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# Turkey Research - 1966

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
Wooster, Ohio

CONTENTS

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# THE OHIO POULTRY INDUSTRY

Robert E. Cook

The poultry industry in Ohio is currently producing approximately $90 million in income at the farm level and contributes well over $200 million to the total economy of the state when considered as a total industry. The industry is changing and growing at a very rapid rate, with the development of integrated, coordinated operations which are organized much the same as any commercial industry. It is anticipated that the industry will continue to play a more important role in Ohio's total agricultural economy and will grow at a much more rapid rate than many other agricultural industries.

The staff of the Poultry Science Department located both at Columbus and Wooster recently reviewed our total research, teaching, and extension programs and developed an overall plan for building a strong department which can be of real service to the dynamic, growing poultry industry in Ohio. In this basic plan, we propose to develop areas of research excellence in the department and strengthen our service to help develop the industry. The areas of concentration which we are working to develop are: (1) research excellence in avian physiology, (2) economic information to use as a basis for industry growth, and (3) reorganization of extension personnel as specialists in specific areas.

This program for development should allow the department to build a staff and program which will be of greatest value to the industry. Members of the industry are encouraged to consult frequently with members of our staff who are specialists in various areas of poultry. We are sincerely interested in aiding the Ohio poultry industry and have as our main objective "to improve the competitive position of the Ohio poultry industry relative to other areas and products."

LIGHTING TURKEYS FOR MAXIMUM REPRODUCTIVE PERFORMANCE

Keith I. Brown

The year-round production of hatching eggs is becoming more and more commonplace as a result of the increased demand for turkeys during the entire year. Now, in addition to a demand for year-round production of light weight turkey roasters, there is an increasing demand for the large tom turkey for further processing on a year-round basis. This means the industry must be able to produce hatching eggs efficiently 12 months of the year.

This paper gives background research material, recommended lighting procedures based upon current knowledge, and areas of research needing further attention.

Many investigations on lighting turkeys for egg production have been concerned with providing long days of approximately 14 hours during the winter months to spring-hatched turkeys. Since the reports of Marr et al (1956) and Harper and Parker (1957), the emphasis on research has changed and is now directed toward getting out-of-season poults from fall- and winter-hatched poults. In their reports, it was shown that winter-hatched turkeys are normally refractory to long days unless given a special pretreatment involving a short day of 9 hours for a period of 3 to 4 weeks. This was done when the hens were 22 or 24 weeks of age.

Restricted photoperiods have been studied singly by the following investigators: Leighton and Shoffner (1961b) and Brown and McCartney (1964) used 6 hours; Marr et al (1956) and Leighton and Shoffner (1961a) used 8 hours; and Harper and Parker (1957) and McCartney et al (1960) used 9 hours. Wilson et al (1962) studied restricted photoperiods of 4, 6, and 8 hours; ages of restriction ranging from 16 to 30 weeks; and increments of light increase from 6 to 10 hours. Ogasawara et al (1962) studied the effects of restricting light during the adolescent period on reproductive performance in both males and females subsequently exposed to 12-, 14-, and 20-hour days.

In addition to the variables studied above, the studies have been conducted on a number of different strains of turkeys. So a single recommendation for lighting turkeys is difficult. However, some general conclusions can be made.

First, it is apparent that regardless of the strain, the light increment (i.e. the difference in hours of light during restriction and hours of light during the subsequent long day) should be 8 hours. When smaller light increments were used, poor egg production resulted.

Second, the length of day during the restriction period should be 6 hours. Four-hour days during the restriction period resulted in low egg production. Eight-hour or longer days during the restriction period followed by 14-hour days resulted in poor egg production. This can be partially corrected by increasing the length of day to 16 hours or longer when lighting the hens for egg production. However, the

TABLE 1.--Effect of Age on Egg Production in Two Strains of White Turkeys (16 week production).

| Approx. age of 1st egg | Large White | | Egg Line | |
|---|---|---|---|---|
| | No. Eggs | Egg Wt. | No. Eggs | Egg Wt. |
| 31 | 45.3 | 83.0 | 62.9 | 75.9 |
| 32 | 48.9 | 83.1 | 59.4 | 76.5 |
| 33 | 41.5 | 81.3 | 61.6 | 72.9 |
| 34 | 53.7 | 80.7 | 65.6 | 71.6 |

evidence indicated that long day length results in the turkey hens becoming refractory, with resulting lower egg production.

Third, the length of daylight used to stimulate egg production should be 14 hours. Twelve-hour days and 20-hour days have resulted in lower egg production than 14-hour days.

Fourth, turkey strains differ in the earliest age at which they should begin laying. The Beltsville white turkey can be lighted to begin laying at 30 weeks of age, whereas the broad-breasted bronze should be 35 weeks of age. Recent research at this Center (Table 1) indicates that the large broad-breasted white turkey can be stimulated to begin laying at 34 weeks of age and the Ohio egg line as early as 31 weeks of age.

Fifth, the period of restriction to a 6-hour day should be no less than 5 weeks. Longer restrictions are not harmful. Table 2 provides general light recommendations for inducing egg production at any time of the year.

TABLE 2.--Recommended Lighting Schedule for Year-Round Egg Production

| Strain | Age To Restrict to a 6 hr. day | Age to Light to a 14 hr. day | Age of First Egg |
|---|---|---|---|
| Beltsville White | 21 weeks | 27 weeks | 30 weeks |
| Broad Breasted Bronze | 21 weeks | 32 weeks | 35 weeks |
| Large Whites | 21 weeks | 31 weeks | 34 weeks |

It is recommended that this procedure be used on all flocks at any season of the year. Since winter days (natural light) are longer than 6 hours, better egg production should be attained with this schedule even during the winter months. The long period of restriction for the large turkey may not be necessary. However, during the spring months the large turkey will begin to develop sexually. If these hens are restricted as late as 26 weeks of age during the spring months (natural daylight), they will molt. It is the author's opinion that it would be better to restrict hens at 21 weeks of age and prevent this premature sexual development and subsequent molt.

It is suggested that all breeder stock should be reared in confinement so that onset of lay can be controlled precisely. With this procedure at the Research Center, it has been possible to obtain good reproductive performance from September through June. Egg production in July and August tends to be down approximately 20 percent, probably due to warm weather.

Based on current information, no light restriction for the male turkey is required. However, the male should be placed on a 14-hour day at least 3 weeks before the hens are lighted to a 14-hour day to insure an adequate semen supply.

Future research needs to be directed to the optimum lighting procedures during the growing period. Research is also needed to determine the optimum environment for reproductive performance so the hatching egg producer will have information on the type of housing required for year-round production. If the cost of providing optimum environment for summer production proves prohibitive, perhaps it will be possible to devise rations which are particularly suited to warm weather egg production. These are some of the areas which need the attention of turkey research workers in the near future.

## References


Brown, K. I. and M. G. McCartney. 1964. Twelve month production of turkey hatching eggs. Ohio Farm and Home Research 49 (3): 39, 44.

Harper, J. A. and J. E. Parker. 1957. Changes in seasonal egg production of turkeys induced through controlled lighting exposure and force molting. Poultry Sci. 36: 967-973.

Harper, J. A. and J. E. Parker. 1961. Effect of full hatch date and length of light restriction on the photoperiodic response of turkey females. Poultry Sci. 40: 1413.

Leighton, A. T., Jr. and R. N. Shoffner. 1961a. Effect of light regime and age on reproduction of turkeys. 1. Effect of 15, 24 hour and restricted light treatment. Poultry Sci. 40: 861-870.

Leighton, A. T., Jr. and R. N. Shoffner. 1961b. Effect of light regime and age on reproduction of turkeys. 2. Restricted vs. unrestricted light. Poultry Sci. 40: 871-884.

Marr, J. E., F. N. Garland, Jr., J. L. Milligan, and H. L. Wilcke. 1956. Effect of controlled light during the growing period upon subsequent performance of breeder turkeys. Poultry Sci. 35: 1156.

McCartney, M. G., V. L. Sanger, K. I. Brown, and V. D. Chamberlin. 1960. Photoperiodism as a factor in turkey reproduction. Poultry Sci. 39: 1273.

Ogasawara, F. X., W. O. Wilson, and V. S. Asmundson. 1962. The effect of restricting light during the adolescent period on reproductive performance in turkeys subsequently exposed to a 12, 14, and 20 hour day. Poultry Sci. 41: 1858-1863.

Wilson, W. O., F. X. Ogasawara, and V. S. Asmundson. 1962. Artificial control of egg production in turkeys by photoperiods. Poultry Sci. 41: 1169-1175.

# FEEDING THE BREEDER TURKEY

S. P. Touchburn

This report is devoted largely to the feeding of hen turkeys. Limited information on the feeding of toms is also included.

## Growing and Holding Rations

How should young birds be fed during the growing stage and the subsequent holding period, generally considered to be from 20 weeks of age until onset of production at 34 weeks of age or later? Anderson et al (1963) fed large type white hens 84% of ad libitum consumption from 12 to 24 weeks of age. This growth restricting treatment resulted in increased hatchability and improved feed utilization for egg production. Similar restriction during a holding period of 24-40 weeks gave no improvement in hatchability. Birds restricted at this later age consumed greater quantities of the subsequently fed breeder diet, thus eliminating the advantage of reduced feed cost to that point.

In a series of experiments conducted at the Research Center with medium type white turkeys, no advantage could be found for restricting the nutrient intake during the growing period. Three methods of restricting nutrient intake were compared. The first was manually restricting daily consumption to 70% of full feed. The second was feeding a high fiber (60% ground oat hulls) ration. The third was addition to the grower feed of 1% of MAM-100, a chemical established as distasteful to the turkey. In the first year these treatments were applied from 18 to 28 weeks of age and in the second year from 12 to 28 weeks of age.

All methods of restricting nutrient intake effectively restricted growth rate, primarily affecting soft body tissue with little or no effect on skeletal growth. However, they all resulted in decreased egg production which was closely correlated with body weight at start of egg production.

In the third year of the study, manually limiting intake to 80% of full feed from 12 to 24 weeks of age caused a depression of egg weight and possibly also of hatchability. The disagreement of these results with the improvement in hatchability reported by Anderson and co-workers may be explainable on the basis that their experiments were conducted with large type turkeys while those here were conducted with a medium type bird.

A very high energy (10% added fat) ration fed from 12 to 29 weeks of age increased egg production but decreased fertility and egg weight. Supplementation with a protein-building hormone (SC-11585) from 20 to 29 weeks of age resulted in increased production and a tendency to greater fertility and hatchability, with no adverse effect on egg weight. Results with this compound have not been repeatable but the original results indicate future possibilities when the physiological conditions affecting the action of the compound are better understood.

TABLE 1.--Effect of Feed Intake Restriction on Body Weight of Tom Turkeys (lbs.)

| | Age in Weeks | | | |
|---|---|---|---|---|
| | 12 | 16 | 20 | 24 |
| Full Fed | 6.6 | 11.9 | 15.9 | 21.0 |
| 80% Full Fed | 7.2 | 10.9 | 15.1 | 18.9 |

These results indicate that using growing or holding rations high in fiber or otherwise restricting nutrient intake of hens should be avoided. Unless further research changes the picture, the best and the most economical recommendation is to feed regular starter, grower, and finisher rations, and to continue a 14% finisher ration through the holding period. Replacement poults should be obtained at a time which will allow them to be brought into egg production as soon as possible after 34 weeks of age. This is the best way to avoid unnecessary cost of feeding during a long, non-productive holding period.

The results of one experiment with growing toms suggests that the situation with this sex may be entirely different. Duplicate pens of toms were fed the growing rations from 12 to 24 weeks of age, either free choice or restricted daily to 80% of the consumption of the free choice groups.

Table 1 shows that by 24 weeks of age the restricted-fed toms averaged 2 pounds lighter in weight than those consuming the feed at will. The results in Table 2 show that restricting nutrient intake from 12 to 24 weeks of age brought about an increase in semen production, whether recorded as volume or on the basis of a score of 1 through 4. This latter method was employed because in some individuals the volume was not easily measurable due to the limited amount and the viscous nature of semen.

## Breeder Rations

The breeder ration should be fed starting at least 1 month before onset of egg production. Best recommendations to date are for 16 to 18% crude protein content and a calorie-protein ratio of 54 to 60 in terms of productive energy. Addition to the feed of at least 2% fat seems to offer one means of minimizing the body weight loss during the peak production period.

Anderson (1964) reported that production and hatchability on a 14.5% protein, 1310 M.E. calorie per pound ration were improved by addition of 4% tallow. He suggested that the increased calorie intake may have resulted in improved protein utilization. These hens were housed in open-front breeder pens which presumably provided minimal protection against the cold winter weather in Massachusetts. This points out the possibility that the C/P ratio might be varied to suit the temperature in the breeder pens. However, more research is needed to ascertain whether egg production can be improved by a diet which prevents the usual body weight loss during the peak laying period.

Recent developments in research have led to changes in mineral levels of diets fed to breeder hens. Jensen et al (1963) reported the results of one feeding trial in which a dietary level of 1.75% calcium appeared adequate for breeders. Diets containing 2.5 or 3.25% calcium yielded significantly lower hatchability, whereas one containing only 1% calcium significantly depressed egg production and shell color.

In a similar experiment, Balloun and Miller (1964a) obtained the best hatchability with diets containing 2 and 2.5% calcium. Levels of 1.5% and 3.0% significantly depressed hatchability but did not adversely affect egg production or egg size. Shell color was decreased on the 1.5% calcium diet, indicating that normal shell formation may have been hindered.

In an attempt to repeat the earlier results, Jensen et al (1964) conducted two experiments with the same strain of broad-breasted bronze turkeys. Contrary to the earlier results, they found no differences in egg production, efficiency of feed utilization, or hatchability among diets ranging in calcium level from 1.75 to 6.25% but the 1.75% level appeared to be minimal. The limestone used in these experiments was a different sample from that of the first test but was obtained from the same supplier. Attempts to explain the discrepancy through differences in trace mineral content of the limestone samples were unsuccessful.

