significant
**highly significant

Table 8. Analysis of Variance of Individual Shank Color of Broilers Used in the Experiment, at the End of the Experimental Period

Source of variation	Degree of freedom	Sum of square	Mean square	F statistic	Approx. significance probability of F statistic
R(1)	3	3.372917	1.124306	3.64639600	.0230*
Z(2)	3	62.622917	20.874306	67.70045000	<.0005**
R X Z	9	71.185417	7.909491	25.65240200	<.0005**
Error	32	9.866667	.308333		
S(3)	1	11.718750	11.718750	7.59621900	.0060**
R X S	3	7.872917	2.624306	1.70110300	.1660
Z X S	3	1.922917	.6409722	.41548500	.7420
R X Z X S	9	14.385417	1.598380	1.03608700	.4100
Pen X S X R Pen X S X Z Pen X S Pen X R X Z X S	32	32.800000	1.025000	.66441594	.9280
Residual error	384	592.400000	1.542708		
Total	479	808.147900			

* significant
** highly significant

(1) Roxarsone
(2) Zinc bacitracin
(3) Sex

Table 9.--Average Shank Color of the Birds Measured From the Different Experimental Groups at the End of the Experiment in The Roche Color Fan Units, Indicating the Levels of Roxarsone and Zinc Bacitracin Used in Their Diets

Roxarsone g/ton	Zinc bacitracin g/ton			
	00	10	30	50
00	6.83	6.83	7.30*	8.90**
15	7.53**	6.47	7.50**	7.53**
30	7.07	7.37**	7.97**	7.43**
45	6.93	7.33**	7.57**	7.67**

*significant
**highly significant

Table 10. Analysis of Variance of Final Average Mortality of Broilers Used in the Experiment

Source of variation	Degree of freedom	Sum of square	Mean square	F statistic	Approx. significance probability of F statistic
Roxarsone	3	10.8626	3.6208	.9148	.445
Zinc bacitracin	3	9.2793	3.0931	.7184	.513
Roxarsone x Zinc bacitracin	9	36.2714	4.0302	1.0182	.447
Residual error	32	126.6629	3.9582		
Total	47	183.0763			

Table 11.--Final Average Mortality of the Different Experimental Groups in Percent Indicating the Levels of Roxarsone and Zinc Bacitracin Added to the Basal Diet Used in the Experiment

Roxarsone g/ton	Zinc bacitracin g/ton			
	00	10	30	50
00	2.50	4.17	1.67	1.25
15	3.54	2.50	2.50	4.58
30	2.50	1.67	1.25	2.50
45	4.58	2.12	2.92	1.25

RESULTS

Data obtained were subjected to statistical analysis, and two statistical tests (F-test and Dunnet's test) were employed to determine the effect of Roxarsone with or without zinc bacitracin on final average body weight gain, final average body weight gain of individual birds, final average feed conversion and on the shank color of broilers.

(a) Final average body weight gain (pen weights)

According to the F-test, the experimental groups which had received only zinc bacitracin in their diets were significantly higher in their final body weight gains than their control. In addition, the final average weight gain of the birds which had received Roxarsone with zinc bacitracin was significantly larger ($p < .01$) than that of their control. In contrast, the experimental groups which had received only Roxarsone in their diets did not show any significant improvement over the control (Table 2). On the other hand, Dunnet's test

indicated that no one of the experimental groups was significantly better in final average body weight gain than the control (Table 3).

(b) Final average body weight gain (individual birds)

When the data on the broilers which had been weighed individually at the end of the fourth week and again at the end of the experiment were analyzed, it was found that the final average body weight gains were significantly larger ($p < .01$) for the experimental groups which had received either Roxarsone or zinc bacitracin or both in their diets, than for the control as indicated by F-test (Table 4). According to Dunnet's test, final average body weight gain of the experimental group which had received 50 grams of zinc bacitracin/ton in its diet was significantly less than that of the control. On the other hand, the final average body weight gains of the other treatments were not significantly higher than that of the control as indicated by Dunnet's test (Table 5).

