EFFECTS OF FEEDING HYGROMIX(R) ON GROWTH, FEED EFFICIENCY AND THE ANTHELMINTIC ACTION ON *ASCARIDIA GALLI* AND *HETERAKIS GALLINARUM* ROUNDWORMS OF POULTRY

by

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INTRODUCTION

Heavy infestations of the nematodes, Ascaridia galli and Heterakis gallinae in young fowl cause variable appetite, emaciation, retarded growth, weakness, and disease susceptibility. In laying fowl, there is loss of condition, weakness, lowered production, loss of lymph, reduction in the amount of blood sugar and a diminution on size of the thymus gland.

The use of an effective anthelmintic has an economic importance in poultry production. Until the present time, no drug that could be used as a mass treatment has been reported that meets the qualifications of an effective anthelmintic as set forth by Goldsby and Todd (1956).

The search for a suitable anthelmintic for control of Ascaridia galli and Heterakis gallinae has been scrutinized for many years (Herms and Beach 1916, Freeborn 1923). Although many drugs have been used with varying degrees of success, none has been completely satisfactory.

Considerable benefit could be reaped by the poultryman if hygromycin (Streptomyces hygroscopius fermentation products, Lilly) could be utilized as an anthelmintic. If hygromycin were palatable, non-toxic, and capable of reducing the reproductive capacity of the worm parasites to prevent reinfestation, it should be useful and valuable.

REVIEW OF LITERATURE

There have been many materials recommended for use as anthelmintics in poultry. These range in effectiveness from zero to nearly 100 percent. No anthelmintic to date has been found that can readily be mixed into the ration that was totally effective for both Ascaridia galli and Heterakis gallinae.

Although phenothiazine and piperazine are the most effective anthelmintics to date, a review of the literature offers many other anthelmintic materials.

Since the report of Herms and Beach (1916) that finely chopped tobacco stems steeped in the drinking water of semifasting chickens was an effective anthelmintic for ascarids, much research has been conducted and various formulations of the principle, nicotine, have been used.

Beach and Freeborn (1922) found that one pound of tobacco dust mixed with 50 pounds of mash, and fed from three to four weeks was effective for nematode control. Mash supplemented with commercial tobacco dust containing from 1.5 to 2 percent nicotine and fed over a period of one month would remove 98 to 100 percent of the Ascaridia galli, and 80 to 85 percent of the Heterakis gallinarum (Freeborn 1923). By mixing the nicotine sulfate with Lloyd's alkaloidal reagent, a selected fuller's earth, Freeborn (1923) has secured perfect elimination of the intestinal worms, although the cecal worms remain unaffected. Rectal injections of nicotine sulfate (40 percent nicotine) diluted at the rate of 1 ml. to 200 ml. of distilled water and administered in 10 ml. injections removed nearly 85 percent of the cecal worms (Freeborn 1923).

Graybill and Beach (1925), experimenting with "Blackleaf 40" in doses of 50 mg., found the dosage was low for efficacy against cecal worms, but was practically 100 percent effective for the intestinal roundworm. These workers also state that finely ground tobacco dust containing 1.62 percent nicotine mixed with dry mash in the proportion of 2 percent by weight was just as effective against cecal worms as "Blackleaf 40", but to a lesser degree against the intestinal roundworms.

Hunter et al. (1934), experimenting with the effect of concentration of nicotine on growth and development of chicks, found that feeding ground Nicotiana rustica, a strain of tobacco possessing a nicotine content equal to 5 percent of its dry weight, at levels up to 1.5 percent of the ration did not interrupt the growth of chicks. On the other hand, the feeding of ground cigar-leaf tobacco with a nicotine content of 0.86 percent at levels of 4.65 percent or above retarded the growth of chicks and caused an increase in mortality. While the use of 0.4 percent Nicotiana rustica was effective in the control of an artificial infestation of roundworms and appeared nearly, if not equally, effective in the control of a natural infection, it was not effective in the control of natural infestation of the cecal worms Heterakis gallinarum. However, the disadvantages of nicotine as an anthelmintic include toxic effects at high levels, poor anthelmintic action at low levels, and activity against mature worms only.