TABLE 2.--Effect of Feed Intake Restrictions of Toms from 12 to 24 Weeks of Age on Semen Production.

| | | Full Fed | 80% of Full Fed |
|---|---|---|---|
| Ave. Semen Volume, cc. | Rep. 1 | 0.124 | 0.136 |
| | Rep. 2 | 0.108 | 0.140 |
| | Ave. | 0.116 | 0.138 |
| Ave. Semen Score* | Rep. 1 | 2.24 | 2.51 |
| | Rep. 2 | 2.04 | 2.68 |
| | Ave. | 2.14 | 2.59 |

*Visual score of volume from 0 to 4.

Naber et al (1963) have shown that some as yet undefined differences in limestones can have an effect on egg production of chickens. For this reason, one should apply caution when tempted to increase dietary calcium levels in efforts to improve shell quality. Jensen and co-workers used a phosphorus level of 0.6% and Balloun and Miller used 0.85%.

Atkinson et al (1964) conducted two experiments with breeder turkeys. They found that the best reproductive performance in cages was obtained with diets containing 2.54% calcium and 0.61% phosphorus. The best performance in the floor pen study was obtained with dietary levels of 3.08% calcium and 0.75% phosphorus. These studies were not exactly comparable and did not justify conclusions concerning requirements for cage vs. floor-housed hens.

Potter et al (1966) in two experiments fed levels of 0.99, 1.77, 2.55, and 3.33% calcium to breeder turkeys. Their results show that the lowest level depressed egg production and possibly hatchability, whereas shell weight and thickness generally increased with increasing levels of calcium in the diet. No differences could be detected between dietary phosphorus levels of 0.64% and 0.82%. The best recommendation would appear to be levels of 2.25 to 2.5% calcium and 0.7 to 0.8% total phosphorus. All of this should be incorporated into the complete mixed feed, with no supplemental feeding of oyster shell or other sources of calcium to avoid the possibility of excessive calcium intake by some individual hens.

A separate ration for breeder tom turkeys has been fed at the Research Center during the past year with good results. This involved modification of the hen breeder ration to meet the requirements of the toms. It was based on the assumption that since toms do not lay eggs, their requirements for protein and calcium would logically be lower than those of hens. Thus, the tom breeder diet was formulated to contain 15.8% protein and 0.9% calcium. The lower calcium level might possibly reduce the incidence of leg problems with the heavy toms during the breeding season. With natural mating when toms were intermingled with the hens, such a ration was not feasible. However, the widespread reliance on artificial insemination today provides the opportunity to use a separate breeder ration for toms.

The need to incorporate unidentified factor sources in rations for breeder turkeys has been generally recognized for some time. Research at this institution has demonstrated that supplementation of a simplified corn-soybean meal diet or a purified glucose-isolated soybean protein diet with 2% dried fish solubles improves the hatchability of the eggs produced and the early growth rate of the poults hatched from these eggs. Hatchability data are presented in Table 3. The lack of response to 4% dried whey product, fed as a supplement to both basal diets, is interesting in light of the fact that when the same sample was fed at the same supplemental level in poult diets, it produced a significant increase in 4-week weights of poults. Responses similar to those of the intact fish solubles were obtained in subsequent experiments by supplementing purified basal diets with the water soluble or methyl alcohol soluble fractions of dried fish solubles (Tables 4 and 5).

TABLE 3.--Effect of Breeder Diet on Hatchability.

| Diet | Hatchability (%) |
|---|---|
| Corn-soy | 49.28 |
| CS + fish | 55.19 |
| CS + whey | 43.25 |
| Purified | 33.31** |
| P + fish | 44.10 |
| P + whey | 35.44 |

**L.S.D. ($P < .05$) = 11.11; ($P < .01$) = 14.16.**

TABLE 4.--Effect of Fish Solubles and Various Fractions on Hatchability.

| Diet | Hatchability (%) |
|---|---|
| 1. Purified basal | 50.1ab* |
| 2. + fish solubles | 66.2c |
| 3. + Methanol extr'd F.S. | 48.9a |
| 4. + Methanol extract | 55.6abc |
| 5. + Ether-sol. of meth. extr. | 65.9c |
| 6. + Water-sol. of meth. extr. | 63.1bc |

***Figures sharing the same letter do not differ significantly ($P < .05$).**

TABLE 5.--Effect of Parent Diet on Growth of Progeny to 3 Weeks of Age.

| Parent Diet | Poult wt. * |
|---|---|
| 1. Purified basal | 287ab** |
| 2. + Fish solubles | 309bc |
| 3. + Methanol extr'd F.S. | 277a |
| 4. + Methanol extract of F.S. | 308bc |
| 5. + Cold water extract of F.S. | 320c |
| 6. + Hot water extract of F.S. | 300abc |
| 7. Corn-soy basal | 312bc |

***Poults fed purified basal starter diet.**
****Figures sharing the same letter do not differ significantly ($P < .05$).**

Variability in results of tests of unidentified factors has been attributed partly to the possibility that corn and soybean meal samples contain variable quantities of one or more unidentified factors. Kratzer et al (1964) have shown that soybean meal contains a factor capable of increasing early growth rate of poults fed purified diets and that it also contains an antiperotic factor. Griffith et al (1966) found that unheated soybean flakes contained two unidentified factors. The first was easily extractable with water and when fed to chicks gave a significant increase in growth over that of the basal diet. The second, which remained in the water extracted residue, increased the availability of phosphorus from anhydrous dibasic calcium phosphate ($CaHPO_4$) in a purified diet.

The recently revised Nutrient Requirements of Poultry (1966) indicates a vitamin A requirement of 1818 U.S.P. units per pound of turkey breeder diet. Jensen (1965) reported that 1000 to 1600 U.S.P. units per pound were adequate for maximum egg production and hatchability. These results are in agreement with earlier findings of Stoewsand and Scott (1961).

The current Research Center formula calls for addition of 2000 U.S.P. units of vitamin A per pound of diet. With the naturally occurring vitamin A and its precursors in the diet, this allows ample safety margin for this, the most unstable of the vitamins.

Jensen et al (1956) presented evidence indicating the need to supplement practical turkey breeder rations with vitamin E. They found the requirement to be 13.6 International units per pound of feed. The present breeder formula at the Research Center calls for the addition of 8 milligrams of alpha tocopherol per pound of feed, which supplements that contributed by the other feed ingredients to the point where an ample margin of safety is provided.

The choline requirement of the turkey breeder diet is 450 milligrams per pound. Balloun and Miller (1964b) obtained no differences in reproductive performance among groups fed diets in which choline levels were 200, 400, or 600 milligrams per pound. Ferguson et al (1961) demonstrated the need for most of the other B-complex vitamins in the diet of the turkey hens. A deficiency of one or more of the B vitamins led to decreased feed consumption. Riboflavin and pyridoxine deficiencies resulted in cessation of egg production after 8 weeks, while a sudden drop in production occurred after 12 weeks of a pantothenic acid deficiency. Hatchability was zero in the absence of dietary biotin or riboflavin and low in the absence of the others of the B complex.

The precise requirement levels for many vitamins have not been worked out for breeder turkeys. In many cases the levels used have been those established for breeding chickens or for starting poults. Much research remains to be done on the nutrient requirements of the breeder turkey.

## Literature Cited


Anderson, D. L. 1964. Effect of body size and dietary energy on the protein requirement of turkey breeders. Poultry Sci. 43: 59-64.

Anderson, D. L., J. R. Smyth, Jr., and R. E. Gleason. 1963. Effect of restricted feeding during the growing period on reproductive performance of large type white turkeys. Poultry Sci. 42: 8-15.

Anon. 1966. Nutrient requirements of poultry. NAS-NRC Publication 1345.

Atkinson, R. L., J. W. Bradley, J. R. Couch, and J. H. Quisenberry. 1964. The calcium and phosphorus requirements of breeder turkeys. Poultry Sci. 43: 1301.

Balloun, S. L. and D. L. Miller. 1964a. Calcium requirements of turkey breeder hens. Poultry Sci. 43: 378-381.

Balloun, S. L. and D. L. Miller. 1964b. Choline requirements of turkey breeder hens. Poultry Sci. 43: 64-69.

Ferguson, T. M., C. H. Whiteside, C. R. Creger, M. L. Jones, R. L. Atkinson, and J. R. Couch. 1961. B-vitamin deficiency in the mature turkey hen. Poultry Sci. 40: 1151-59.

Griffith, M., R. J. Young, and M. L. Scott. 1966. Influence of soybean meal on growth and phosphorus availability in turkey poults. Poultry Sci. 45: 189-199.

Jensen, L. S. 1965. Vitamin A requirement of breeding turkeys. Poultry Sci. 44: 1609-1610.

Jensen, L. S., H. C. Saxena, and J. McGinnis. 1963. Nutritional investigations with turkey hens. 4. Quantitative requirement for calcium. Poultry Sci. 42: 604-607.

Jensen, L. S., M. L. Scott, G. F. Heuser, L. C. Norris, and T. S. Nelson. 1956. Studies on the nutrition of breeding turkeys. 1. Evidence indicating a need to supplement practical turkey rations with vitamin E. Poultry Sci. 35: 810-816.

Jensen, L. S., R. K. Wagstaff, J. McGinnis, and F. Park. 1964. Further studies on high calcium diets for turkey hens. Poultry Sci. 43: 1577-1581.

Kratzer, F. H., B. Starcher, and E. W. Martin. 1964. Fractionation of soybean meal for growth and antiperotic factors. 1. Growth promoting activity in benzene soluble fraction. Poultry Sci. 43: 663-667.

Naber, E. C., Elizabeth MacKay, and S. P. Touchburn. 1963. The effect of calcium gluconate and ascorbic acid on productive performance and egg shell quality in chickens. OAES Res. Circ. 120.

Potter, L. M., A. T. Leighton, and A. B. Chu. 1966. Calcium, phosphorus and Nopgro as variables in diets of breeder turkeys. Poultry Sci. 45: 1117.

Stoewsand, G. S. and M. L. Scott. 1961. The vitamin A requirements of breeding turkeys and their progeny. Poultry Sci. 40: 1255-1262.

# A COMPARISON OF METHODS FOR ARTIFICIALLY INSEMINATING TURKEYS

Karl E. Nestor and K. I. Brown

Low fertility is a serious problem in producing turkey eggs, even though most turkeys are artificially inseminated. Generally, the fertility of turkey eggs is relatively high at the beginning of the breeding season and then declines as the season progresses.

Several factors may be responsible for the decline in fertility with time. Among these are faulty insemination techniques and mechanical spread of infectious organisms from hen to hen by the insemination technique.

Many turkey hatching egg producers are now using a disposable plastic tube for inseminating in order to prevent spread of disease. Although the use of the tube method has become an established practice commercially, there has been little experimental evidence to show that it is a superior method.

Unpublished data at the Center indicate that fertility data obtained at the beginning of the laying season may be misleading. Semen treatments may result in good fertility early in the season but relatively poor fertility late in the productive period.

An experiment was conducted to determine the influence of method and frequency of insemination on turkey fertility late in the laying season when fertility is normally low. The methods of insemination compared were the syringe, tube, and glass rod.

With the syringe method, semen was inseminated by means of a 0.25 cc syringe.

The tube method differed from that being used commercially in two aspects. In this experiment the tube was attached to a 3-foot length of flexible plastic tubing and the semen was blown into the oviduct by mouth. Commercially, the semen is usually blown into the oviduct by some mechanical device. In commercial practice the tubes are usually discarded after insemination, with one tube being used to inseminate one hen. In this experiment the tubes were washed and re-used. They were washed in detergent water, rinsed in distilled water and then allowed to soak in a 95% ethyl alcohol solution for at least 1 day. After soaking, they were dried and re-used.

A glass rod with a small concave cup on one end was used with the glass rod method. The end of the rod with the cup was dipped into the semen and then inserted into the oviduct of the hen and wiped clean.

The syringe and rod methods, as used in this experiment, would be conducive to the mechanical spread of disease from hen to hen since repeated inseminations were made with the same syringe or rod. A different clean tube was used for each hen with the tube method.

Data collected in several fertility trials are presented. The hens used in all trials were from a line selected for and exhibiting high egg production. Two different flocks of this line were used. Flock A was used for trials 1 and 2 and Flock B for trials 3 and 4. The semen used in all trials represented a pooled sample from 20 to 30 males. A different aliquot of the pooled sample was used for each treatment. The semen was collected and held at 15° C. during insemation.

Trial 1

The treatments compared in this trial were weekly and biweekly inseminations and rod and tube methods of insemination. The trial was conducted for a 6-week period during the 10th to 15th weeks of production.

The tube method resulted in higher fertility than obtained with the rod method (Table 1). This was true with both weekly and biweekly inseminations. However, the differences were not statistically significant and could have been due to chance. There were no significant differences in fertility between weekly and biweekly inseminations nor in hatchability of fertile eggs between any treatments.

Trial 2

The three methods of insemination were compared in this trial, with the birds inseminated weekly. The tube method again gave higher fertility than the rod method but the difference was not statistically significant. Slightly higher fertility was obtained with the syringe than with the rod method. There was no significant difference in hatchability of fertile eggs (Table 2).

Trial 3

The tube and syringe methods were compared in this trial under conditions of weekly and biweekly inseminations (Table 3). The tube method gave significantly higher fertility than the syringe method with both weekly and biweekly inseminations. Weekly inseminations also gave significantly higher fertility than biweekly inseminations with both methods of insemination. These results, with those obtained in trial 1 (Table 1), indicate that frequency of insemination is more important late in the laying season. There was no significant difference in hatchability.

Since 86 percent fertility was obtained with the combination of tube method and weekly insemination, washing and re-using the tube had no apparent detrimental influence on fertility.

Trial 4

Trial 4 was similar to the second trial in that the three methods of insemination were compared. The fertility obtained with the tube method was significantly higher than obtained with the other two methods. The results obtained with the syringe and rod methods were similar (Table 4). The hatchability was not significantly different between treatments.

