THE EFFECTS OF FEEDING DIETS CONTAINING FURAZOLIDONE* ON EXPERIMENTAL *SALMONELLA GALLINARUM* INFECTION IN CHICKENS

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SUMMARY

Twenty eight week-old chickens infected orally with 16.5×10^9 viable *Salmonella gallinarum* organisms in 3ml. brain heart infusion broth were shown to be protected against infection by feeding them on diets containing either 0.0055 percent or 0.011 percent furazolidone. The higher concentration was more effective as judged by the clinical symptoms, mortality, egg production, post mortem lesions and the isolation of the infecting organism from the visceral organs of the dead chickens. About 600 isolates of *E. coli* from the chickens both before and during the course of infection were sensitive to furazolidone disc (100mcg). The infecting organism and about 300 isolates of the organism tested during the course of infection were also sensitive to furazolidone. No "carriers" were detected in chickens fed on diet containing 0.011 percent furazolidone.

It is therefore recommended that furazolidone can be used effectively as feed additive for poultry.

*N-(5-Nitro-2-Furfury lidene)-3-Amino-2-Oxazolidone.

INTRODUCTION

Furazolidone has been shown to be highly effective in controlling bacterial infection in livestock (Herbert and Chang, 1969; Gross, 1961; Richey and Morgan, 1959; Bierer and Vickers, 1960; Smith, 1955 and Smith and Tucker, 1975). *In vitro* tests showed that only 5 out of 2143 *Salmonella* strains isolated from animals in England and Wales were resistant to furazolidone disc (50 mcg) (Sojka, Slavin, Brand and Davies, 1972). Sojka and Hudson (1976) found only 0.8 percent of 2116 *Salmonella* strains isolated from animals in England and Wales resistant to furazolidone (15 mcg). Walton (1972) made quantitative studies of the resistance of faecal *E. coli* in pigs given furazolidone or nitrovin in their feed for 24 days. There were fluctuations in resistance (greater than 5 mcg/ml.) but no cross reaction between the 2 drugs nor development of resistance to other drugs occurred.

Salmonella and *E. coli* strains isolated from animals in Ibadan were shown to be resistant to the tetracyclines (10 mcg) and some other antibiotics (Ojo, 1972a; Ojo and Moomaw, 1972b and Ojo, 1973) but none of these was resistant to furazolidone (Ojo and Ahanihu, 1974). In Nigeria, presently, the antibiotics used as feed additives are the tetracyclines to which majority of strains of *Salmonella* and *E. coli* isolated from animals are found to be resistant. Falade and Thomlinson (personal communication) have shown that high rate of transfer of R-factor occurred in 4 out of 11 strains of *E. coli* isolated in Ibadan while the other strains also showed low rate of transfer. The information obtained so far show that furazolidone resistance, when it occurs, is not infective.

The present work was carried out to determine the effects of diets containing furazolidone on chickens infected orally with *Salmonella gallinarum.* The experiments described in this report were undertaken in an attempt to simulate a naturally occurring bacterial disease in poultry which would oprovide a test of the value of furazolidone in conditions similar to those of veterinary practice. *S. gallinarum* was selected as the infecting organism because of its economic importance in the poultry industry and also because the salmonellae are among the few

genera of bacteria with which experimental diseases can be produced without resorting to unnatural routes of infection. The oral route was also chosen because this is the natural route of infection and the route permits the development of immunity which is often of importance in the therapy of natural diseases.

MATERIALS AND METHODS

Animals. Two hundred and fifty Haco chicks were purchased as day-old from a reputable local poultry farmer. They were reared together in a brooder from day-old till 6 weeks of age and then on deep litter till the age of 24 weeks when they were transferred to battery cages. The chicks were fed *ad lib.* on Pfizer feed (Pfizer Ltd., Ikeja).

Salmonella strain. A local strain, isolated during an outbreak of fowl typhoid in a group of layers, was used. The strain was confirmed to be *Salmonella gallinarum* by Dr. B. Rowe of Salmonella/Shigella Reference Laboratory, Central Public Health Laboratory, Colindale, London.