Areca nut and eucalyptus were tried and found ineffective against Heterakis gallinarum; while turpentine was more effectively administered in doses of 2 ml. of turpentine plus 2 ml. of olive oil, with the birds being fasted from the previous day, and then followed at once with 8 ml. of castor oil. This treatment was found fairly satisfactory for the large roundworms in the small intestine of chickens, as it removed more than 75 percent of the worms present (Hall and Foster 1918, Riley and James 1922). A 6 ml. dosage of 20 parts oil of turpentine and one part chloroform introduced into the crop by means of a soft rubber catheter proved from 80-100 percent effective for nematodes (Riley and James 1922). Using six birds, Hall and Shillinger (1923) showed that turpentine in doses of 0.2 to 1 ml. in

5 ml. of bland oil was only 5 percent effective for heterakids. Oil of chenopodium in doses of 8 to 12 drops was fairly efficient, but death of the birds occurred (Riley and James 1922). Hall and Shillinger (1923a) stated that oil of chenopodium in doses of 0.1 to 1 ml. in 5 ml. of bland oil for 10 birds was about 90 percent effective in removing cecal worms by rectal injections. Mohan (1954), working with oil of chenopodium in India, thoroughly mixed it with damp mash at a dose rate of one dram for each group of 12 birds, and found it was about 94 percent effective. Oil of chenopodium is more costly than carbon tetrachloride, and more difficult to administer, and is not superior to carbon tetrachloride. It is therefore recommended that carbon tetrachloride should be administered to the entire flock, directly into the crop, at four to six week intervals (Mohan 1954). Hall and Shillinger (1923) found carbon tetrachloride by rectal injection in doses of 2 to 10 ml., 66 percent effective for Heterakis gallinarum in the ceca. Carbon tetrachloride administered per os was non-toxic in doses up to 10 ml., but was unsatisfactory against cecal worms; however, it was nearly 100 percent effective against intestinal roundworms Ascaridia galli. It is most conveniently and safely administered in gelatin capsules at doses of 3 ml. for adults (Graybill and Beach 1925, Ackert and Graham 1935).

It has been found that giving 1 ml. of tetrachlorethylene to average-size chickens would in most instances remove all or practically all of the roundworms present, but doses of 1 ml. may have no effect whatever in some cases (Schlingman 1927, Schlingman 1929).

Other common teniacides, including pomegranate, root bark, areca nut,

thymol and male fern have been tested with unsatisfactory results (Wickware 1921). Using 10 experimental birds, Hall and Shillinger (1923a) found that a 1 percent aqueous solution of copper sulfate in doses of 2 to 10 ml. had an efficacy of less than 2 percent.

Edgar (1948), working with the sodium fluoride at nearly effective levels for ascarid elimination, found it was toxic to mature birds and caused them to go out of production. Sodium fluoride is very inactive against heterakids.

The majority of commercial anthelmintics of choice on the market today for Ascaridia galli and Heterakis gallinarum contain piperazine or phenothiazine. The latter drug was used because of its efficacy against the cecal worm, Heterakis gallinarum (McCulloch and Nicholson 1940). Phenothiazine and nicotine-bentonite had anthelmintic action against both Ascaridia galli and Heterakis gallinarum (Harwood and Guthrie 1944, Jaquette and Wehr 1949).

Reid (1946) indicated that phenothiazine had poor activity against Ascaridia galli, but it was highly effective against Heterakis gallinarum.

It is interesting to note that other workers likewise found phenothiazine to be relatively ineffective against Ascaridia galli. Roberts (1940) used 1 gm. phenothiazine per pound body weight and found it only 56.2 percent effective against this parasite.

Oliver et al. (1943) found that birds fed phenothiazine medicated mash for one hour with an average intake of 0.4 gm. per bird was only 57 percent effective in removing Heterakis gallinarum. However, when birds were treated with phenothiazine mash over a 7½ hour period, the intake of drug

per bird was 0.46 to 0.91 gm. and removed most of the cecal worms from infected chickens.