One of the main differences between the tube technique and the other two methods was the possible prevention, by use of the tube method, of spread of organisms which would be detrimental to fertility. A test was conducted to determine the effect on fertility of using a single tube for all hens. Another similar group was inseminated with a clean tube for each hen. There was no significant difference in fertility or hatchability between the two treatments (Table 5). This indicates that the superiority of the tube method is due to some other factor than preventing spread of disease.

The question arose whether inseminating more frequently than once a week might increase fertility late in the season. To test this point, data were collected on the fertility obtained in eggs laid from 2 through 8 days following insemination. Due to the time involved in egg formation, eggs are normally not fertilized until the 2nd day following insemination. Thus, the 2nd day following an insemination would represent the 1st day in which eggs were fertilized by that insemination.

The data collected on 216 hens over a 9-week period are presented in Table 6. The test was conducted during the 18th to 26th weeks of production. Fertility reached a peak 3 days after insemination and then declined somewhat. The fertility obtained 8 days after insemination was 10 percent less than that obtained on the 3rd day following insemination. These results indicate that insemination every 6 days probably would improve fertility late in the laying period.

The results of this study indicate that the tube method of insemination is superior to either the syringe or rod methods. More frequent inseminations will result in higher fertility late in the laying season when fertility is at a low level.

TABLE 1.--Fertility Data Obtained During 10th to 15th Weeks of Production.

| Treatment | Method | No. Hens | No. Eggs Set | Percent Fert. | Percent Hatch. of Fertile Eggs |
|---|---|---|---|---|---|
| Weekly insemination | Rod | 37 | 734 | 64 | 71 |
| Weekly insemination | Tube | 39 | 743 | 76 | 69 |
| Biweekly insemination | Rod | 41 | 812 | 65 | 74 |
| Biweekly insemination | Tube | 40 | 790 | 78 | 72 |

TABLE 2.--Fertility Data Obtained During 16th to 21st Weeks of Production.

| Method of Insemination | No. Hens | No. Eggs Set | Percent Fert. | Percent Hatch. of Fertile Eggs |
|---|---|---|---|---|
| Syringe | 12 | 107 | 74 | 64 |
| Rod | 16 | 187 | 66 | 51 |
| Tube | 17 | 199 | 86 | 70 |

TABLE 3.--Fertility Data Obtained During 18th to 27th Weeks of Production.

| Treatment | Method | No. Hens | No. Eggs Set | Percent Fert. | Percent Hatch. of Fertile Eggs |
|---|---|---|---|---|---|
| Weekly insemination | Tube | 18 | 625 | 86 | 57 |
| Weekly insemination | Syringe | 17 | 572 | 68 | 61 |
| Biweekly insemination | Tube | 17 | 590 | 64 | 68 |
| Biweekly insemination | Syringe | 17 | 626 | 56 | 54 |

TABLE 4.--Fertility Data Obtained During 28th to 36th Weeks of Production.

| Method of Insemination | No. Hens | No. Eggs Set | Percent Fert. | Percent Hatch. of Fertile Eggs |
|---|---|---|---|---|
| Syringe | 11 | 280 | 40 | 43 |
| Rod | 10 | 265 | 39 | 45 |
| Tube | 12 | 231 | 69 | 31 |

TABLE 5.--Common Tube vs. Changing Tubes.

| Treatment | No. Eggs Set | Percent Fertility | Percent Hatch. of Fertile Eggs |
|---|---|---|---|
| Common tube | 2,057 | 87.3 | 63.2 |
| Tubes changed | 1,992 | 88.4 | 67.6 |

TABLE 6.--Fertility of Eggs According to Days Following Insemination.

| | Days Following Insemination | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| No. Eggs | 513 | 499 | 445 | 542 | 543 | 508 | 527 |
| Percent Fertility | 69 | 71 | 70 | 66 | 64 | 65 | 61 |

# BROODY MANAGEMENT AND EGG PRODUCTION OF TURKEYS

Philip A. Renner and Karl E. Nestor

Broody turkey hens have been, and will continue to be, a problem in the management of turkey breeder flocks. It is unlikely that turkey hens in the near future will reach the stage of chickens today where broodiness is not a problem. Meat production is of prime importance in selection of turkey breeders and egg production carries little emphasis in selection at the present time. Therefore, a broody management system is essential to cut down the loss of eggs caused by broodiness. The system discussed in this paper is a possible solution to this problem.

During the 1966 laying season, a new broody management system was initiated at the Research Center. This system differed from the system used in previous years. The 1966 broody system was tried on five lines of hens: randombred control line, egg line, semen line, and two well-known commercial lines. The randombred control line was established in 1955 and represents the egg production of turkeys at that time. The egg line was selected primarily for high egg production. The semen line was selected to produce a large volume of high quality semen. The two commercial lines represent commercial egg production and body conformation at the present time.

The five lines were placed randomly, 18 birds per pen, in the new windowless breeder building. They were housed in one 12-pen unit. The walls and ceilings of the pens are painted white, so the building is bright inside. These hens were trapnested and individual egg records were kept on each hen.

Broody hens were removed to a broody pen after the hens were in production for 3 weeks. Hens which were on the nest before the lights went out and did not lay an egg that day were palpated. If the hens did not have a hard-shelled egg in their uterus, they were removed to the broody pen.

The broody pen was in a different building than the breeder house. This building was not insulated, had windows, and the floor was constructed of wood slats. Eight 200-watt bulbs were spaced evenly in the ceiling of each pen and lighting was continuous.

The hens stayed in the broody pen for 36 hours and then were placed in their original pens in the breeder house. The effect of change in environment from a house which was comfortable to a house which was not seemed to be an important factor in breaking up broodies. The breeder house was insulated and had controlled temperature, ventilation, and a floor with litter. In contrast, temperature and ventilation could not be controlled in the broody pen. Because of the slatted floor, there was no place for the broody hen to sit and be comfortable.

When hens were in production for 6 weeks and had not laid for 7 days or more, they were caught and palpated. Hens which did not have an egg in the uterus were removed to the broody pen and held there for 50 hours. Then they were returned to their original pens. These hens were probably in a pause rather than being broody because broody hens normally enter the nest and these hens did not.

Broody management at the Center has varied in the past 6 years. There was no control for data obtained in 1966 so this year is compared with the system used in 1965.

In 1965 removal of broody hens was based on egg records. Hens which did not lay for a designated period of time (approximately 3 to 4 days) were moved to the broody pen. Hens which could not be broken easily at the time of insemination also were placed in the broody pen. All hens remained in the broody pen for 72 hours. This broody pen was similar to the one used in 1966 except that it had a wire floor and was located in the same building as the breeder hens.

Table 1 shows that the average length of the broody period was shorter in the randombred control group in 1966 than in 1965. In both 1965 and 1966, a period of nonproduction for 5 or more consecutive days was considered a broody period. The average lengths of the broody periods were 18.4 and 10.1 days, respectively, for 1965 and 1966.

The turkey breeder is interested in decreasing the number of days a hen is broody. This means more eggs per hen and an increase in total returns. For example, if a breeder has 1,000 hens, obtains 6 more eggs per hen, and receives 20¢ per egg, data from this study show that he would realize $1.20 per hen of extra income or profit. For the entire flock this would amount to $1200. So a turkey breeder could well afford to spend extra time in removing broodies from his flock.

In this study, extra labor was not needed because of the new windowless breeder building. The pens were lighted from 3 a.m. to

TABLE 1.--84 Day Broody Data

| Line | Year | Eggs Prod. | No. Broody Periods | Length Broody Periods | Total Days Broody | Percent Hens Broody |
|---|---|---|---|---|---|---|
| Randombred Control | 1965 | 38 | 1.47 | 18.4 | 23.8 | 85.3 |
| | 1966 | 41 | 1.91 | 10.1 | 19.3 | 85.7 |
| Egg Line | 1965 | 73 | 0.25 | 5.4 | 1.4 | 19.4 |
| | 1966 | 68 | 0.43 | 8.0 | 3.4 | 31.9 |

5 p.m. and the regular crew could take out broodies. If natural daylight was used, the broodies could not be taken out until dark.

A modified version of the broody management system used by the Center could fit into a commercial breeder flock operation. The hens in the nest could be palpated just before dark or after dark. Those without a hard-shelled egg in the uterus could be removed to a broody pen. The broody pen would have to be constructed in such a way that eggs would not be broken. Broody hens should be removed at least twice a week and three times a week if possible. These hens should be held in the broody pen for a minimum of 36 hours.

Since egg production is directly related to broodiness, a comparison was made of the five lines at the Center in 1966. With high egg production, broody periods were shorter and fewer (Table 2).

The egg production of the two commercial lines was better than the randombred control. This indicates that some commercial breeders are selecting for increased egg production.

The egg line, selected primarily for egg production, had an average egg production of 68.1 percent. This high egg production in the egg line was primarily due to less broodiness in the hens. The broodiness is being bred out of them, much the same as with Leghorn chickens.

Turkey hens tend to lay in a pattern over a period of weeks. Egg production goes up for the first few weeks, reaches a peak, and goes down after the peak due to a period of broodiness. When the broodiness is broken up, production goes back up but not to the original level. Then another period of broodiness occurs. This happens throughout egg production (Fig. 1). If the length of the broody period is cut down, egg production will stay at a higher level for a longer period of time and will not show fluctuations due to broodiness.

The egg line did not show as drastic a decrease in egg production during broody periods as the commercial line (Fig. 1). This production curve of the egg line resembles that of chickens.

TABLE 2.--Summary of Broodiness - 1966

| Line | No. Hens | Percent Eggs Prod. Days 84 | 180 | Total No. of Broody Periods Days 84 | 180 | Av. No. of Broody Periods Days 84 | 180 | Av. Length of Broody Periods Days 84 | 180 | Percent Out of Prod. | Percent Broody Days 84 | 180 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R B Control | 35 | 51.7 | 41.1 | 67 | 133 | 1.91 | 3.80 | 10.08 | 10.68 | 74.3 | 85.7 | 94.3 |
| Egg | 69 | 68.1 | 60.3 | 30 | 130 | 0.43 | 1.88 | 8.02 | 8.50 | 18.8 | 31.9 | 73.9 |
| Semen | 36 | 55.7 | 45.2 | 50 | 121 | 1.39 | 3.36 | 11.51 | 12.41 | 58.3 | 77.8 | 97.2 |
| Kimber | 36 | 56.2 | 52.1 | 51 | 110 | 1.42 | 3.06 | 9.09 | 10.07 | 63.9 | 72.2 | 97.2 |
| Williams | 34 | 58.0 | 56.7 | 41 | 94 | 1.21 | 2.76 | 9.19 | 9.58 | 73.5 | 64.7 | 94.1 |

Turkey hens reach a point during egg production (even though they are still laying) when income from egg production does not pay expenses. For example, the data in Fig. 2 show that an average commercial hen produced 90 percent of the total eggs she laid in 28 weeks by the 20th week of production. On the other hand, the egg line produced 79 percent of the total eggs during the 28-week period by 20 weeks. At 17 weeks of production, the commercial line produced 82 percent of the total eggs. By the 18th week, 85 percent of total production had been attained. Thus, it is probable that turkey layers should be marketed somewhere between 17 and 20 weeks of production. This depends on the operation, feed costs, whether another hatch of turkeys is to be raised in the same house, labor costs, and similar factors.

Decreasing the length of the broody period increases egg production. Until turkeys reach the point where broodiness is bred out of

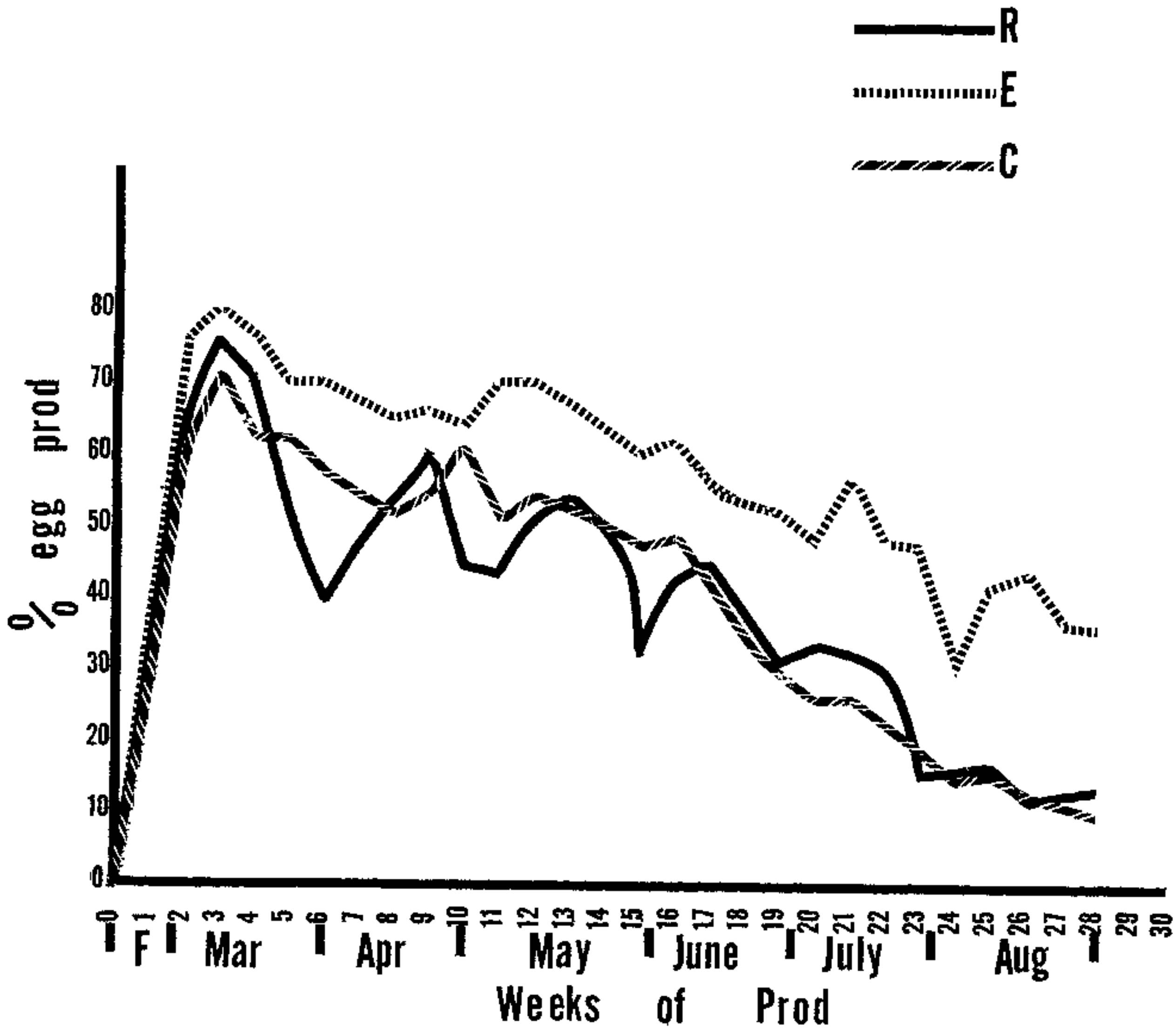


FIG. 1.--Egg production patterns of randombred, egg line, and commercial lines of turkeys.

them, some type of broody system should be practiced. An important advantage of the 1966 system is that it is routine. It does not depend on one person looking at records and removing hens after they are already well into the broody period. When this system is in operation, removal of broody hens can be scheduled at regular intervals throughout egg production.