Infection method. The smooth strain of *S. gallinarum* was inoculated into brain heart infusion broth (Oxoid) and incubated at 37°C for about 18h. The chickens were starved for 48h. before oral dosing with 16.9×10^9 organisms in 3ml. brain heart infusion broth. One hundred and fifty chickens were infected when they were 28 weeks old.

Bacteriological examinations. Viable counts on sample of challenge cultures were carried out immediately after use on nutrient ager (Oxoid) by the method of Miles and Misra (1938). The average of 3 counts was taken as the infecting dose. Cloacal and tissue swabs as well as contents of eggs laid by the infected chickens were examined by direct plating on MacConkey agar (Oxoid) incubated at 37°C for about 18h. The identity of suspected *S. gallinarum* was confirmed by serological test.

In vitro sensitivity of 300 isolates of *E. coli* from the chickens before experimental infection, the infecting organism S. gallinarum as well as 300 isolates each of *E. coli* and *S. gallinarum* from the experimentally infected chickens, was determined on "Well cotest" agar (Wellcome Reagents Ltd., Ikeja) against furazolidone (100mcg., BBL, Maryland, U.S.A.) by the disc diffusion method. The plates were left at room temperature (25°—28°C) for 1h. before incubation at 37°C for 24h. The zones of inhibition were then measured in mm.

Clinical observations. Daily records of general physical appearance, appetite, consistency of faeces, the number of eggs laid and mortality were kept.

Diets. Normal layer's mash with or without furazolidone was used throughout the experiment. Normal layer's march consisted of:-

Maize	581.90kg
Groundnut cake	110.45kg
Yeast	22.70kg
Blood meal	45.70kg
Rice bran	22.70kg
Luru (Dried vegetable leaves)	36.36kg
Oyster shells	50.00kg
Dicalcium phosphate	45.40kg
Salt	3.20kg
Agricare mix (Pfizer Ltd., Ikeja.	5kg

The materials were thoroughly mixed without antibiotic. This feed was designated diet C.

Diet A. It was prepared by mixing 500gm of nf—180 furoxone (11 percent furozolidone, Eaton Laboratories, New York) with 1,000kg of diet C, so that the final concentration of furazolidone in the feed was 0.0055 percent.

Diet B. Similar to diet A but with double the amount of furazolidone (0.011 percent).

Post mortem examinations. Thorough post mortem examinations were carried

out on the chickens which died and those which were killed at the termination of the experiment. Specimens of lung, liver, ovary/oviduct, brain, bone marrow, spleen, heart and kidney tissues were cultured for *S. gallinarum* on MacConkey agar.

Serology. Stained antigen slide agglutination test using S. pullorum antigen and tube agglutination test according to the method of Smith, Larkin and Brooksbank (1972) were carried out on the sera of slaughtered chickens at the end of the experiment.

Experimental designs. The experimental chickens were divided into 8 groups, as shown in Table 1.

Group 1 (A1): was put on diet A 3 days before infection.

Group 2 (A2): was put on diet A on the day of infection.

Group 3 (A3): was put on diet A when clinical signs of fowl typhoid were seen in the infected chickens.

Group 4 (B1): was put on diet B 3 days before the infection.

Group 5 (B2): was put on diet B when clinical signs of fowl typhoid were seen in the infected chickens.

Group 7 (C1): was infected and put on diet C.

Group 8 (CU): was uninfected and put on diet C.

The chickens were kept on their various diets for 20 days to permit evaluation of the prohyllactic and chemotherapeutic efficacy of the 2 concentrations of furazolidone. All the chickens were then put on diet C and observed for relapse of infection for 7 days then put on their respective diets. All the chickens were killed 40 days post infection.

RESULTS

Clinical Observations: The significant clinical observations in the infected chickens were anorexia, soft yellowish-green faeces, droopiness and ventral recumbency. Clinical signs were first noted 4—7 days post infection in C1 group. The severity varied according to the type of diet fed to the birds. Birds in A2 and B2 groups were least affected while those in C1 group were the most severely affected. The birds in CU group did not show any clinical signs of fowl typhoid.