Piperazine derivatives may not show equal anthelmintic action against a specific parasite. For example, Riedel (1950) found Caricide to be most effective (69.4 percent) against Ascaridia galli in an oral dose of 1 gm. per bird followed by a 0.5 gm. redose several hours later. Riedel (1951) also reported that 2 percent Caricide in feed was 81 percent effective against Ascaridia galli. Subsequent studies have shown that lower levels of piperazine citrate are more effective against this parasite than the stated levels of Caricide.

Bradley (1955) used piperazine citrate against Ascaridia galli in two commercial broiler flocks of 15,600 8-week old birds given 8,000 mcg. piperazine citrate per gallon of drinking water free-choice for 60 hours. They contained no mature worms and an average of 0.24 immature worms as compared with averages of 6.87 mature and 2.42 immature worms in the untreated controls. The other flock, treated with 6,000 mcg. piperazine citrate per gallon of drinking water for 24 hours, averaged 0.14 mature worms and 0.85 immature worms; whereas, the controls harbored an average of 2.53 mature and 2.44 immature worms.

Shumard and Eveleth (1956) tested low levels of piperazine citrate in drinking water against Ascaridia galli in chickens. They reported that over a 24-hour period this drug given free-choice in the drinking water at levels of 2000, 1000, and 500 mcg. per gallon removed 82.4, 74.7, and 38.5 percent of the worms, respectively.

Kerr (1956) administered piperazine in the feed at continuous low levels

and found that levels of a tenth or less of the therapeutic dose were ineffective in preventing infection with Ascaridia galli. The piperazines were not consistently effective against Heterakis gallinarum and with a dosage effective for Ascaridia galli maximum removal of Heterakis gallinarum was about 40 percent.

Riedel and Ackert (1951) experimented on groups of chickens to determine if quantity and source of proteins are factors in the resistance of the host to the nematode Ascaridia galli. They concluded that rations of the less resistant groups of chickens were markedly deficient in arginine, glycine, leucine, and lysine, while the ration of the most susceptible group of chickens was low in all the amino acids required by chickens, except tryptophan. Evidence of age resistance of chickens to Ascaridia galli was shown by the reduced numbers and lengths of the worms as the age of the chickens progressed.

Hansen et al. (1953), initiated a study to determine the effect of an all-plant protein diet supplemented with aureomycin and vitamin B_{12} on experimental infections of chicks with Ascaridia galli. The criteria used in judging the effect of an ascarid infection were the numbers and lengths of worms recovered, weight gains made by experimental chicks, as well as the mortality and infection rates. Apparently these chicks given the dietary supplement of aureomycin and vitamin B_{12} were growing at peak efficiency for their particular diet, so the effects of a few worms were intensified; whereas, the relatively low efficiency of the chicks given the nonsupplemented basal ration was not appreciably disturbed by a comparatively heavier ascarid infection. There was no statistically significant difference in

the lengths of worms recovered from the two groups; however, the supplemented diet harbored the fewest worms at the termination of the experiment.

Todd (1951a) fed methionine-supplemented diets to New Hampshire chicks (2-10 weeks of age) infected with the large roundworms (Ascaridia galli) to find if the chicks could better withstand the effects of parasitism as evidenced by superior growth rates when compared with growth rates of infected chicks, fed with basal ration only. No consistent evidence was found to support such a conclusion.

Todd (1951), working with penicillin, streptomycin, and neomycin at the rate of 15 mg. per pound of feed, found the anthelmintic action of penicillin considerably enhanced and significantly reduced numbers of worms developing from controlled exposures. Todd and Stone (1952) investigated use of two levels of procaine penicillin in the diet of chicks given experimental exposures to large roundworms, Ascaridia galli. Both levels resulted in reduction of numbers of the test parasites present at postmortem examination in comparison with numbers of test parasites recovered from exposed birds fed the basal ration only. The higher level of penicillin, 30 mg. per pound of feed, did not result in greater anthelmintic action than was obtained with 15 mg. per pound of feed. Brown (1952), experimenting with the use of antibiotics in treatment of helminthic infections, found that young, immature worms were more susceptible to the action of antibiotics, and that several short series of treatments at intervals, directed at larval forms, might be most effective. The effects of certain anthelmintics and an antibiotic on lumen and tissue phase larvae of Ascaridia galli have been studied by Hansen et al. (1954). These men