(c) Final average feed conversion

The F-test showed that the experimental groups which had received only Roxarsone in their diets were

significantly better in their final feed conversion than was their control (Table 6). None of the other experimental groups was statistically different from the control in this respect. On the other hand, Dunnet's test (Table 7) indicated that the final average feed conversion of the experimental groups which had received 30 grams of Roxarsone and 50 grams of zinc bacitracin/ton in their diet was significantly ($p < .05$) better than that of the control. The experimental groups which had received 45 grams of Roxarsone and 50 grams of zinc bacitracin/ton in their diet were significantly ($p < .01$) better in their feed conversion than the control.

(d) Shank Color

According to the F-test, the experimental groups which had received Roxarsone only in their diets were significantly improved ($p < .05$) in their shank pigmentation compared with their control. Shank pigmentation of the experimental groups which had received zinc bacitracin alone, or with Roxarsone, in their diets was significantly ($p < .01$) improved over that of the control (Table 8). Dunnet's test indicated that all of the experimental groups which had received 30 grams/ton or more zinc

bacitracin with or without Roxarsone were significantly ($p < .01$) improved in their shank color compared with that of the control except for the experimental group which had received 30 grams zinc bacitracin/ton without Roxarsone which was significantly improved ($p < .05$) in their shank color compared with their control. The experimental groups which had received 15 grams Roxarsone only, or 30 grams and more Roxarsone with 10 grams zinc bacitracin/ton in their diets were significantly ($p < .01$) improved in their shank pigmentation over thier control (Table 9).

(e) Sex differences

The inclusion of Roxarsone with or without zinc bacitracin in the experimental diet did not result in any significant improvement of one sex over the other in respect to the final average body weight gain or shank pigmentation as indicated by the F-test (Tables 4 and 8).

(f) Livability

According to the F-test (Table 10) and Dunnet's test (Table 11), there was no significant improvement in the livability of the different experimental groups over

their control, when Roxarsone with or without zinc bacitracin was added to the experimental diets.

DISCUSSION

From the result reported herein, Roxarsone, with or without zinc bacitracin, when supplemented to the diet of commercially hatched broiler type chicks did not result in any significant improvement in final average body weight gains (pen weights) compared with that of the control. This might be due to the optimal conditions under which the chicks have been grown in respect to the environment, the type of ration being fed and to the managerial procedure. However, the final average body weight gains (individual birds) of the birds which had received a diet supplemented with 50 grams/ton zinc bacitracin and no Roxarsone were significantly less than that of control which might be due to experimental error. In contrast to this result, Morehouse et al. 1946, and Morehouse 1949, have reported that accelerated growth rate has been obtained when Roxarsone was fed in a growing chicks ration. The same positive effect has been indicated by Milligan et al. 1955, when arsonic acid was included in a commercial type broiler diet containing an effective level of

antibiotics. In this study, feed conversion was significantly improved when the diet had been supplemented with 30 grams/ton Roxarsone and 50 grams/ton zinc bacitracin and showed a highly significant improvement when 45 grams/ton Roxarsone and 50 grams/ton zinc bacitracin were included in the diet, which suggests that Roxarsone, with zinc bacitracin, had a positive and synergistic effect upon feed conversion, when each ton of the diet included 30 grams or more/ton Roxarsone and 50 grams/ton zinc bacitracin. In respect to shank pigmentation, the study reported herein showed that Roxarsone did not significantly improve shank pigmentation, except for the experimental group which had received 15 grams/ton Roxarsone only in their diet. This result was probably due to experimental error, since the experimental groups which had received 30 grams and 45 grams/ton Roxarsone alone in their diets did not show any significant improvement in their shank pigmentation. On the other hand, zinc bacitracin alone, when added to the diet at the level of 30 grams or more per ton, resulted in a significant improvement in shank pigmentation. However, when zinc bacitracin was supplemented to the diet at the level of 10 grams/ton,

no significant improvement in shank pigmentation was seen unless Roxarsone was also added at the level of 30 grams or more per ton. This result suggests that Roxarsone when supplemented alone to the diet did not significantly improve shank pigmentation. In contrast, zinc bacitracin when added to the diet at the level of 30 grams or more/ton, with or without Roxarsone, did improve shank pigmentation. However, there was no positive synergistic effect between Roxarsone and zinc bacitracin when the zinc bacitracin level in the diet was 30 grams or more per ton, with the same result when the Roxarsone level in the diet was less than 30 grams/ton, and the level of zinc bacitracin was 10 grams/ton. On the other hand, there was a positive synergistic effect between the two drugs, when the level of Roxarsone was 30 grams or more/ton and the level of zinc bacitracin was 10 grams/ton of feed. However, this result in respect to feed conversion and shank pigmentation does agree with that of Milligan, who has indicated that the inclusion of arsonic acid in a broiler diet that contained an effective level of antibiotic had significantly improved feed conversion and shank pigmentation. In addition, the inclusion of Roxarsone with or without zinc bacitracin did not significantly improve the