TABLE 1

Experimental designs and mortality patterns

Group	No. infected	No. of dead chickens on days																									Total dead	Percentage mortality
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29		
		30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52				
		53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75				
		76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98				
		99	100																									
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	28	96.6
	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	28	96.6
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
0*		27**				20*			27**			20*			A1		A2		A3		B1		B2		B3		C1(A)	C1(B)	CU.
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6		
7	7	7	7	7	7	7	7	7	77	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		
8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	88	8	8	8	8	8	8	8	8	8	8	8		

* Birds were put on C feed

** Birds were put back on their respective feeds

Birds in C1 and CU groups were put on C feed throughout the period of experiment.

EFFECT OF DIETARY FURAZOLIDONE ON *SAMONELLA* INFECTED CHICKS

TABLE 2

The effects of diets and infection on egg production

Group	No. of chickens	Eggs laid by chickens on days	Total	Average per chicken

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

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1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 12

2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

3 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4

4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4

4 45 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 55 5 5 5

5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5

5 5 5 5 5 5 56 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6

7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7

7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8

8 8 8 89 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9

9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9

9 9 A1 A2 B1 B2 B3 C1(A) C1(B) CU 10 10 10 20 20 19 19 19

1.25 3.15 0.7 2.7 4.4 1.2 0.65 0 1.9 0 0 0 0 0 0 0 0 0 010

10 10 10 10 10 20 20 20 30 30 30 40 40 50 50 50 60 60 60 70 70 70 80

80 80 90 90 90 1 11 11 11 11 12 12 12 13 13 13 122 22 22 23 23 24 24

25 26 26 27 28 38 38 48 48 58 59 59 62 6 12 23 2 4 25 26 27 28 39 33

TABLE 3
Post Mortem Lesions

Group	*Liver*	*Kidney*	*Spleen*	*Intestine*	*Brain*	*Egg peritonitis*
A1	Enlarged	Some cases enlarged	Some cases enlarged	Empty in one case	—	1 case
A2	Enlarged (2)	Enlarged (2)	Enlarged (2) 10x in one	—	—	—
A3	Soft, yellowish-green in some cases	—	Enlarged in some cases	empty in one	—	—
B1	Enlarged & pale in some	—	—	—	—	1 case
B2	Slightly enlarged in some cases	Slightly enlarged in some cases	—	—	—	—
B3	Pale, enlarged and soft in cases	—	Enlarged 3	—	—	—
C1	Markedly enlarged yellow & soft in some	Congested in some	Enlarged and dark in colour	empty	congested	Hydroperito-neum (2)
CU	—	—	—	empty in one	—	—

Mortality patterns: The mortality patterns are shown in Table 1. The highest mortality was in the C1 groups, the average mortality being 69 percent. Most of the deaths in this group occurred between the 7th and 9th days post infection. The only death in CU group was from cannibalism and light coccidiosis.

Egg production: This is shown in Table 2 where it will be seen that egg production was lowest in A3 and C1 groups. The average egg per bird is highest in B2 followed by A2.

Post mortem examination: A summary is shown in Table 3, the important lessions consisted of enlarged yellow liver, enlarged kidney and spleen. The only bird which died in CU group had no gross lesions in the visceral organs but the intestine was empty. The bird probably died from cannibalism.

Bacteriological examinations: The results of the bacteriological examinations of cloacal swabs are shown in Table 4a.

2. gallinarum was isolated from the cloacal swabs of chickens in group B3 on the 4th, 6th, 8th, 9th, 12th and 13th days post infection. The growth of the organism was moderate. Cloacal swabs of group C1 chickens yielded heavy growth on the 5th, 8th, 10th, 11th and 13th days

post infection. No growth from cloacal swabs of chickens in groups A1, B1, B2 and CU, was obtained throughout the period of observation. Table 4b shows the summary of bacteriological examinations of post mortem tissues where it will be seen that heavy growth was obtained from tissues of chickens in A3, B3 and C1 groups. No salmonella was isolated from the organs of all the chickens in the different groups killed at the end of the experiment except 2 in group C1 in which *S. gallinarum* was recovered from the liver only.