found that aureomycin given at the rate of 18.0 mcg. per chick per day did not affect the numbers of lumen larvae, and even stimulated the growth of the lumen larvae. They found also that aureomycin did not affect either the numbers or the size of tissue phase larvae. Dixon et al. (1959) investigated the efficacy of low-level continuous feeding of hygromycin B and phenothiazine NF[1] for the control of Ascaridia galli and Heterakis gallinae in broilers. Each group of birds received a corn-soybean type ration with seven percent added animal fat with the following added: no anthelmintic, 7.2 gm. hygromycin B per ton, 7.2 gm. hygromycin B and 0.05 percent phenothiazine per ton. The nontreated birds had the greatest worm incidence. Those receiving hygromycin B alone had a reduction in the number of adult and immature Ascaridia galli and only a few adult Heterakis gallinae. Those birds receiving hygromycin B and phenothiazine NF harbored only a few adult and immature Ascaridia galli and Heterakis gallinae as compared to the nontreated group. The phenothiazine alone reduced the numbers of both parasites, but not as effectively as did hygromycin alone or the combination of the two. Frazier (1959) found that hygromycin was effective against both Capillaria obsignata and Ascaridia galli when fed at the rate of 8 gm. per ton of feed for 8 weeks. Frazier also found that hygromycin did not adversely affect egg production or feed efficiency when fed at the rate of 8 gm. per ton for 12 weeks, and had complete control of Heterakis gallinae.

Foster et al. (1960) stated that hygromycin is more effective

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[1]National Formulary

against cecal worms than against roundworms. These workers found that use of 12 gm. of hygromycin per ton of feed resulted in significantly fewer parasitized birds than either the basal group or those fed 6 gm. of hygromycin B; however, 6 gm. per ton resulted in a significantly lower number of birds parasitized than did the basal lot. Continuous feeding of hygromycin B during the growing period was effective in reducing the number of parasitized birds under conditions of relatively severe exposure.

MATERIALS AND METHODS

Battery Phase

The chicks used in this experiment were straight-run crossbred broiler strain chicks[1]. They were hatched May 2, 1958, at the Lowe Hatchery, Topeka, Kansas. The day old chicks were randomized into 22 lots of 20 chicks each. They were vaccinated intranasally for Newcastle and bronchitis, wing-banded, and placed in the level of battery brooders which had been randomly assigned. The chicks were started on chick broiler mash which was placed on egg flats for the first four days. Fresh water was supplied ad lib. The chick starter mash fed during this period was the Kansas State University 20 percent protein ration, plus selected levels of Hygromix.(R) The ration was prepared at the Kansas State University Poultry Farm. This was true for all diets used in this experiment. When the chicks were two weeks of age they were

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[1]Peterson Cornish x Arbor Acres White Rock chicks.

(R) = Registered trade-mark.

artificially infected with Ascaridia galli and Heterakis gallinarum.

The Ascaridia galli eggs used in the tests were cultured using the methods of Hansen et al. (1954, 1956).

The body contents of adult worms were stripped out and the uteri were placed in artificial digestive juice (1.0 percent pepsin and 0.5 percent hydrochloric acid) in a petri dish. When the uterine walls had been digested, tap water was added and after the eggs had settled to the bottom of the dish the supernatant solution was withdrawn. The digestive juice was removed in three to four additional washings with tap water.

Due to the small size of Heterakis gallinarum, the following egg culture technique was devised (Larson 1957). A group of Heterakis gallinarum was placed on a small 30-mesh screen and pressure was applied thoroughly crushing the worms against the screen. The macerated worms were washed from the screen into a petri dish containing artificial digestive juice. In four to five minutes, the mixture was poured through an 80-mesh screen into another petri dish. This screen retained the worm cuticula and other debris. The eggs were then washed until the digestive juice was removed.

It was found that mold growth in egg culture could be inhibited by addition of merthiolate. Therefore, a drop of 1:1000 merthiolate solution was added to 10 ml. water in each petri dish culture. All egg cultures were incubated at 30° to 33°C. for 14 days (Larson 1957).