Although a good broody system helps to obtain maximum egg production, it is not the complete answer. Factors such as breeding, nutrition, and management play an important part in egg production. As shown in the cumulative egg production curve, in most instances hens should be marketed after approximately 18 weeks egg production.

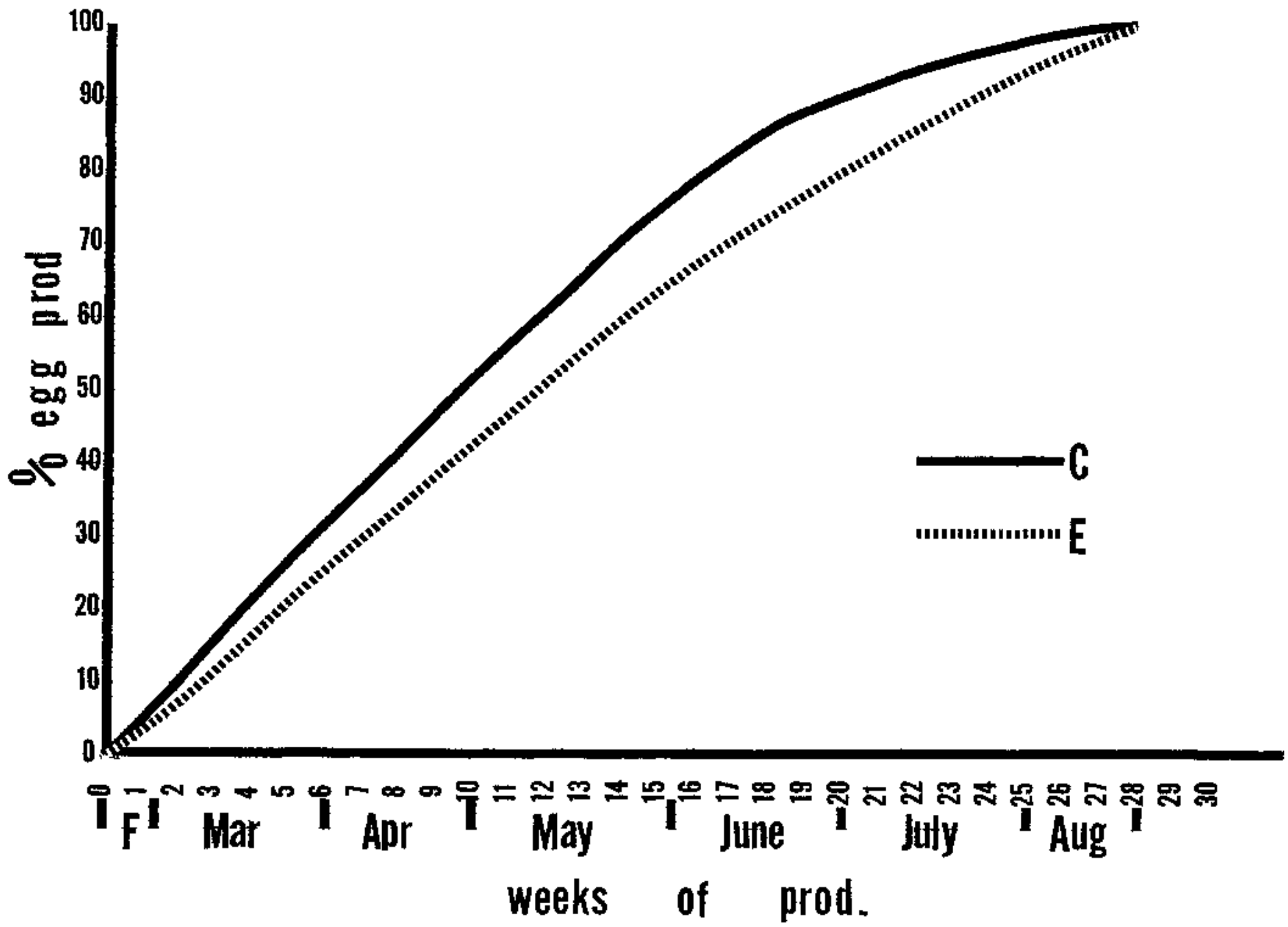


FIG. 2.--Cumulative egg production by weeks of egg line and commercial lines of turkeys.

## EGG QUALITY AND HATCHABILITY IN TURKEYS

Karl E. Nestor

Fertility and hatchability of turkey eggs are usually highest at the beginning of lay and then decline as the laying season progresses Reproductive data obtained early and late in the laying season are compared in Table 1. The females of each line were inseminated with semen obtained from males of the same line in order to obtain the data in the first period (0 to 8 weeks). A single pooled semen sample was used to inseminate the females of all lines during the last period (17 to 26 weeks). Fertility and hatchability were consistently lower late in the laying season. There were large line differences in the magnitude of the differences between the early and late parts of the reproductive season.

Quality of turkey eggs exhibits a seasonal decline similar to that observed with fertility and hatchability. An experiment was conducted to determine the relationship between egg quality and hatchability in order to determine if the drop in hatchability was due to the decline in egg quality.

The egg quality traits measured were albumen height, shell weight, weight loss after eight days of incubation, and incubation weight loss expressed as percent of initial egg weight. The means of the egg quality traits and various reproductive traits are presented in Table 2 for the different lines. There were highly significant line differences in egg weight, shell weight, weight loss, egg production, and number of poults. The line differences in albumen height and percent weight loss were not statistically significant.

The egg quality traits were correlated with reproductive traits to determine if there was any relationship between egg quality and reproduction. Correlations measure the type and degree of relationship

TABLE 1.--Reproductive Data Obtained in Various Lines.

| | Percent Fertility | | | Percent Hatch. of Fertile Eggs | | | Percent Hatch. of all Eggs | | |
|---|---|---|---|---|---|---|---|---|---|
| Line | 0-8 wks. | 17-26 wks. | diff. | 0-8 wks. | 17-26 wks. | diff. | 0-8 wks. | 17-26 wks. | diff. |
| Randombred Control | 89.3 | 54.5 | -34.8 | 78.8 | 64.0 | -14.8 | 71.4 | 37.4 | -34.0 |
| Egg | 93.0 | 72.6 | -20.4 | 82.7 | 53.1 | -29.6 | 77.4 | 39.4 | -38.0 |
| Semen | 89.3 | 62.8 | -26.5 | 83.5 | 54.8 | -28.7 | 74.8 | 39.6 | -35.2 |
| Williams X Kimber | 85.2 | 60.5 | -24.7 | 74.3 | 62.3 | -12.0 | 64.5 | 46.0 | -18.5 |
| Kimber X Williams | 80.6 | 53.6 | -27.0 | 73.9 | 50.8 | -23.1 | 59.0 | 30.0 | -29.0 |

between characteristics. A positive correlation between two traits indicates that they will increase or decline in magnitude together. A negative correlation indicates that as one trait increases in size, the other declines. A zero correlation indicates no association between the characteristics being correlated. The size of the correlation measures the closeness of the relationship. The value of correlation coefficients can range from -1.00 to +1.00. A large correlation (near 1.00) indicates a close association. The correlation coefficients are presented in Table 3.

Egg weight was positively correlated with all egg quality measurements except percent weight loss. The lack of a correlation between egg weight and percent weight loss was expected since the conversion to percentage was made to remove the influence of egg weight. Albumen height was not significantly correlated with the other egg quality measurements. Albumen height and egg production were negatively correlated, which means that an increase in egg production reduces albumen height. No other correlations with albumen height were significant.

TABLE 2.--Means of Egg Quality and Reproductive Traits.

| | Line | | | | |
|---|---|---|---|---|---|
| Trait | Randombred Control | Egg | Semen | Kimber | Williams |
| Egg Weight (gm.) | 86.2 | 78.5 | 87.8 | 91.7 | 90.4 |
| Albumen Height (mm.) | 7.10 | 6.73 | 7.37 | 7.28 | 7.39 |
| Shell Weight (gm.) | 7.91 | 7.35 | 8.13 | 8.63 | 8.08 |
| Weight Loss (gm.) | 4.64 | 4.22 | 4.59 | 4.99 | 5.07 |
| % Weight Loss | 5.39 | 5.38 | 5.24 | 5.43 | 5.57 |
| Egg Production | | | | | |
| 84 days (no.) | 44.2 | 55.7 | 45.9 | 47.0 | 48.0 |
| 120 days (no.) | 61.9 | 77.5 | 62.3 | 66.0 | 66.9 |
| 180 days (no.) | 79.1 | 105.5 | 82.4 | 81.2 | 84.7 |
| No Poults | | | | | |
| 0-8 weeks | 23.9 | 31.2 | 25.3 | 21.9 | 20.0 |
| 17-26 weeks | 5.2 | 10.9 | 7.5 | 6.2 | 4.9 |

TABLE 3.--Correlation Coefficients with Egg Quality Traits.

| | Albumen Height | Shell Weight | 8 Day Weight Loss | Percent Weight Loss |
|---|---|---|---|---|
| Egg Weight | .21** | .43** | .29** | -.02 |
| Albumen Height | ------ | -.05 | -.01 | -.08 |
| Shell Weight | -.05 | ------ | -.07 | -.22* |
| Weight Loss | -.01 | -.07 | ------ | .95** |
| % Weight Loss | -.08 | -.22* | .95** | ------ |
| % Fertility | | | | |
| 0-8 weeks | .01 | .02 | -.03 | -.06 |
| 17-26 weeks | .02 | -.07 | -.14 | -.13 |
| % Hatch. F.E. | | | | |
| 0-8 weeks | -.10 | .07 | -.20* | -.20* |
| 17-26 week | .04 | .16* | -.24** | -.22* |
| % Hatch. A.E. | | | | |
| 0-8 weeks | -.07 | .06 | -.13 | -.15 |
| 17-26 weeks | .05 | .12 | -.23** | -.21* |
| Eggs Prod. | | | | |
| 84 days | -.10 | .13 | .02 | .02 |
| 120 days | -.17* | .12 | .01 | .01 |
| 184 days | -.15 | .15 | -.08 | -.09 |
| No. Poults | | | | |
| 0-8 weeks | -.10 | 114 | -.05 | -.07 |
| 17-26 weeks | .01 | .13 | -.15 | -.15 |

*P $<$ .05
**P $<$ .01

Shell weight was positively correlated with hatchability of fertile eggs late in the productive period (Table 3). The positive, though non-significant, correlations between shell weight and egg production and between shell weight and number of poults are also noteworthy. This indicates that the better producers lay eggs with better shells.

Weight loss and percent weight loss were highly correlated (+.95). Percent weight loss was negatively correlated with shell weight, which indicates that eggs with thicker shells lose a smaller percentage of weight upon incubation. Both weight loss and percent weight loss were negatively correlated with hatchability of fertile eggs and number of poults. Although these correlations were not high, they demonstrated that shell quality influences reproduction. Shell quality has a larger influence on reproduction late in the laying season.

Table 4 gives correlation coefficients obtained between percent fertility and other reproductive traits. Fertility was positively correlated with hatchability and number of poults in each period. The positive association between fertility and hatchability of fertile eggs suggests that conditions favorable for fertility will also be favorable for hatchability.

The data obtained in this experiment show that the seasonal decline in shell quality is partially responsible for the similar decline in hatchability. It might be possible to improve hatchability late in the season by selecting for improved shell quality at this time. Preliminary data indicate that the heritability of weight loss and percent weight loss was higher than that for shell weight and these probably would be the most desirable traits for selection purposes.

TABLE 4.--Correlation Coefficients with Fertility.

| | Percent Fertility | |
|---|---|---|
| | 0-8 Weeks | 17-26 Weeks |
| % Fertility | | |
| 0-8 weeks | ------ | .14 |
| 17-26 weeks | .14 | ------ |
| % Hatch. Fertile Eggs | | |
| 0-8 weeks | .48** | .11 |
| 17-26 weeks | -.18* | .20* |
| % Hatch. All Eggs | | |
| 0-8 weeks | .85** | .14 |
| 17-26 weeks | .03 | .64** |
| Egg Production | | |
| 84 days | .18* | -.04 |
| 120 days | .14 | -.06 |
| 180 days | .10 | -.05 |
| Number Poults | | |
| 0-8 weeks | .70** | .12 |
| 17-26 weeks | .07 | .47** |

*$P < .05$
**$P < .01$

# IMPORTANCE OF FEMALE SEX HORMONES IN THE REPRODUCTIVE PERFORMANCE OF TURKEY HENS

D. P. Bajpayee and K. I. Brown

The sexual functions of the female bird are designed primarily for the process of reproduction. These functions are divided mainly into two major phases: 1) preparation of the feminine body (oviduct, uterus, etc.) for the processes of ovulation, conception, and egg formation; and 2) successful egg laying.