TABLE 4a

Bacteriological examinations of cloacal swabs

Group	1	2	3	4	5	6	7	8	9	10	11	12	13
A1	—	—	—	—	—	—	—	—	—	—	—	—	—
B1	—	—	—	—	—	—	—	—	—	—	—	—	—
B2	—	—	—	—	—	—	—	—	—	—	—	—	—
CU	—	—	—	—	—	—	—	—	—	—	—	—	—
A2	—	—	—	—	—	—	—	+	—	—	—	—	—
A3	—	—	—	—	—	+ +	—	—	—	+ +	—	—	+ +
B3	—	—	—	+ +	—	+ +	—	+ +	+ +	—	—	+ +	+ +
C1	—	—	—	—	+ + +	—	—	+ + +	—	+ + +	+ + +	—	+ + +

— No Growth
+ Scanty Growth (1—10 colonies)
+ + Moderate Growth (11—20 colonies)
+ + + Heavy Growth (20 colonies and confluent).

TABLE 4b

Bacteriological examinations of post mortem tissues

Group	*Spleen*	*Lung*	*Bone marrow*	*Liver*	*Ovary*	*Kidney*	*Brain*
B3	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ +
A3	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ +
C1	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
B1	+	+	—	+	—	+	—
A1	+ +	+ +	+	+ + +	+	+	+ +
B2	+ + + (1)	—	+ + + (1)	+ + + (1)	—	—	—
CU	—	—	—	—	—	—	—
A2	—	—	—	—	—	—	—

— No Growth
+ Scanty Growth
+ + Moderate Growth
+ + + Heavy Growth

In vitro sensitivity test: The results are shown in Figs. 1—2. There was not much difference between the sensitivity patterns of *E. Coli* isolates both before and during the period of the experiment.

Serology: The results are shown in Tables 5a and 5b. The sera from group C1 and one each from groups B3, A3 and A2 were strongly positive (+ + +) with the strained antigen of *S. pullorum.* All the sera from group B2 were megative by the slide agglutination test. The results of the tube agglutination test were similar to those of the slide agglutination test (Table 5b).