livability of experimental birds; also it did not result in any significant sex differences in respect to the final average body weight gain or shank pigmentation. However, the response to arsenicals is sometimes variable depending obviously upon environment and type of ration being supplemented. For example, Harrison et al. (1954) showed that both penicillin and Roxarsone caused highly significant growth stimulation in broilers in an old environment but not in those in a new environment. Some anticoccidial activity against E. tenella due to the feeding of Roxarsone also appears to be well-established (Morehouse and McKay, 1951).

The result of the experiment reported herein shows that Roxarsone when added to the diet alone had no beneficial effect upon body weight gain, feed conversion, shank pigmentation and livability of broilers. This result does not agree with that of many investigators. On the other, hand Roxarsone with zinc bacitracin when added to the experimental diet at certain levels resulted in a significant improvement in feed conversion and in shank pigmentation, which supports the hypothesis that Roxarsone and antibiotic have an additive positive effect upon feed conversion and shank pigmentation. In addition,

when both of the druggs were added to the diet of broilers, no significant improvement in body weight or livability was obtained.

CONCLUSIONS

A) The inclusion of Roxarsone, with or without zinc bacitracin, in the diet of broiler type chicks from one day of age to seven weeks did not significantly improve the final average body weight gains (pen weights) or the final average body weight gains (individual birds) over their control, which might be due to the optimal conditions under which the chicks were grown.

B) The experimental groups which had received the diet supplemented with 30 grams/ton Roxarsone and 50 grams/ton zinc bacitracin showed a significant improvement, and the experimental group which had received 45 grams/ton Roxarsone and 50 grams/ton zinc bacitracin in their diet showed a highly significant improvement, in their feed conversion over the control, which suggests a positive synergistic effect of Roxarsone and zinc bacitracin upon feed conversion of growing chicks.

C) Roxarsone did not produce any significant improvement in shank pigmentation, when it was supplemented without zinc bacitracin to the broiler diet. In contrast,

zinc bacitracin when added at the level of 30 grams or more per ton in the diet with or without Roxarsone, improved shank pigmentation. When zinc bacitracin was added to the diet at the level of 10 grams/ton, it resulted in a significant improvement in shank pigmentation only when Roxarsone was added at the level of 30 grams or more per ton in the same diet. Therefore, it is concluded that there was a positive synergistic effect between Roxarsone and zinc bacitracin on this trait only when the level of zinc bacitracin was less than 30 grams/ton and that of Roxarsone was 30 grams or more per ton in the diet.

D) Roxarsone with or without zinc bacitracin, when added to the broilers' diet did not significantly improve the livability.

LITERATURE CITED

LITERATURE CITED

Abbott, O. J., H. R. Bird and W. W. Cravens, 1954. Effects of dietary arsenilic acid in chicks. Poultry Sci., 33:1245-1253.

Agricultural Research Administration. Report of the Chief of the Bureau of Animal Industry, 1950. Areomycin stimulates growth in chickens. Pp. 27-28.

Anderson, G. W., J. D. Cunningham and S. J. Slinger, 1952. Effect of terramycin and certain phenylarsonic acid derivatives on the growth and intestinal flora of turkey poults. Journal of Nutr., 48:539.

Bird, H. R., A. C. Croschke and M. Rubin, 1948. Effect of arsenic acid derivatives in stimulating growth of chicks fed certain diets. Fed. Proc., 7:283.

Carpenter, L. E., 1951. The effect of 3-nitro-4-hydroxy-phenylarsonic acid on the growth of swine. Arch. Biochem. Biophys., 32:181-186.

Combs, G. F. and C. K. Laurent, 1953. The value of aureomycin hydrochloride and 3-nitro-4-hydroxy-phenylarsonic acid in broiler rations. Maryland Agr. Exp. Station Misc. Publ. 155.