Among domestic livestock, genetic selection has made the bird the most remarkable and potentially the most prolific reproductive organism. The study of estrogens, female sex hormones which are growth substances and factors causing feminineness, has reached the stage in which minute amounts of estrogens can be detected.

Most birds lay eggs in clutches. A clutch consisting of more than five eggs is not uncommon. This pattern is followed by at least 1 day of rest. The growing follicle in the ovary secretes increasing amounts of estrogens, which is a good indicator of the health and vigor of the ovary in general and the ripening follicle in particular. A further understanding of a bird's ovulation cycle depends on the identification of estrogens and their circulating levels at the time of release of the first ovum in this clutch pattern.

The study of estrogen levels also are important in understanding the calcium and fat metabolism. The mobilization of body calcium for egg shell formation is a normal feature of the reproductive cycle. This is not merely due to dietary insufficiency. With the onset of ovarian activity and estrogen synthesis, there is a stoppage of bone growth. However, the rate of calcium deposition is actually increased at this stage. Physiological levels of calcium and estrogens may be helpful in interpreting the problem of soft shell turkey eggs.

Studies at the Research Center have been concentrated on developing a method of detecting estrogens in the blood of turkey hens. The investigation was initiated with the use of known methods of detecting these hormones in microgram quantities.

First the turkey hens were anaesthetized. Then a polyethylene tubing (catheter) was passed through the right limb into the posterior vena cava via the femoral vein. The catheter was pushed until the other end reached an area just above the ovary. By this means, ovarian rich blood flowing into the vena cava could be obtained. Blood from three turkey hens was successfully obtained by this means. The blood was collected and pooled samples were extracted by known methods for obtaining estrogens.

When it was found that turkey hens secrete estrogens, blood was collected from wing veins, which are the easiest and safest site to obtain blood for routine determinations. No estrogenic fluroescence was detectable in blood from the wing veins and this method was abandoned.

TABLE 1.--Mean Estrogen Values ± Standard Deviation.

| Source of Blood | No. of Observations | ug/100 ml. blood | | |
|---|---|---|---|---|
| | | Estrone* | Estradiol* | Estriol* |
| Catheter | 9 | .24±.012 | .23±.015 | .16±.012 |
| Heart | 20 | .15±.01 | .16±.008 | .29±.002 |

*Difference obtained between catheter and heart is highly significant statistically ($P < .01$).

The next choice was to collect blood from the heart. Repeated observations showed that all three estrogens were present but in different quantities than found in the blood obtained through a catheter. The data are summarized in Table 1.

The results show that laying hens secrete all three estrogens, which are very quickly metabolized by the system. No estrogens were detectable in the peripheral system with the method used. At present, the biological activity of the isolated material is being determined with the use of ovariectomized mice. The experiments are not completed but preliminary assays of fractions of estrone and estradiol show a significant response.

# SOME FACTORS AFFECTING STORAGE OF TURKEY SEMEN

K. I. Brown

Previous work at the Research Center has shown that turkey semen can be collected at 15° C. (60° F.) and stored for 2 hours without a significant loss in fertility. In every study conducted, however, the average fertility was lower after storage but no statistical significance could be shown. When semen was collected and stored at temperatures lower than 15° C., i.e. 10° C. or 3° C., a significant drop in fertility was always observed. Low temperature slows down metabolism and prolongs the life of the sperm but, for some reason not understood at the present time, semen stored at these low temperatures exhibits a lower fertilizing capacity. In spite of these negative results, it is generally believed that low temperature storage will have to be used if turkey semen is to be successfully stored for long periods of time. It is probable that a solution to this problem will be found only after a great deal of fundamental research.

For the above reasons, a systematic study was undertaken to develop methods for storing semen, using a Linde liquid nitrogen freezer and controller. The first step was to determine the optimum collection temperature and cooling rate to 3° C. (refrigerator temperature). If techniques can be developed to cool semen to 3° C. without loss of fertility, the next step will be to study special freezing techniques.

## Effect of Collection Temperature on Abnormal Sperm

Previous work has shown a high negative correlation between bent sperm and fertility. For that reason, the number of bent sperm is used for laboratory evaluation of semen subjected to various temperatures and cooling rates.

Previously it was indicated that if semen is to be held for any length of time, it should be collected and held at 15° C. Dr. Leighton (V.P.I.) has conducted a series of fertility trials which indicate that collection and holding turkey semen at 80° F. (27° C.) may result in slightly higher fertility than semen collected and held at 60° F. (15° C.). In this study, Leighton made all inseminations within 15 minutes of collection.

To further test the temperature at which turkey semen should be collected, in the Ohio studies semen was collected directly into thermos bottles at 40°C. (104° F.), 30° C. (76° F.), and 20° C. (68° F.). The increases in percent bent sperm after 1 hour and 4 hours of storage at these temperatures are shown in Table 1. It was concluded that semen should be collected at temperatures higher than 20° C. For the purpose of these studies, all semen was collected at 30° C. (76° F.).

TABLE 1.--Effect of Collection Temperature on Bent Sperm

| Collection and Storage Temperature | Change in Bent Sperm (%) 1 hr. | 4 hr. | Ave. |
|---|---|---|---|
| 20°C | +10.2 | +12.2 | 11.2 B |
| 30°C | - 0.85 | + 4.7 | 2.0 A |
| 40°C | - 2.10 | + 7.9 | 2.9 A |

Different letters indicate significant differences ($P < .05$).

## Effect of Different Cooling Rates from 30° C. to 3° C. on Motility and Bent Sperm

Semen samples were collected at 30° C. The control sample was held at 30° and 1 ml. aliquots were removed and cooled at different rates to 3° C. Motility and percent bent sperm of the original sample and of all samples after 4 hours' storage were determined. The results are shown in Table 2.

The motility was excellent for all treatments. However, the smallest increase in bent sperm occurred in the samples cooled at 4° C. and 8° C. This indicates that the optimum cooling rate for turkey semen from 30° C. to 3° C. is somewhere between 4° C. and 8° C. A preliminary fertility trial indicates that cooling at the rate of 8° C. did not lower fertility significantly (Table 3). The low fertility in the control hens in the trial is due to the fact that these hens had been in production 16 weeks before this trial began. Low fertility late in the season is common.

A study is currently being conducted to determine more precisely the effect of different cooling rates on fertility. If semen can be successfully cooled to 3° C. without loss in fertilizing capacity, studies will be initiated to develop methods of freezing semen for long term preservation.

The benefits to be gained by storage of turkey semen are tremendous. Semen from superior males could be collected every 2 days for as long as they produced good quality semen. This semen could be stored and shipped to the hatching egg producer as needed. There would be no need to house males with each breeder flock. The hatchery or the primary breeder could supply semen from centralized male farms. This would result in large savings to the industry because fewer males would be required and specialization results in more efficient use of labor and facilities.

Because this is so important to the turkey industry, the Research Center is instituting a crash program to try and obtain the necessary information for storage of turkey semen.

TABLE 2.--Effect of Cooling Rate on Turkey Spermatozoa. (Storage = 4 hrs.)

| Rate of Cooling | Motility | Increase in Abnormal Sperm |
|---|---|---|
| Control Collected and Held at 30°C | 5 | + 6.8% |
| 8°C/min. | 5 | + 2.5* |
| 4°C/min. | 5 | + 2.3* |
| 3°C/min. | 5 | + 9.5 |
| 1°C/min. | 5 | + 7.0 |
| 0.5°C/min. | 5 | + 9.0 |
| Icebath (approx. 15°C/min.) | 5 | +23.9* |

*Different from control ($P < .05$).

TABLE 3.--Effect of Diluents and Cooling on Fertility. (Cooled 8°C/min. to 3°C).

| Treatments | Percent Fertility Ave. of 4 Weeks |
|---|---|
| Control collected and held at 30°C | 54.2 |
| Undiluted | 67.4* |
| Equal parts 11% lactose - glutamate | 1.1* |
| Equal parts 11% lactose - glutamate + 2% PVP | 12.6* |
| Equal parts 22% lactose - glutamate | 27.3* |
| Equal parts 22% lactose - glutamate + 2% PVP | 45.6 |

*Different from control ($P < .05$).

PVP = polyvinylpyrrolidone

All treatments except control were cooled to 3° C.

Glutamate = 2.761 gm. monosodium glutamate, 0.300 gm. glucose, 0.0488 gm. $MgCl_2 6H_2O$ made up to 100 ml. vol. with distilled $H_2O$.

## FEEDING SCHEDULES FOR GROWING TURKEYS

S. P. Touchburn and V. D. Chamberlin

The search continues for a set of feed formulations to fit the needs of the turkey at each age during the growing period. In this report, the different rations are described in terms of their percent protein content. This really refers to their content of the critical nutrients, including the vitamins and minerals which are adjusted in approximately the same proportions as their protein. Since these nutrients are provided at a level which allows a certain excess or margin of safety, it is likely that the protein is the first limiting nutrient. Therefore it is legitimate to refer to the rations by their protein content. It should be kept in mind that, as the protein level decreases, the energy level and the calorie-protein ratio increase.

Earlier studies have shown that individual strains of turkeys require different protein levels in their growing rations. These differences were found, however, only between strains which were extremely different in rate of growth and final body size. For the 1965 study, only one strain of turkey was used and this was the Large Type White.

The three feeding schedules compared were 4-ration, 5-ration, and 6-ration systems. The schedules are outlined in Table 1. The 4-ration schedule, for example, involved feeding the toms a 28% protein ration from 0 to 8 weeks, 20% to 16 weeks, 16% to 24 weeks, and 14% to 26 weeks of age. The hens were fed the same feeds but each feed was fed for a shorter length of time. The 5- and 6-ration systems involved more frequent changes of the diet composition during the course of the growing period, with the obvious aim of more closely meeting the changing nutrient requirements of the growing turkey.

All poults received bacitracin-methylene-disalicylate at a level of approximately 200 grams per ton of feed to 4 weeks of age, then 4 grams per ton to 8 weeks of age. After 8 weeks of age, two blackhead preventive drugs were compared for their effects on growth rate and feed conversion. These were p-ureidobenzenarsonic acid at 0.0375% of the diet and dimetridazole at 0.015% of the diet. These were supplied by Carbosep at 2 lb. and Emtrymix at 1 lb. per ton of feed respectively in the 25% protein growing ration. Lower protein levels contained these drugs in proportion to the protein content. For example, the 16% protein rations contained 16/25 of the original drug levels.

Since this test was intended to measure the relative effects of the drugs on growth and feed conversion, but was not intended to compare their efficacy, no clinical measurements were made. From past experience, a reasonably high exposure to Histomonas meleagridis was assumed but no incidence of blackhead was observed. Furthermore, a report by McGregor et al (1964) indicated that both drugs were very effective in controlling the disease.

This experiment was conducted between May 13, when the poults hatched, and November 10, when the toms reached 26 weeks of age. The poults were reared in conventional brooding facilities to 8 weeks of age. After this time, they were reared in pens of 25 each in two types of houses. One (house 8) was a brooding facility with windows and exhaust fans. The other (house 9) was an open construction pole barn. Records of body weight and feed consumption were collected at 4-week intervals up to 20 and 24 weeks of age in the hens and toms, respectively, then weekly to 24 weeks of age in the hens and 26 weeks in the toms. These frequent weighings toward the end of the experiment provided data for determining the most opportune point at which to market turkeys in order to maximize profits. A report based on these data is presented by Dr. Ralph Baker (see page 42).

For some time a controversy in the industry has centered around the best method of producing the broiler or fryer-roaster turkey. The Small or Medium Type of turkey yields a fairly good fryer-roaster. Will the hen of the Large Type strains successfully compete for this

TABLE 1.--Feeding Schedule of the 4-, 5- and 6-Ration Systems with Rations Represented by Their Percent Protein Contents.

| Date | Age Wks. | 4-Ration Toms | 4-Ration Hens | 5-Ration Toms | 5-Ration Hens | 6-Ration Toms | 6-Ration Hens |
|---|---|---|---|---|---|---|---|
| 5/13 | 0 | 28 | 28 | 30 | 30 | 29 | 29 |
| 19 | 1 | | | | | | |
| 26 | 2 | | | | | | |
| 6/ 2 | 3 | | | 26 | 26 | | |
| 9 | 4 | | | | | | |
| 16 | 5 | | | | | | |
| 23 | 6 | | | | | 25 | 25 |
| 30 | 7 | | 20 | | | | |
| 7/ 7 | 8 | 20 | | 22 | 22 | | |
| 14 | 9 | | | | | | |
| 21 | 10 | | | | | 20 | 20 |
| 28 | 11 | | | | | | |
| 8/ 4 | 12 | | | | 18 | | |
| 11 | 13 | | | | | | |
| 18 | 14 | | 16 | 18 | | | 18 |
| 25 | 15 | | | | | | |
| 9/ 1 | 16 | 16 | | | 14 | 18 | |
| 8 | 17 | | | | | | 16 |
| 15 | 18 | | | | | | |
| 22 | 19 | | | | | 16 | |
| 29 | 20 | | | 14 | | | |
| 10/ 6 | 21 | | | | | | |
| 13 | 22 | | 14 | | | | 14 |
| 20 | 23 | | | | | | |
| 27 | 24 | 14 | | | | 14 | |
| 11/ 3 | 25 | | | | | | |
| 10 | 26 | | | | | | |

position? This question reached practical significance with the development of the further processing segment of the industry. Its demand for Large Type toms creates a surplus of hens which, if acceptable to the consumer, could supply a large part of the fryer-roaster market.

To investigate this problem, a sample of six hens near the average weight of the group was removed from the 6-ration treatment groups at 12, 16, 20, and 24 weeks of age. These birds were killed, dressed, frozen, and held until the end of the growth trial, when they were subjected to taste comparison tests. The results of this phase of the experiment are presented by Dr. George Mountney (see page 54).