Each chicken to be infected was given 100±10 Ascaridia galli and 100± 10 Heterakis gallinarum eggs per os. A calibrated micropipette was used in feeding the eggs to the birds. A variation of the egg administration technique of Hansen et al. (1954) was used. All water was withdrawn from the petri dish egg culture and 10 to 15 ml. of a 1.25 M. sucrose solution was

poured into the dish. After the eggs had been scraped from the bottom of the dish, the sugar-egg suspension was poured into a small bottle. A drop of the suspension was placed on a glass slide and the eggs were counted under a compound microscope. When it was necessary to dilute the suspension, additional 1.25 M. sugar solution was added and the eggs in several drops of the new suspension were counted. The suspension was diluted until the micropipette would deliver 100±10 eggs when filled to the calibration point.

At four weeks of age the chicks were transferred to growing batteries. The levels of Hygromix selected were 2, 4, 8, 16 and 32 gm. per ton of feed, and was fed from the start of the experiment as shown in Table 1.

At eight weeks of age the birds were transported to a commercial processing plant, where the abdominal viscera of each bird was placed in a separate polyethylene bag sealed and labeled. Each bag was then examined separately for roundworms and cecal worms.

The hydraulic method of Ackert and Nolf (1929) was used to recover Ascaridia galli from the small intestine lumen. The intestine from the gizzard to the yolk sac diverticulum was removed from the body cavity and was then attached to a small water hose and the contents flushed out into pint jars. The flushings were poured through a 20-mesh sieve which held back the worms. The worms were counted and their length measured, then preserved in a 10 percent formalin solution.

Heterakis gallinarum were recovered from chicken ceca by using an adaptation of the Ackert and Nolf (1929) hydraulic method for worm recovery. A longitudinal cut was made in the blind extremity of the cecum which was then

Table 1. Hygromix(R) levels.

Lot no.	Floor phase					Battery phase			
1	Basal	0	supp.	Nat.	Infect.[1]	Basal	0	supp.	non-infect.
2	Basal	0	supp.	Nat.	Infect.	Basal	0	supp.	infect.
3	Basal	0	supp.	Imp.	Infect.[2]	Basal	2gm.	supp.	non-infect.
4	Basal	0	supp.	Imp.	Infect.	Basal	4gm.	supp.	non-infect.
5	Basal	4gm.	supp.	Nat.	Infect.	Basal	4gm.	supp.	infect.
6	Basal	4gm.	supp.	Nat.	Infect.	Basal	8gm.	supp.	non-infect.
7	Basal	4gm.	supp.	Imp.	Infect.	Basal	8gm.	supp.	infect.
8	Basal	4gm.	supp.	Imp.	Infect.	Basal	16gm.	supp.	non-infect.
9	Basal	8gm.	supp.	Nat.	Infect.	Basal	16gm.	supp.	infect.
10	Basal	8gm.	supp.	Nat.	Infect.	Basal	32gm.	supp.	non-infect.
11	Basal	8gm.	supp.	Imp.	Infect.	Basal	32gm.	supp.	infect.
12	Basal	8gm.	supp.	Imp.	Infect.	Basal	0gm.	supp.	non-infect.
13	Basal	12gm.	supp.	Nat.	Infect.	Basal	0gm.	supp.	infect.
14	Basal	12gm.	supp.	Nat.	Infect.	Basal	2gm.	supp.	infect.
15	Basal	12gm.	supp.	Imp.	Infect.	Basal	4gm.	supp.	non-infect.
16	Basal	12gm.	supp.	Imp.	Infect.	Basal	4gm.	supp.	infect.
17	Basal	16gm.	supp.	Nat.	Infect.	Basal	8gm.	supp.	non-infect.
18	Basal	16gm.	supp.	Imp.	Infect.	Basal	8gm.	supp.	infect.
19	Basal	8gm.	supp.	Imp.	Infect.	Basal	16gm.	supp.	non-infect.
20						Basal	16gm.	supp.	infect.
21						Basal	32gm.	supp.	non-infect.
22						Basal	32gm.	supp.	infect.