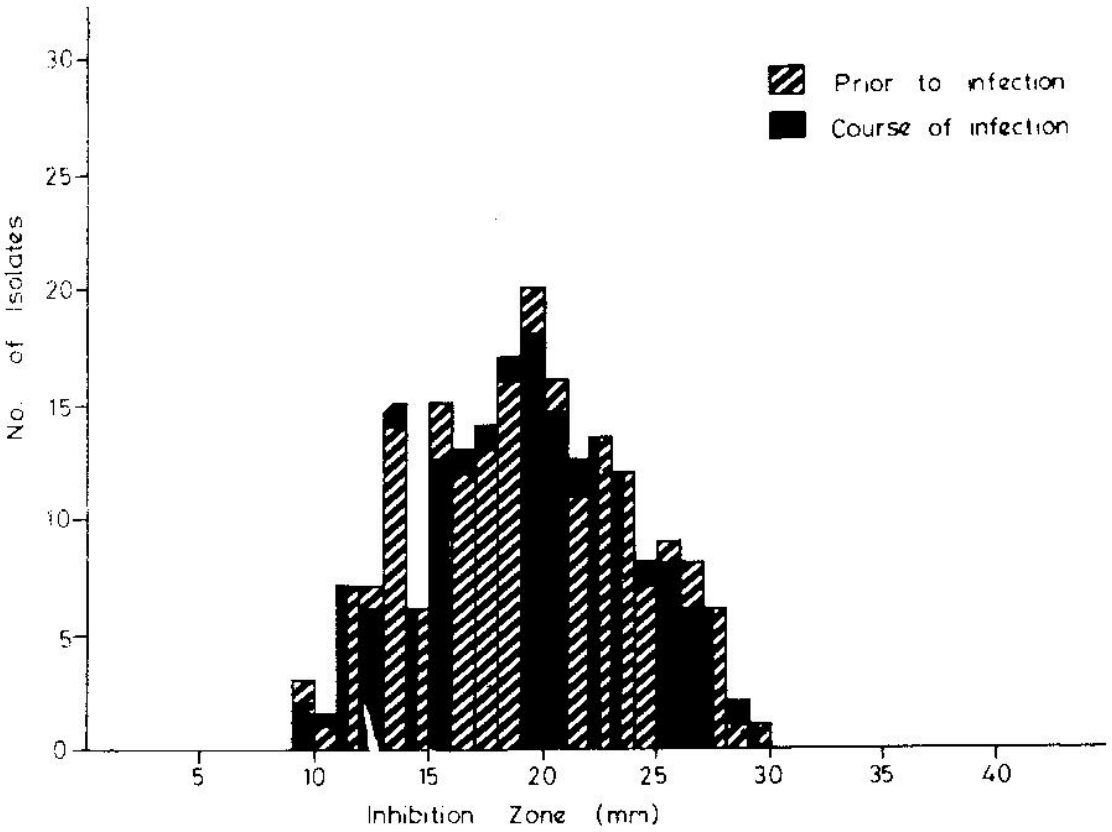


Fig. 1. In vitro sensitivity test of E. coli isolates from chickens prior to and during course of infection.

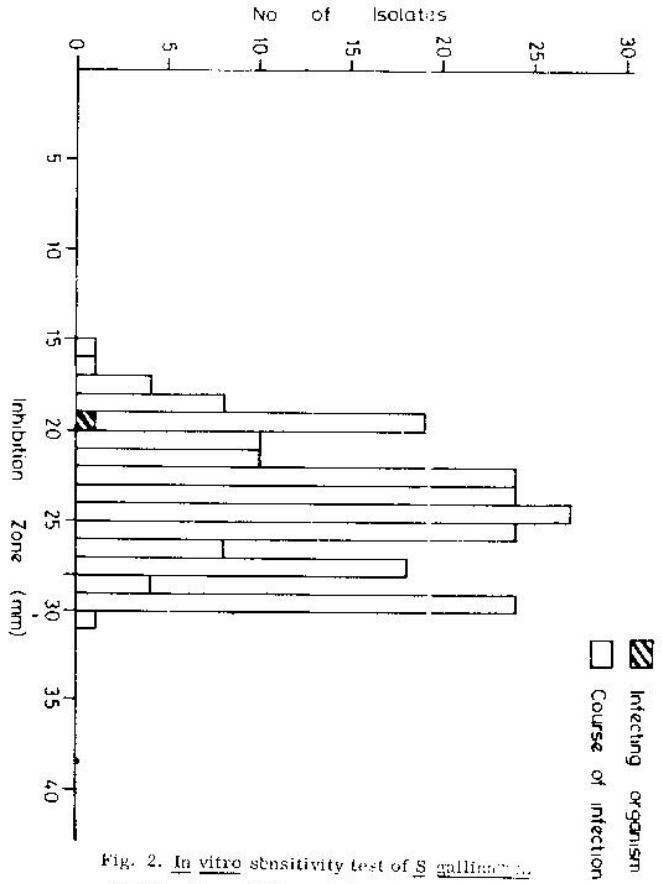


Fig. 2. In vitro sensitivity test of S. gallinarum isolates from chickens during the course of infection.

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TABLE 5a

Stained antigen slide agglutination

+ + +	+ +	+	—
A2(2)	A3	B1	B2
A3(1)	B3	A1	C1
B3(2)		A2	
B3(1)			
C1			

— Negative
\+ Weakly Positive
\+ + Moderately Positive
\+ + + Strongly Positive

TABLE 5b

Tube Agglutination Test Reciprocal of Tires

	10	20	40	80	160	320	640
A1	A1	C1	C1	C1	C1	C1	C1
B2	A2						
	A3						
	B3				B3(1)		

DISCUSSION

In the experiments described, the mortality was low in groups A1, A2, B1 and B2 before the birds in the groups were put on diet C. There were significant differences between these groups and C1 group (Table 6a). The mortality was relatively high in B3 and A3 for the same period, however there was significant difference between A3 and C1. The interval between infection and death in groups A1, A2, B1 and B2 was longer than in groups A3 and B3. Relapse was clinically more manifested in groups A1 and A2 than in groups B1 and B2 but the mortality due to relapse was the same in groups A1 and B1 and about the same in groups A2 and B2. Statistically there was no significant difference between A1, B1 and C1 at the end of the experiment (Table 6b), but there were significant differences between A2, B2 and C1 for the same period.