## Results and Discussion

Tables 2 and 3 show the effects of the three feeding schedule treatments on growth rate and feed conversion for toms and hens, respectively. In the last section of each table, the feed cost per pound of gain is included for each interval. Feed costs used in determining the latter were actual costs of ingredients plus mixing and handling charges quoted by the O.A.R.D.C. feed processing plant. Charges for the medications were included, even though these materials had been donated by the manufacturers. The price charged for corn was $52 per ton and for 44% protein soybean meal, $95 per ton.

By examination of these tables in conjunction with Table 1, which shows the protein level of the ration fed, it is possible to arrive at an estimate of the best feeding schedule for each interval. The cost per pound of gain refers to feed costs only. Since 30 to 40 percent of the total cost of producing turkeys must be assigned to costs other than feed (labor, etc.), the actual growth performance must be considered along with the feed cost. For example, in Table 2 the feed cost per pound of gain of toms from 8 to 12 weeks of age was 10.86 cents for the 4-ration system. This was as cheap as that for the 6-ration and probably not different from the 10.94 cents per pound for the 5-ration system. However, the body weight at 12 weeks and the weight gain from 8 to 12 weeks of age were much poorer on the 4-ration system, which also required more feed per unit gain. Thus, the 5- or 6-ration systems were considered to be the best rations for this interval.

Reducing the protein content to 20% at 8 weeks of age, as done on the old system of feeding, did not allow sufficient protein intake to meet the increased requirements of the modern, fast-growing Large Type turkey toms. Similarly for the 16 to 20-week age period, the preference would be given the 18% protein rather than the 16% protein ration. Sixteen weeks of age appears to be a little early to reduce the protein level to 16% but the discrepancy between nutritional performance and feed cost per pound of gain suggests that perhaps a compromise should be made.

From 20 to 24 weeks of age, the 5-ration system, which had been more or less satisfactory up to this point, was surpassed in gain and feed conversion efficiency by the 4-ration system. The differences of 0.52 pounds of gain and 0.45 pounds of feed required per pound of gain were very dramatic. Thus, the level of 16% protein provided under the 4-ration system was chosen over the 14% level of protein of the 5-ration system, despite the fact that the two systems gave equal feed costs per pound of gain. However, this again suggests that a compromise would more likely give the best overall performance. The resulting schedule was an 18% protein ration from 13 to 18 weeks of age and a 16% protein ration from 18 to 24 weeks of age.

The hen data in Table 3 were subjected to the same scrutiny. The most striking contrast here was the difference between the 4-ration and the other treatments from 16 to 20 weeks of age. Weight gain was greatest and the amount of feed required per unit gain was lowest, resulting in the lowest cost of feed per pound of gain. The 6-ration

TABLE 2.--Effect of Feeding System on Average Body Weight, Average Weight Gain, and Feed Conversion of Large White Turkeys.

| Toms | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Age in Weeks | | | | | | | |
| | 4 | 8 | 12 | 16 | 20 | 24 | 25 | 26 |
| **Average Body Wt., lbs.** | | | | | | | | |
| 4-Ration | 1.53 | 5.14 | 10.06 | 15.42 | 20.68 | 27.20 | 28.35 | 29.41 |
| 5-Ration | 1.62 | 5.15 | 10.40 | 15.78 | 21.25 | 27.35 | 28.49 | 29.53 |
| 6-Ration | 1.61 | 5.12 | 10.27 | 15.39 | 20.95 | 27.24 | 28.28 | 29.22 |
| Ave. | 1.59 | 5.14 | 10.25 | 15.53 | 20.96 | 27.33 | 28.38 | 29.39 |
| | Age Interval, Wks. | | | | | | | |
| | 0-4 | 4-8 | 8-12 | 12-16 | 16-20 | 20-24 | 24-25 | 25-26 |
| **Average Wt. Gain, lbs.** | | | | | | | | |
| 4-Ration | 1.39 | 3.62 | 4.92 | 5.36 | 5.26 | 6.63 | 1.04 | 1.06 |
| 5-Ration | 1.49 | 3.53 | 5.25 | 5.37 | 5.47 | 6.11 | 1.14 | 1.04 |
| 6-Ration | 1.47 | 3.52 | 5.15 | 5.12 | 5.56 | 6.36 | 0.97 | 0.93 |
| Ave. | 1.45 | 3.55 | 5.11 | 5.28 | 5.43 | 6.37 | 1.05 | 1.01 |
| **Interval Feed/Gain** | | | | | | | | |
| 4-Ration | 1.665 | 2.168 | 2.804 | 3.562 | 4.674 | 4.672 | 8.048 | 7.724 |
| 5-Ration | 1.611 | 2.090 | 2.715 | 3.544 | 4.536 | 5.122 | 7.530 | 8.675 |
| 6-Ration | 1.531 | 2.133 | 2.662 | 3.532 | 4.628 | 5.416 | 8.961 | 9.677 |
| Ave. | 1.602 | 2.130 | 2.72[illegible] | 3.546 | 4.613 | 5.070 | 8.180 | 8.692 |
| **Interval Feed Cost (Cents)/lb. Gain** | | | | | | | | |
| 4-Ration | 9.91 | 10.32 | 10.36 | 13.80 | 16.3[illegible] | 16.38 | 26.72 | 25.62 |
| 5-Ration | 9.45 | 9.41 | 10.94 | 13.61 | 16.74 | 16.34 | 24.99 | 28.73 |
| 6-Ration | 9.17 | 9.74 | 10.87 | 13.69 | 16.86 | 18.93 | 29.80 | 32.08 |
| Ave. | 9.51 | 9.82 | 10.8[illegible] | 13.70 | 16.66 | 17.23 | 27.17 | 28.81 |

system produced growth and feed conversion which was fairly close to this performance. However, it involved the use of some more expensive 18% protein feed, thus yielding a higher feed cost per pound of gain.

Obviously, 16 weeks of age was too early to reduce the protein level of the ration for growing Large Type hens to 14%, as on the 5-ration system. Of the levels tested, the 16% protein level of the 4-ration system appeared best for the age interval of 16 to 20 weeks. In contrast, the 14% protein ration of the 5-ration system resulted in the best performance and also was the most economical from 20 to 21

TABLE 3.--Effect of Feeding Systems on Average Body Weight, Average Weight Gain and Feed Conversion of Large White Turkeys.

| | Hens | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Age in Weeks | | | | | | | | |
| | 4 | 8 | 12 | 16 | 20 | 21 | 22 | 23 | 24 |
| **Average Body Wt., lbs.** | | | | | | | | | |
| 4-Ration | 1.48 | 4.04 | 7.[illegible]3 | 11.15 | 14.17 | 14.80 | 15.36 | 15.70 | 16.16 |
| 5-Ration | 1.21 | 3.89 | 7.66 | 11.13 | 13.83 | 14.46 | 15.11 | 15.46 | 15.95 |
| 6-Ration | 1.47 | 4.15 | 7.87 | 11.26 | 14.16 | 14.66 | 15.20 | 15.64 | 16.08 |
| Ave. | 1.39 | 4.03 | [illegible].75 | 11.18 | 14.05 | 14.64 | 15.22 | 15.60 | 16.06 |
| | Age I.terval, Wks. | | | | | | | | |
| | 0-4 | 4-8 | 8-12 | 12-16 | 16-20 | 20-21 | 21-22 | 22-23 | 23-24 |
| **Average Wt. Gain, lbs.** | | | | | | | | | |
| 4-Ration | 1.35 | 2.56 | 3.69 | 3.42 | 3.02 | 0.64 | 0.55 | 0.34 | 0.46 |
| 5-Ration | 1.08 | 2.67 | 3.78 | 3.4[illegible] | 2.70 | 0.64 | 0.65 | 0.35 | 0.49 |
| 6-Ration | 1.33 | 2.68 | 3.73 | 3.39 | 2.91 | 0.50 | 0.54 | 0.44 | 0.44 |
| Ave. | 1.25 | 2.64 | 3.73 | 3.43 | 2.88 | 0.59 | 0.58 | 0.38 | 0.46 |
| **Interval Feed/Gain** | | | | | | | | | |
| 4-Ration | 1.682 | 2.912 | 2.803 | 3.896 | 5.106 | 6.527 | 8.310 | 11.167 | 8.566 |
| 5-Ration | 1.795 | 2.184 | 3.064 | 3.832 | 5.584 | 6.556 | 7.076 | 12.352 | 9.046 |
| 6-Ration | 1.668 | 2.311 | 2.828 | 3.926 | 5.350 | 8.296 | 8.292 | 8.776 | 9.014 |
| Ave. | 1.715 | 2.469 | 2.890 | 3.835 | 5.347 | 7.126 | 7.893 | 10.765 | 8.875 |
| **Interval Feed Cost (Cents)/lb. G·in** | | | | | | | | | |
| 4-Ration | 9.99 | 12.82 | 10.86 | 14.36 | 1[illegible].90 | 22.91 | 29.12 | 37.10 | 28.43 |
| 5-Ration | 10.59 | 9.83 | 12.35 | 14.14 | 18.48 | 21.77 | 23.48 | 40.92 | 29.96 |
| 6-Ration | 9.99 | 10.57 | 11.60 | 14.84 | 19.01 | 29.06 | 29.06 | 29.10 | 29.91 |
| Ave. | 10.19 | 11.07 | 11.60 | 14.45 | 18.46 | 24.53 | 27.22 | 35.71 | 29.43 |

and 22 weeks of age. Beyond this age, the low weight gains and high feed conversions demonstrated the high cost of producing gains at this plateau stage of the growth curve. The greater variability in feed conversion and cost per pound of gain in the later stages is because most of the feed is being used for body maintenance. Another factor is the variable amount of body fat being deposited, which requires considerable energy but contributes only slightly to gross weight.

From examination of the results in Tables 2 and 3, a new feeding schedule was developed which should more closely meet the nutrient requirements of growing turkeys as they change with increasing age. Following is the recommended schedule:

| Ration Protein | Age in Weeks | |
|---|---|---|
| % | Toms | Hens |
| 28-29 | 0-3 | 0-3 |
| 26 | 3-8 | 3-8 |
| 22 | 8-13 | 8-11 |
| 18 | 13-18 | 11-15 |
| 16 | 18-24 | 15-18 |
| 14 | 24- | 18- |

When the data of the three feeding programs are grouped together, they provide the average values for body weights, weight gains, and feed conversion for the flock as a whole. Since none of the treatments tested was beyond that which might be encountered in the field from flock to flock, these overall averages provide a good set of practical information. The feed costs per pound of gain in Tables 2 and 3 must be considered as relating only to the particular set of conditions of this test.

Although the growth of this flock of turkeys was quite comparable to that attained with this strain in industry, it was considered likely that several factors which would not be encountered under commercial conditions might have hindered performance. First of these was the handling of the birds every 4 weeks and even weekly in the last part of the test. Another was that the feed was all fed in mash form, while in industry it is practically all fed as pellets or crumbles which are generally believed to increase the nutrient availability. Finally, most commercial feeds contain at least small amounts of added fats which would be expected to improve the performance. With present facilities at the Research Center, fats cannot be conveniently added to feeds.

In Table 4, the growth rates and feed conversions are compared for the effects of the blackhead preventive drugs Carbosep and Emtrymix. The results were very good with both drugs and the differences between them were small. Carbosep yielded a heavier body weight and Emtrymix resulted in better feed conversion. While there was no unmedicated control with which to compare the performance, it appears that neither compound had any serious undesirable effects on performance.

The effects of type of house on grower performance are shown in Table 5. The average weights were much greater in house 9, the pole barn, than in house 8, the brooder house. The birds in house 9 generally ate much more feed per unit of gain. Both responses can be attributed to the cooler conditions prevailing in house 9, which led to greater feed intake.

The differences in feed conversion became much more pronounced toward the end of the experiment as a result of two factors. First, as shown by the average weights, the growth rate in house 9 had slowed more than that in house 8. Second, the open construction of house 9 afforded much less protection against the cold temperature which prevailed in October and early November.

TABLE 4.--Effect of Blackhead Preventive Drug on Body Weights and Feed Conversions of Large White Turkeys.

| | Age in Weeks | | | |
|---|---|---|---|---|
| Toms | 20 | 24 | 25 | 26 |
| Ave. Wt., lbs. | | | | |
| Carbosep | 20.96 | 27.64 | 28.74 | 29.65 |
| Emtrymix | 20.96 | 27.00 | 28.00 | 29.12 |
| Ave. Feed Conversion | | | | |
| Carbosep | 3.288 | 3.708 | 3.862 | 4.009 |
| Emtrymix | 3.202 | 3.627 | 3.782 | 3.898 |
| | Age in Weeks | | | |
| Hens | 12 | 16 | 20 | 22 |
| Ave. Wt., lbs. | | | | |
| Carbosep | 7.76 | 11.23 | 14.16 | 15.35 |
| Emtrymix | 7.74 | 11.13 | 13.96 | 15.10 |
| Ave. Feed Conversion | | | | |
| Carbosep | 2.893 | 3.886 | 5.473 | 8.245 |
| Emtrymix | 2.904 | 3.882 | 5.220 | 7.542 |

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TABLE 5.--Effect of Housing on Body Weights and Feed Conversions of Large White Turkeys.

| | Age in Weeks | | | |
|---|---|---|---|---|
| Toms | 20 | 24 | 25 | 26 |
| Ave. Wt., lb. | | | | |
| House 8* | 20.63 | 26.65 | 27.72 | 29.00 |
| House 9* | 21.28 | 28.00 | 29.02 | 29.77 |
| Ave. Feed Conversion | | | | |
| House 8 | 4.582 | 5.270 | 7.268 | 6.096 |
| House 9 | 4.643 | 4.870 | 9.092 | 11.288 |
| | Age in Weeks | | | |
| Hens | 12 | 16 | 20 | 22 |
| Ave. Wt., lb. | | | | |
| House 8 | 7.59 | 10.65 | 13.71 | 14.93 |
| House 9 | 7.91 | 11.71 | 14.40 | 15.52 |
| Ave. Feed Conversion | | | | |
| House 8 | 2.796 | 3.994 | 5.000 | 7.152 |
| House 9 | 3.001 | 3.776 | 5.744 | 8.634 |

*House 8 is a brooder house, House 9 is a pole barn.