[1]Natural infection.
[2]Imposed infection.
(R) = Registered trade-mark.

connected, at the constricted end, to a small water hose. After the contents had been flushed into a pint jar, the cecum was opened and the lining scraped. These scrapings were added to the jar.

In three to four hours most of the pasty material in the flushing was emulsified and suspended in the supernatant solution which was withdrawn. Water was added, and after the sediment had settled, the supernatant was withdrawn again. After several washings, the sediment was poured into a petri dish and examined with a wide field binocular microscope and findings recorded. Recorded also were any indications of typhlitis in the cecal tissue.

Floor Phase

The straight-run chicks used in the floor phase were the same strain as used in the battery phase. They were hatched September 24, 1959, at the Lowe Hatchery, Topeka, Kansas. The chicks were randomized into 19 lots of 30 chicks each on the 25th of September, as shown in Table 1. They were vaccinated intranasally for Newcastle and bronchitis, wing-banded and placed in the floor pen which had been randomly assigned. The litter in the floor pens was not changed from a previous experiment in hope of obtaining some degree of natural infection of helminths.

The floor pens were 10 x 10 ft., with one cone-type automatic waterer per pen. Two four-foot feeders were placed in each pen and adjusted and changed to larger feeders as the birds grew. The first four days feed was placed on egg flats to get the chicks started eating. All pens were supplied with a one-gallon glass water fountain until the chicks learned to use

the autmoatic waterers. The diet used through the entire experiment was the Kansas State University 20 percent protein broiler ration, plus the level of Hygromix selected. The basal ration was mixed at the Kansas State University Feed Technology Mill, and then returned to the Kansas State University Poultry Farm to mix in the level of supplement required. Part of the ration was then returned to the Feed Technology Mill to be made into granules. Samples were randomly selected from each experimental ration and were sent to the Eli Lilly laboratory for determination of the actual level of Hygromix per treatment. At 14 days of age the birds were artificially infected as in the battery phase. The birds were weighed every two weeks, and feed consumption data collected. The experiment was terminated when the birds were eight weeks of age. The birds were transported to a commercial processing plant and the visceral organs from each bird were placed in a polyethylene bag and labeled, and then frozen until they could be processed for recovery of Ascaridia galli and Heterakis gallinarum.

RESULTS

The analysis of variance, chi square test, and Spearman rank test, applied are described by Snedecor (1956). The Kruskal-Wallis one-way analysis applied are described by Siegel (1956).

Battery Phase

Feed Conversion. Analysis of the feed conversion data showed there was no significant difference between the different levels of supplement. Feed conversion was determined and calculated at eight weeks of age (Table 2).

Table 2. Analysis of variance of feed conversion during growing period.

Source of variation	df.	ms.	F-test	Sig.
Infections	1	.0044	.94	ns.
Levels	4	.0177	3.77	ns.
L x I (error)	4	.0047		

ns. - not significant at 0.05 level.

Body Weight. There was no significant difference in the body weights of the levels of supplements supplied (Table 3).

Table 3. Comparison of body weights during growth.

Source of variation	df.	ms.	F-test	Sig.
Infections	1	1946.0250	0.64	ns.
Levels	4	2997.4020	0.99	ns.
L x I (error)	4	3017.3736		

ns. - not significant at 0.05 level.

Roundworm Length. Analysis of Ascaridia galli length was determined by the U-test (Snedecor 1956). A value for χ = 4.64 in the treated birds was highly significant for reduced length. The male birds had a χ = 2.63 which was significant. Thus all levels were effective in reducing roundworm length.

Analysis of Ascaridia galli Counts. Lots which were treated alike were combined into six treatment groups. The counts among all the groups were ranked and the average ranks tested for significance according to the Kruskal-Wallis one-way analysis of variance (Siegel 1956). This procedure yielded a value of H = 30.10; when compared to chi square with 5 df., H was significant beyond the .001 level of probability.

Since it was concluded the treatment groups were not the same with

respect to Ascaridia galli counts, an attempt to explain the differences was made. The lots were ranked according to treatment level and according to average worm count. The Spearman coefficient of rank correlation (Snedecor 1956) was computed for the two sets of ranks, $r_s = -.9708$ ($P < .01$). A significant, negative correlation between level of Hygromix and worm count indicates that this substance had an anthelmintic effect. Since some worms were found in all groups, there is no evidence that the optimum anthelmintic level was reached in any of the diets.