Combs, G. F., G. L. Ramper and R. W. Bishop, 1954. Influence of arsanilic acid for certain unidentified growth factors. J. Nutr., 53:511-522.

Dunnett, C. W., 1955. A multiple comparison procedure for comparing several treatments with a control. J. Amer. Statist. Assoc., 50:1096-1121.

Elam, J. F., R. L. Jacobs, W. L. Tidwell, L. L. Gee and J. R. Couch, 1953. Possible mechanisms involved in growth promoting responses obtained from antibiotics. J. Nutr. 49:307-316.

Feed Additive Compendium, 1972. Roxarsone. Miller Publishing Company, Minneapolis, Minnesota. Page 324.

Frost, D. V. and H. C. Spruth, 1953. Further studies on arsanilic acid and related compounts in nutrition. Poultry Sci., 32:900.

Frost, D. V., L. C. Overby and H. C. Spruth, 1955. Studies with arsanilic acid and related compounds. J. Agr. Food Chem., 3:234-243.

Goates, M. W., M. K. Davies and S. K. Kon, 1955. The effect of antibiotics on the intestine of the chick. Brit. J. of Nutr., 9:110-119.

Kowalski, L. M. and W. M. Reid, 1969. Efficacy of Roxarsone against E. brunetti infection. Poultry Sci., 48:1831.

Kowalski, L. M. and W. M. Reid, 1972. Roxarsone efficacy against E. brunetti, Poultry Sci., 51:1586-1589.

Lillie, R. J., J. R. Sizemore and C. A. Denton, 1957. Effect of arsenical, fat and antibiotic upon the reproductive performance of chickens. Poultry Sci., 36:755.

McDonald, M. W., 1955. A failure of chickens to respond to arsanilic acid. Poultry Science, 34:55-56.

Milligan, J. L., H. L. Wilcke, J. E. Marr and R. M. Bethke, 1955. Arsonic acid in commercial broiler rations. Poultry Sci., 34:794-798.

Morehouse, N. F. and O. J. Mayfield, 1946. The effect of some arylarsonic acids on experimental coccidiosis infections in chickens. J. Parasitol., 32:20-24.

Morehouse, N. F., 1949. Accelerated growth in chickens and turkeys produced by 3-nitro-4-hydroxy-phenylarsonic acid. Poultry Sci., 28:375-384.

Morehouse, N. F. and F. M. McKay, 1951. On the chemotherapeutic action of 3-nitro-4-hydroxy-phenylarsonic acid against the coccidium E. tenella in chickens. Proc. Iowa Acad. Sci., 58:507-516.

Morrison, A. B., W. G. Hunsaker and J. R. Aitken, 1954. Influence of environment on the response of chicks to growth stimulants. Poultry Sci., 33: 491.

Pope, C. W. and P. J. Schaible, 1958. Effect of arsanilic acid in low and normal protein mashes upon egg production. Poultry Science, 37:1234.

Scott, H. M. and W. A. Glista, 1950. The effect of aureomycin and arsonic acids on chick growth. Poultry Sci., 29:921-922.

Summers, J. D., W. F. Pepper and S. J. Slinger, 1959. Sources of unidentified factors for practical poultry diet: The value of fish meals, meat meals and fish solubles for chicks and broilers. Poultry Sci., 38:816-825.

Wisman, E. L., 1960. Chick growth response to fish by-products and arsanilic acid. Poultry Sci., 39: 1141-1148.

APPENDIX

Appendix Table 1.--Composition of the basal diet used in the experiment in pounds

Ingredient	Pounds
Soybean meal, 49% protein	251.25
Corn, ground yellow	575.00
Fish, meal 60%	15.00
Meat and bone meal 50%	40.00
Whey	15.00
Corn gluten meal	40.00
Dicalcium phosphate	5.00
Limestone	7.50
Salt	4.00
Vit. premix 5003	6.25
Fat	40.00
Methionine	.50
Coccidiostat. (Ampro Hi. E.)	.50

Appendix Table 2.--Nutrient composition of the basal diet used in the experiment based on calculated analysis

Nutrient	%
Protein	22.41
Fat	7.09
Fiber	2.19
Calcium	.98
Phosphorus	.58
Arginine	1.65
Glycine	1.30
Methionine	.43
Cystine	.38
Lysine	1.18
Tryptophan	.28
Metablizable energy Cal/lb	1483.18