# DETERMINING SELLING AGE OF TURKEYS BY RETURNS OVER FEED COSTS

Ralph L. Baker

Turkeys, because of their biological requirements, provide one of the best examples among all livestock of the application of marginal analysis. By selling at the point where marginal costs and marginal returns are equal, net returns may be maximized for any brood of turkeys.

Feed is an important part of the total additional cost of keeping turkeys when they approach market age. So expected selling prices and feed costs can be used to obtain returns above feed costs, giving an accurate indicator of the best age at which to sell turkeys.

In deciding whether to keep turkeys 1 week longer, or in making a contract to sell hens at 19, 20, or 21 weeks or toms at 22, 23, 24 weeks or some other age, the following formula can be used:

(Difference in market value per bird in periods 1 and 2)-(Expected number of pounds of feed used per bird during the period under consideration) (Cost per pound of feed).

This gives the expected added value per bird and the major variable cost for the time period concerned.

Dr. Touchburn indicated that the hens in the OARDC 1965 feeding experiment were weighed at the end of the 20th week and each successive week through the 24th and that the toms were weighed at the 24th, 25th and 26th weeks, in addition to earlier weights for each sex. These data provide the necessary physical information to which price and cost data can be applied to determine the best age to sell turkeys under given conditions.

The marginal principle says in effect that if more is added to the value of the bird than is added to the cost of the bird during any time period, net income will increase for that time period. Previous costs make no difference. The cost during the period in which a decision can be made is the only important cost in determining the best time at which to sell the birds. This means that all costs such as poults, building depreciation, and feed used before the time under consideration must be considered as fixed costs and do not have a bearing upon the best age at which to sell the birds. The reason for this is simple. As long as more is added to the value of the bird than is added to the cost of the bird, the net income position of the operator will be improved regardless of previous cost levels. By the same token, if more is added to the cost of the bird than is added to the value of the bird, net income will decrease regardless of costs during previous time periods.

The data gathered by Dr. Touchburn, which are fairly typical of feed consumption and growth rates obtained under usual field conditions, will be used to demonstrate three things:

1. The change in return over feed cost is a relatively accurate indicator of the change in net income which results from keeping the birds during any particular time period in which the birds are marketable.

2. If turkey prices are expected to remain the same from one time period to another, relatively high prices must be received to cover feed costs if hens are kept beyond 20 weeks and toms beyond 24 weeks.

3. A relatively small increase from one time period to another in the price received per pound of turkey will make it desirable to hold the birds to an older age.

In the 1965 test, the toms were weighed at 20 weeks and then not again until the 24th week. It is highly probable that under many conditions the best selling age would be before 24 weeks of age. So the 1966 toms are being weighed at weekly intervals beginning with the 22nd week.

Table 1 shows the feed cost in cents per pound gained for selected time intervals with given costs per ton of feed. From these data it is obvious that if feed costs were $55 a ton and a producer received less than 22.49 cents per pound for tom turkeys, he would have had a higher income by selling them at 24 weeks of age than at 25 weeks. The other figures can be used in the same manner. The data in this table assume that the price received per pound for the turkeys did not change from the 24th to the 25th week.

Tables 2 and 3 are work tables. In Table 2, the weight of the birds at each age was multiplied by the price in the left hand column to obtain the sales value of the birds at that age.

In Table 3, feed costs per bird to date are shown for selected feed prices. The number of pounds of feed consumed per bird to the particular age was multiplied by the cost per pound. For example, the toms at 24 weeks had eaten 99.93 pounds of feed each. With feed costs at $55 per ton, the cost per bird was $2.75.

The returns above feed cost per tom turkey at the selected feed prices and turkey prices shown in Tables 2 and 3 are given in Table 4. The figures in Table 4 were obtained by subtracting the comparable data in Table 3 from those in Table 2. For example, at 24 weeks of age and 18 cents a pound, the birds would sell for $4.92. At 24 weeks of age with $55 feed costs per ton, feed cost per bird was $2.75. Subtraction of $2.75 from $4.92 gives the $2.17 shown as the first figure in the left hand column of Table 4. The other figures in Table 4 were computed in the same manner to obtain return above feed cost.

The point concerning age is well emphasized in Table 4. The data around which the boxes are drawn indicate the highest net return per bird among the three age groups. Other marginal costs of 2 1/2 cents a bird per week have been added to the feed costs. These are the added costs of keeping the birds during the added time period.

TABLE 1.--Feed Cost in Cents per Pound Gained for Selected Time Intervals, Tom Turkeys, OARDC Test, 1965, at Given Ration Costs.

| Ration Cost per Ton | 20th to 24th Week | 24th to 25th Week | 25th to 26th Week |
|---|---|---|---|
| $55 | 13.94 | 22.49 | 23.90 |
| $60 | 15.21 | 24.54 | 26.07 |
| $65 | 16.48 | 26.58 | 28.24 |
| $70 | 17.74 | 28.63 | 30.41 |
| $75 | 19.01 | 30.67 | 32.59 |
| $80 | 20.28 | 32.72 | 34.76 |

TABLE 2.--Sales Value of Toms per Head at Selected Ages and Prices.

| Price per Pound, Live (cents) | Age of birds, weeks | | |
|---|---|---|---|
| | 24 | 25 | 26 |
| 18 | $4.92 | $5.11 | $5.29 |
| 19 | 5.19 | 5.39 | 5.58 |
| 20 | 5.47 | 5.68 | 5.88 |
| 21 | 5.74 | 5.96 | 6.17 |
| 22 | 6.01 | 6.24 | 6.47 |
| 23 | 6.29 | 6.53 | 6.76 |
| 24 | 6.56 | 6.81 | 7.05 |

TABLE 3.--Feed Cost per Bird to Date at Selected Feed Prices, Toms.

| Cost per Ton of Feed | Age of birds, weeks | | |
|---|---|---|---|
| | 24 | 25 | 26 |
| $55 | $2.75 | $2.98 | $3.23 |
| $60 | 3.00 | 3.26 | 3.52 |
| $65 | 3.25 | 3.53 | 3.81 |
| $70 | 3.50 | 3.80 | 4.11 |
| $75 | 3.75 | 4.07 | 4.40 |
| $80 | 4.00 | 4.34 | 4.69 |

TABLE 4.--Return Above Feed Cost per <u>Tom</u> Turkey Sold at Selected Feed Costs and Turkey Prices.

| Price per Pound Live, (cents) | Feed Cost per Ton | | | | | |
|---|---|---|---|---|---|---|
| | $55 | $60 | $65 | $70 | $75 | $80 |
| | | | **24 Week Toms** | | | |
| 18 | $2.17 | $1.92 | $1.67 | $1.42 | $1.17 | $0.92 |
| 19 | 2.44 | 2.19 | 1.94 | 1.69 | 1.44 | 1.19 |
| 20 | 2.72 | 2.47 | 2.22 | 1.97 | 1.72 | 1.47 |
| 21 | 2.99 | 2.74 | 2.49 | 2.24 | 1.99 | 1.74 |
| 22 | 3.26 | 3.01 | 2.76 | 2.51 | 2.26 | 2.01 |
| 23 | 3.54 | 3.29 | 3.04 | 2.79 | 2.54 | 2.29 |
| 24 | 3.81 | 3.56 | 3.31 | 3.06 | 2.81 | 2.56 |
| | | | 25 Week Toms | | | |
| 18 | $2.13 | $1.85 | $1.58 | $1.31 | $1.04 | $0.77 |
| 19 | 2.41 | 2.13 | 1.86 | 1.59 | 1.37 | 1.05 |
| 20 | 2.70 | 2.42 | 2.15 | 1.88 | 1.61 | 1.34 |
| 21 | 2.98 | 2.70 | 2.43 | 2.16 | 1.89 | 1.62 |
| 22 | 3.26 | 2.98 | 2.71 | 2.44 | 2.17 | 1.90 |
| 23 | 3.55 | 3.27 | 3.00 | 2.73 | 2.46 | 2.19 |
| 24 | 3.83 | 3.55 | 3.28 | 3.01 | 2.74 | 2.47 |
| | | | 26 Week Toms | | | |
| 18 | $2.06 | $1.77 | $1.48 | $1.18 | $0.89 | $0.60 |
| 19 | 2.35 | 2.06 | 1.77 | 1.47 | 1.18 | 0.89 |
| 20 | 2.65 | 2.36 | 2.07 | 1.77 | 1.48 | 1.19 |
| 21 | 2.94 | 2.65 | 2.36 | 2.06 | 1.77 | 1.48 |
| 22 | 3.24 | 2.95 | 2.66 | 2.36 | 2.07 | 1.78 |
| 23 | 3.53 | 3.24 | 2.95 | 2.65 | 2.36 | 2.07 |
| 24 | 3.82 | 3.53 | 3.24 | 2.94 | 2.65 | 2.36 |

☐ Assuming other marginal costs are 2 1/2¢ per bird per week this is best time to sell. Other costs are mortality, interest, tractor fuel, electricity, hired labor and any other cost that will be discontinued when the birds are sold.

With this in mind, it then becomes obvious that the best time to sell these toms with $55 a ton feed was at 24 weeks if the price to be received for the toms was 24 cents or less per pound and was not expected to increase.

With the hen turkeys in the test, it is highly probable that the best time to sell the birds was before 20 weeks. However, the turkey weights and feed data do not give the necessary information to determine this. So weekly weights are being obtained at earlier ages in the 1966 test.

In Table 5, it should be noted that the feed cost per pound gained from the time the birds were 20 weeks old until they were 21 weeks old was 21.39 cents with feed at $60 a ton. If hens were expected to sell below 21.39 cents a pound, obviously it would have been better to sell them before the 21st week if the price was not expected to increase. The other data in Table 5 point up that the cost of keeping hens goes up rapidly. There was a quirk in the data, with the highest cost week from 22 to 23 weeks of age.

If prices are expected to remain the same from one week to the next, the data in Tables 6 and 7 can be used in the same way as the data for toms were used in Tables 2 and 3 to prepare Table 4. However, a table like Table 4 was not prepared for hens. Computing the figures would be relatively easy. With hens selling at 20 cents a pound, the birds in this test would have brought $2.81 at 20 weeks. The feed cost at $60 a ton was $1.45, which means that the return over feed cost was $1.36.

At 21 weeks with a 20 cent price, $2.93 would be received per turkey. The amount of feed consumed per bird times its price at $60 a ton gives $1.57 as the average cost of feeding the birds to 21 weeks. Subtraction of $1.57 from $2.93 gives $1.36--the same figure obtained at the 20-week period. This indicates that since there are marginal costs other than feed, with no expected change in price the best time to have sold these birds was 20 weeks or before.

Instead of using a table like the one used on the toms, a table on the hens was prepared in a little different manner. This is Table 8. All the previous time was ignored.

To obtain at least one column of figures in which all the data were positive, a $55 per ton feed cost was added during this finishing period. Again, the price of the turkeys was not expected to change in the example. The data in Table 8 indicate that it would not pay to carry the birds beyond 20 weeks unless feed costs were $55 a ton and hen prices were 26 cents a pound or more, feed costs $60 a ton and hen prices 28 cents a pound or more, or feed costs $65 a ton and hen prices 30 cents a pound or more.

The data in Table 8 were computed in a simple manner. The gain in pounds per bird during each week was multiplied by the price figure in the left hand column, feed consumed per bird during each week was multiplied by feed cost per ton in the upper line. This latter figure was subtracted from the gain in value per bird. In other words, this

TABLE 5.--Feed Cost in Cents per Pound Gained for Selected Time Intervals, Hen Turkeys, OARDC Test, 1965, if Ration Costs Given Amount.

| Ration Cost per Ton | 16th to 20th Week | 20th to 21st Week | 21st to 22nd Week | 22nd to 23rd Week | 23rd to 24th Week |
|---|---|---|---|---|---|
| $60 | 16.05 | 21.39 | 23.67 | 32.28 | 26.64 |
| $65 | 17.39 | 23.17 | 25.64 | 34.97 | 28.86 |
| $70 | 18.72 | 24.95 | 27.61 | 37.66 | 31.08 |
| $75 | 20.06 | 26.74 | 29.59 | 40.35 | 33.30 |
| $80 | 21.40 | 28.52 | 31.56 | 43.04 | 35.52 |

TABLE 6.--Sales Value of Hens per Head at Selected Ages and Prices.

| Price per Pound, Live (cents) | Age of birds, weeks | | | | |
|---|---|---|---|---|---|
| | 20 | 21 | 22 | 23 | 24 |
| 20 | $2.81 | $2.93 | $3.05 | $3.12 | $3.21 |
| 21 | 2.95 | 3.07 | 3.20 | 3.28 | 3.37 |
| 22 | 3.09 | 3.22 | 3.35 | 3.43 | 3.53 |
| 23 | 3.23 | 3.37 | 3.50 | 3.59 | 3.69 |
| 24 | 3.37 | 3.51 | 3.66 | 3.74 | 3.85 |
| 25 | 3.51 | 3.66 | 3.81 | 3.90 | 4.01 |
| 26 | 3.66 | 3.81 | 3.96 | 4.06 | 4.18 |

TABLE 7.--Feed Cost per Bird to Date at Selected Feed Prices, Hens.

| Cost per Ton of Feed | Age of birds, weeks | | | | |
|---|---|---|---|---|---|
| | 20 | 21 | 22 | 23 | 24 |
| $60 | $1.45 | $1.57 | $1.71 | $1.83 | $1.95 |
| $65 | 1.57 | 1.70 | 1.85 | 1.98 | 2.11 |
| $70 | 1.69 | 1.83 | 2.00 | 2.13 | 2.28 |
| $75 | 1.81 | 1.96 | 2.14 | 2.29 | 2.44 |
| $80 | 1.93 | 2.09 | 2.28 | 2.44 | 2.60 |

TABLE 8.--Return Over Feed Cost for Week if Price of Turkeys Is Not Expected to Change from Previous Week for Selected Turkey Prices per Pound and Feed Costs per ton, Hens, Cents per Turkey.