Heterakis gallinarum Counts. Treatment groups were again formed from lots treated alike, and the ranked data were tested by the Kruskal-Wallis procedure (Siegel 1956). The value of H was significantly large ($H = 17.90$, $P < .01$) to conclude that differences existed among the treatment groups. When the relationship among the ranked lots was examined, there was once again a significant, negative correlation ($r_s = -.7583$, $P < .05$) between level and worm count. Thus there was strong evidence that Hygromix was effective against both helminths.

Floor Phase

Feed Conversion. Analysis of the data for feed conversion showed no significant difference between treatment levels of infected and noninfected birds (Table 4).

Body Weight. Analysis of weight gain data was determined and found nonsignificant (Table 5).

Roundworm Length. Correlations were determined between the noninfected, 0-supplement and the noninfected with varying levels of supplement. The

Table 4. Analysis of feed conversion for growing period.

Source of variation	df.	ms.	F-test	Sig.
Replications	1	.0780	.63	ns.
Infections	1	.0180	.14	ns.
Levels	4	.0913	.73	ns.
L x I (error)	4	.0534	.43	ns.
Residual	7	.1246		

ns. - not significant at 0.05 level.

Table 5. Analysis of variance of body weight during growing period.

Source of variation	df.	ms.	F-test	Sig.
Replications	1	43.0148	.94	ns.
Infections	1	50.9041	1.11	ns.
Levels	4	16.7826	.37	ns.
L x I (error)	4	45.3212	.99	ns.
Residual	7	45.7330		

ns. - not significant at 0.05 level.

correlations were nonsignificant for both males $Z = -.824$ and females $Z = -1.307$. Correlations were determined between infected O-supplement groups and infected groups at the varying levels of supplementation (Table 1). The correlation value of the males was $Z = -3.381$ and $Z = -4.97$ for the females both values being highly significant. Thus the 4 gm. per ton level was as effective in reducing worm length as was the 16 gm. per ton level.

Ascaridia galli Counts. The counts among all groups were ranked and the average ranks tested for significance according to the Kruskal-Wallis one-way analysis of variance (Siegel 1956). This procedure yielded a value of $H = 107.22$ when compared to chi square with 18 df., H was significant beyond the .001 level of probability. As in the battery phase, it was concluded the treatment groups were not the same with respect to Ascaridia galli counts, and thus an attempt to explain the difference was made. The

lots were ranked according to treatment level and according to average worm count. The Spearman coefficient of rank correlation (Snedecor 1956) was computed for the two sets of ranks, $r_s = -.2984$ $P < .05$ ns. and indicated this substance does not have a significant anthelmintic effect on Ascaridia galli.

Analysis of Heterakis gallinarum Counts. The ranked data were tested by the Kruskal-Wallis procedure (Siegel 1956). The value of H was significantly large (H - 157.17, $P < .001$) to conclude that differences existed among the treatment groups. When relationship among the ranked lots was examined, there was a significant correlation ($r_s = -.5578$, $p < .05$) between level and worm count. Thus there was evidence that Hygromix was effective against Heterakis gallinarum.

DISCUSSION

The objective of this experiment was to ascertain the anthelmintic effect of Hygromix (hygromycin B.) fed at varying levels upon the helminths Ascaridia galli and Heterakis gallinarum in broiler chicks.

The experiment was conducted as a battery phase and as a floor phase. The results of the battery phase showed no significant difference in feed conversion between the varying levels of Hygromix (Table 2). This statement holds true also for rate of chick growth (Table 3). Roundworm length was reduced however at all levels of supplementation. A significant decrease in the number of Ascaridia galli at all levels of supplementation indicates that Hygromix has an anthelmintic effect upon Ascaridia galli. There was no evidence that the optimum anthelmintic level was reached in any of the diets, as some worms were found in all groups.

The floor phase of the experiment showed no significant difference in

feed conversion between treatment levels of infected and noninfected birds (Table 4). Body weight analysis was found nonsignificant in the floor phase (Table 5).