TABLE 6a

Statistical Analysis of the Mortality of the Infected Chickens 20 Days Post Infection using "t" test

Group		*'t' value*	*Remark*
A1	B1	0.06	No significant difference (NSD)
A2	B2	0.04	NSD
A3	B3	0.37	NSD
A1	C1	4.24	Significant difference (SD) (P 0.001)
A2	C1	6.00	SD (P 0.001)
A3	C1	2.55	SD (P 0.05)
B1	C1	4.39	SD (P 0.001)
B2	C1	5.89	SD (P 0.001)
B3	C1	1.92	NSD
A1	CU	1.88	NSD
A2	CU	1.87	NSD
A3	CU	2.66	SD (P 0.05)
B1	CU	1.87	NSD
B2	CU	1.03	NSD
B3	CU	2.79	SD (P 0.05)

TABLE 6b

Statistical Analysis of the Mortality of the Infected Chickens 35 Days Post Infection using 't' test

Group		't' Value	Remark
A1	B1	0.12	No significant difference (NSD)
A2	B2	0.34	NSD
A3	B3	0.23	NSD
A1	C1	1.81	NSD
A2	C1	3.62	Significant difference (SD)
A3	C1	1.23	NSD
B1	C1	1.99	NSD
B2	C1	4.09	SD (P 0.001)
B3	C1	1.42	NSD
A1	CU	2.07	SD (P 0.05)
A2	CU	0.77	NSD
A3	CU	2.41	SD (P 0.05)
B1	CU	1.98	NSD
B2	CU	0.46	NSD
B3	CU	2.02	SD (P 0.05)

In groups A3 and B3 mortality due to relapse was low and the clinical manifestation of the disease mild. The latter was probably due to recovery of the chickens in these groups from the clinical infection. These were clinically sick before they were put on feed containing furazolidone. Egg production was highest in group B2 followed by A2 and B1 and low in groups A3, B3 and C1. Groups B2 and B1 maintained their levels of egg production even after the feed was changed

to diet C. The relatively high egg production in groups B3 and A3 after the feed has been changed to diet C was probably due to the recovery of the chicken from clinical infection. The egg production in C1 group occurred only after recovery of the chickens from infection. No salmonella organism was isolated from eggs. The sensitivity of *E. coli* to furazolidone (100 mcg) before and during the course of experiment remained almost unchanged (Fig. 1) while the infecting organism failed to develop resistance to furazolidone throughout the course of infection (Fig. 2).

Although the chickens were not weighed during the period of the experiment, there was no apparent difference in weight between the chickens in groups fed furazolidone in their diet and the uninfected group on C diet, when they were slaughtered at the termination of the experiment.

On the basis of clinical symptoms, post mortem lesions, egg production, serology, mortality and sensitivity of *E. coli* isolated and *S. gallinarum* to furazolidone, we conclude that furazolidone is a drug of choice in the prevention and treatment of *S. gallinarum* infection. Hence we recommend 0.011 percent concentration of the drug for the treatment and prevention of infection. A lower concentration of 0.0055 percent may be used for prevention of disease. Treatment should commence as soon as clinical signs of an infection are noticed and this should continue until when the animals show no signs of infection like absence of loose faeces or anorexia. The chemotherapeutic effects of the drug can only be shown if the affected animals consume the feed containing the drug. From our results "carriers" did not occur when 0.011 percent was fed to infected animals. This is important in breeding flocks.

The bactericidal property of furazolidone in low concentrations, its tolerance by livestock, ability to keep its properties even on long storage and the fact that resistance to it by bacteria is slow, and when it occurs, it is not infectious, makes it superior to other agents, for livestock feed.

ACKNOWLEDGEMENTS

This study was conducted under a grant-in-aid from Eaton Laboratories, New York who has also supplied the NF—180 premix and furazolidone sensitivity discs. We thank Wellcome Reagents Ltd., Ikeja, Lagos for the free samples of "Wellcotest" agar used for the sensitivity test. We would like to acknowledge with appreciation the technical assistance and co-operation of the University Farm Director, Mr. F.A. Roberts and his Staff. The statistical analysis for which we are grateful was done by Dr. Ayeni of the Department of Preventive and Social Medicine, University of Ibadan. Finally, we thank Mr. I.A. Obiwale who typed the manuscript.

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