It was found in the floor phase that the 4 gm. per ton level of supplement was as effective in reducing Ascaridia galli length as was the 16 gm. per ton level. In the floor phase the Ascaridia galli count in relation to treatment groups was not found to have significant anthelmintic effect. There was however evidence that Hygromix was effective against Heterakis gallinarum in both battery and floor phases.

SUMMARY AND CONCLUSIONS

This study was conducted to determine the anthelmintic effects of Hygromix (hygromycin B.) upon Ascaridia galli and Heterakis gallinarum in broiler strain chicks raised in batteries and in floor pens. Criteria of measurement involved effects upon feed conversion, body weight, worm length, and worm numbers.

During the eight week growing period, no significant difference was found in either the battery phase or the floor phase in feed conversion or body weight. There was however a significant difference in the battery phase in Ascaridia galli lengths and numbers. There was a significant difference in Ascaridia galli lengths, but not in numbers in the floor phase. The battery and floor phase both showed a highly significant difference in numbers of Heterakis gallinarum.

On the basis of these findings one may draw the following conclusions:

1. Feed conversion and body weight are not affected by Hygromix

(hygromycin B.).

2. There was some doubt in the effectiveness of Hygromix upon *Ascaridia galli*.

3. Hygromix is an effective anthelmintic for *Heterakis gallinarum*.

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Generous quantities of the following materials were supplied: CCC-244 (trace mineral mix) by Calcium Carbonate Company, Quincy, Illinois; vitamin B_{12}, and choline chloride by Commercial Solvents Corporation, Terre Haute, Indiana; Bifuran (coccidiostat) by Hess and Clark, Inc., Division of Richardson-Merrill Company, Ashland, Ohio; Merck 58A (B-complex vitamin mix), and D-L methionine by Merck and Company, Inc., Rahway, New Jersey; vitamin A and D_3 by NOPCO Chemical Company, Harrison, New Jersey. This research project was financed, in part, by a grant-in-aid from Eli Lilly and Company, Indianapolis, Indiana.

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EFFECTS OF FEEDING HYGROMIX(R) ON GROWTH, FEED EFFICIENCY AND THE ANTHELMINTIC ACTION ON ASCARIDIA GALLI AND HETERAKIS GALLINARUM ROUNDWORMS OF POULTRY

by

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There are many anthelmintic substances with relatively little therapeutic value against a specific parasite; however, they are too expensive to justify mass treatment, or they possess toxic properties which can be more harmful than the worm burden. Therefore the efficacy and toxicity of a compound should be determined before it is widely used. The control of Ascaridia galli, the large roundworm of chickens, and Heterakis gallinarum, the cecal worm of chickens, is economically important especially when these parasites are present in large poultry flocks. In commercial broiler raising areas many birds are confined to a limited space and thus the probability of parasite infection is increased.

This experiment was conducted to evaluate Hygromix(R) as an anthelmintic against Ascaridia galli and Heterakis gallinarum, in chickens. A total of 1010 crossbred chicks of the Peterson Cornish x Arbor Acres White Rock strain were used in the two experiments. The battery phase consisted of 22 lots of 20 birds each and the floor phase had 19 lots of 30 birds each. The Kansas State University 20 percent broiler ration was used as the control diet. The Hygromix levels selected for the battery phase were 2, 4, 8, 16 and 32 gm. per ton of feed, the levels in the floor phase were 4, 8, 12, and 16 gm. per ton of feed. Each chicken to be infected was given 100 $\pm$ 10 Ascaridia galli eggs and 100 $\pm$ Heterakis gallinarum eggs per os at 14 days of age.

Body weights and feed consumption data were recorded at two week intervals. Each phase was conducted for a period of eight weeks. At the completion of each experiment, the birds were taken to a commercial

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(R) = Registered trade-mark.

processing plant for slaughtering. The visceral organs from each bird were placed in a separate tagged polythylene bag and frozen until they could be examined for parasite burden. The statistical analysis of the parasite burden was computed on the basis of feed conversion and body weights of the birds. Also used were the numbers and lengths of roundworms, and numbers of cecal worms present in each bird.