| Sales Price of Turkeys, Cents per Lb. | Cost per Ton of Feed Fed During Week $55 | $60 | $65 | $70 | $75 | $80 |
|---|---|---|---|---|---|---|
| | | | 21st Week | | | |
| 20 | 0.2 | -0.8 | -1.9 | -2.9 | -3.9 | -5.0 |
| 21 | 0.8 | -0.2 | -1.3 | -2.3 | -3.3 | -4.4 |
| 22 | 1.4 | 0.4 | -0.7 | -1.7 | -2.7 | -3.8 |
| 23 | 1.9 | 0.9 | -0.2 | -1.2 | -2.2 | -3.3 |
| 24 | 2.5 | 1.5 | 0.4 | -0.6 | -1.6 | -2.7 |
| 25 | 3.1 | 2.1 | 1.0 | 0 | -1.0 | -2.1 |
| 26 | 3.7 | 2.7 | 1.6 | 0.6 | -0.4 | -1.5 |
| 28 | 4.8 | 3.8 | 2.7 | 1.7 | 0.7 | -0.4 |
| 30 | 6.0 | 5.0 | 3.9 | 2.9 | 1.9 | 0.6 |
| | | | 22nd Week | | | |
| 20 | -1.0 | -2.2 | -3.3 | -4.5 | -5.7 | -6.8 |
| 21 | -0.4 | -1.6 | -2.7 | -3.9 | -5.1 | -6.2 |
| 22 | 0.2 | -1.0 | -2.1 | -3.3 | -4.5 | -5.6 |
| 23 | 0.8 | -0.4 | -1.5 | -2.7 | -3.9 | -5.0 |
| 24 | 1.4 | 0.2 | -0.9 | -2.1 | -3.3 | -4.4 |
| 25 | 2.0 | 0.8 | -0.3 | -1.5 | -2.7 | -3.8 |
| 26 | 2.5 | 1.3 | 0.2 | -1.0 | -2.2 | -3.3 |
| 28 | 3.7 | 2.5 | 1.4 | 0.2 | -1.0 | -2.1 |
| 30 | 4.9 | 3.7 | 2.6 | 1.4 | 0.2 | -0.9 |
| | | | 23rd Week | | | |
| 20 | -3.5 | -4.5 | -5.5 | -6.5 | -7.5 | -8.5 |
| 21 | -3.1 | -4.1 | -5.1 | -6.1 | -7.1 | -8.1 |
| 22 | -2.8 | -3.8 | -4.8 | -5.8 | -6.8 | -7.8 |
| 23 | -2.4 | -3.4 | -4.4 | -5.4 | -6.4 | -7.4 |
| 24 | -2.0 | -3.0 | -4.0 | -5.0 | -6.0 | -7.0 |
| 25 | -1.6 | -2.6 | -3.6 | -4.6 | -5.6 | -6.6 |
| 26 | -1.3 | -2.3 | -3.3 | -4.3 | -5.3 | -6.3 |
| 28 | -0.5 | -1.5 | -2.5 | -3.5 | -4.5 | -5.5 |
| 30 | 0.2 | -0.8 | -1.8 | -2.8 | -3.8 | -4.8 |
| | | | 24th Week | | | |
| 20 | -2.0 | -3.0 | -4.1 | -5.1 | -6.1 | -7.1 |
| 21 | -1.5 | -2.5 | -3.6 | -4.6 | -5.6 | -6.6 |
| 22 | -1.1 | -2.1 | -3.2 | -4.2 | -5.2 | -6.2 |
| 23 | -0.6 | -1.6 | -2.7 | -3.7 | -4.7 | -5.7 |
| 24 | -0.2 | -1.2 | -2.3 | -3.3 | -4.3 | -5.3 |
| 25 | 0.3 | -0.7 | -1.8 | -2.8 | -3.8 | -4.8 |
| 26 | 0.8 | -0.2 | -1.3 | -2.3 | -3.3 | -4.3 |
| 28 | 1.7 | 0.7 | -0.4 | -1.4 | -2.4 | -3.4 |
| 30 | 2.6 | 1.6 | 0.5 | -0.5 | -1.5 | -2.5 |

☐ Maximize net income by selling at this age if added costs other than feed equal 2 1/2 cents a week.

is a gain in value minus the gain in cost and equals the return over feed cost for the week. The basic data for this table are shown in Table 9.

## Effects of a Price Change

A relatively small price change will have considerable bearing on a decision of when to sell the birds. This paper deals only with expected price increases. However, the same principle applies to expected price decreases. Any price change applies not only to the added pounds but to all pounds.

Table 10 shows the returns above feed costs to date as shown in the upper portion of Table 4 for 24-week-old toms. One more set of data were added for 25-week toms but the assumptions now have changed.

Instead of selling these birds at the same price for both 24- and 25-week-old toms, it is assumed that 1 cent more per pound could be received at 25 weeks than at 24 weeks. This completely changes the situation. Now it is better to sell at 25 weeks than at 24 weeks. For instance, 25-week-old toms yielded only $2.13 over feed cost at 18 cents a pound and $55 a ton feed in Table 4. Now they yield $2.41 a bird over feed costs by moving up to 19 cents a pound. This is an improvement of 28.38 cents per bird or 1 cent times the average weight of the birds at 25 weeks. Instead of subtracting $2.98 from $5.11 as for Table 4, the $2.98 was subtracted from $5.39. The amount subtracted remained the same but the value of the birds increased 28 cents.

The expected weight of the bird at 25 weeks was multiplied by the selling price per pound. Then the feed cost to date was subtracted. If this difference is positive and higher than the difference between sales value and feed costs at 24 weeks by more than the amount of the other marginal costs, it will pay to carry the birds to 25 weeks.

The data on added value can be computed in the same manner used on the hen data in Table 8. For example, Table 11 shows the approximate return over feed cost for the 20- to 24-week period at the indicated feed costs and turkey prices. For the 4-week period with the other marginal costs estimated at 2 1/2 cents a bird per week, the other added costs were 10 cents a bird. These added costs will vary among individual operations. However, if the price per pound of turkey was expected to be the same at each age, returns over feed costs in Table 11 indicate, under the assumptions of other marginal costs, that it would not pay to carry the birds from 20 to 24 weeks under any of the turkey price or feed cost assumptions at the rates of gain and feed consumption in the OARDC test. In fact, returns over feed costs would be lowered in all but six of the situations shown in Table 11.

This contrasts with the situation in which the turkey price per pound increases by 1 cent from 20 to 24 weeks for the hens. All data used are the same as those in Table 11 except the weight of the bird times 1 cent a pound (16.1 cents) was added to the sales value of each

TABLE 9.--Work Table for Data in Table 8.

| | 21st Week | 22nd Week | 23rd Week | 24th Week |
|---|---|---|---|---|
| Pounds of Gain per Turkey | 0.58 | 0.59 | 0.37 | 0.46 |
| Value of Gain per Turkey (cents) | | | | |
| @ 20 cents/lb | 11.6 | 11.8 | 7.4 | 9.2 |
| 21 cents/lb | 12.2 | 12.4 | 7.8 | 9.7 |
| 22 cents/lb | 12.8 | 13.0 | 8.1 | 10.1 |
| 23 cents/lb | 13.3 | 13.6 | 8.5 | 10.6 |
| 24 cents/lb | 13.9 | 14.2 | 8.9 | 11.0 |
| 25 cents/lb | 14.5 | 14.8 | 9.3 | 11.5 |
| 26 cents/lb | 15.1 | 15.3 | 9.6 | 12.0 |
| 28 cents/lb | 16.2 | 16.5 | 10.4 | 12.9 |
| 30 cents/lb | 17.4 | 17.7 | 11.1 | 13.8 |
| Pounds of Feed Used Per Turkey | 4.14 | 4.66 | 3.98 | 4.08 |
| Cost of Feed Per Turkey (Cents) | | | | |
| @ $55/ton | 11.4 | 12.8 | 10.9 | 11.2 |
| $60/ton | 12.4 | 14.0 | 11.9 | 12.2 |
| $65/ton | 13.5 | 15.1 | 12.9 | 13.3 |
| $70/ton | 14.5 | 16.3 | 13.9 | 14.3 |
| $75/ton | 15.5 | 17.5 | 14.9 | 15.3 |
| $80/ton | 16.6 | 18.6 | 15.9 | 16.3 |

TABLE 10.--Return Above Feed Cost per Tom Turkey Sold at Selected Feed Costs and Turkey Prices at 24 and 25 Weeks if Can Get 1 Cent More per Pound of Live Turkey at 25 Weeks than at 24 Weeks.

| Price per Pound, Live at 24 Weeks, (Cents) | Feed Cost per Ton | | | | | |
|---|---|---|---|---|---|---|
| | $55 | $60 | $65 | $70 | $75 | $80 |
| | | | 24 Week Toms | | | |
| 18 | $2.17 | $1.92 | $1.67 | $1.42 | $1.17 | $0.92 |
| 19 | 2.44 | 2.19 | 1.94 | 1.69 | 1.44 | 1.19 |
| 20 | 2.72 | 2.47 | 2.22 | 1.97 | 1.72 | 1.47 |
| 21 | 2.99 | 2.74 | 2.49 | 2.24 | 1.99 | 1.74 |
| 22 | 3.26 | 3.01 | 2.76 | 2.51 | 2.26 | 2.01 |
| 23 | 3.54 | 3.29 | 3.04 | 2.79 | 2.54 | 2.29 |
| 24 | 3.81 | 3.56 | 3.31 | 3.06 | 2.81 | 2.56 |
| | | | 25 Week Toms | | | |
| 18 | $2.41 | $2.13 | $1.86 | $1.59 | $1.32 | $1.05 |
| 19 | 2.70 | 2.42 | 2.15 | 1.88 | 1.61 | 1.34 |
| 20 | 2.98 | 2.70 | 2.43 | 2.16 | 1.89 | 1.62 |
| 21 | 3.26 | 2.99 | 2.72 | 2.45 | 2.18 | 1.91 |
| 22 | 3 55 | 3.27 | 3.00 | 2.73 | 2.46 | 2.19 |
| 23 | 3.83 | 3.55 | 3.28 | 3.01 | 2.74 | 2.47 |
| 24 | 4.11 | 3.84 | 3.57 | 3.30 | 3.03 | 2.76 |

[Boxed values] Assuming other marginal costs are 2 1/2¢ per bird per week, this is best time to sell. Other costs are mortality, interest, tractor fuel, electricity, hired labor, and any other cost which will be discontinued when the birds are sold.

TABLE 11.--Approximate Return Over Feed Cost for Period if Price of Turkeys Is Not Expected to Change from 20 to 24 Weeks for Selected Turkey Prices per Pound and Feed Costs per Ton, Hens, Cents per Turkey.

| Sales Price of Turkeys, Cents per Lb. | Cost per Ton of Feed Fed During Period | | | | |
|---|---|---|---|---|---|
| | $60 | $65 | $70 | $75 | $80 |
| | 20 to 24 Weeks | | | | |
| 20 | -10.5 | -14.8 | -19.0 | -23.2 | -27.4 |
| 21 | - 8.4 | -12.7 | -16.8 | -21.0 | -25.2 |
| 22 | - 6.5 | -10.7 | -15.1 | -19.3 | -23.5 |
| 23 | - 4.5 | - 8.7 | -12.9 | -17.3 | -21.5 |
| 24 | - 2.5 | - 6.7 | -10.9 | -15.1 | -19.3 |
| 25 | - 0.4 | - 4.6 | - 8.8 | -13.0 | -17.2 |
| 26 | 1.5 | - 2.7 | - 6.9 | -11.1 | -15.3 |
| 28 | 5.5 | 1.3 | - 2.9 | - 7.1 | -11.3 |
| 30 | 9.5 | 5.3 | 1.1 | - 3.1 | - 7.3 |

Producer probably could not gain in net income by carrying turkeys to 24 weeks under any of these conditions.

TABLE 12.--Approximate Return Over Feed Cost for Period if Price of Turkeys is Expected to Increase 1 Cent per Pound from 20 to 24 Weeks for Selected Turkey Prices per Pound and Feed Costs per Ton, Hens, Cents per Turkey.

| Sales Price of Turkeys at 20 Weeks, Cents per Lb. | Cost per Ton of Feed Fed During Period | | | | |
|---|---|---|---|---|---|
| | $60 | $65 | $70 | $75 | $80 |
| | 20 to 24 Weeks | | | | |
| 20 | 5.6 | 1.3 | - 2.9 | - 7.1 | -11.3 |
| 21 | 7.7 | 3.4 | - 0.7 | - 4.9 | - 9.1 |
| 22 | 9.6 | 5.4 | 1.0 | - 3.2 | - 7.4 |
| 23 | 11.6 | 7.4 | 3.2 | - 1.1 | - 5.4 |
| 24 | 13.6 | 9.4 | 5.2 | 1.0 | - 3.2 |
| 25 | 15.7 | 11.5 | 7.3 | 3.1 | - 1.1 |
| 26 | 17.6 | 13.4 | 9.2 | 5.0 | 0.8 |
| 28 | 21.6 | 17.4 | 13.2 | 9.0 | 4.8 |
| 30 | 25.6 | 21.4 | 17.2 | 13.0 | 8.8 |

[Boxed] Producer probably would gain in net income by carrying turkeys to 24 weeks under these conditions.

[Wavy outline] If price increased by 2 cents a pound these additional situations would likely yield gain in net income.

hen turkey. Under these conditions, it paid to carry the birds to 24 weeks of age in 13 of the feed cost-turkey price situations shown in Table 12. For instance, if turkey prices moved from 23 cents at 20 weeks to 24 cents at 24 weeks, with feed costs at $60 a ton, returns over feed cost would be approximately 11.6 cents per bird. This would pay for the other marginal costs and give an additional return of 1.6 cents a bird.

Addition of 2 cents a pound to the turkey price is not shown in the table but the figures would be obtained by adding another 16.1 cents to the value of the birds. In all but four of the feed and sales price situations, it would pay to keep the birds the additional 4 weeks.

How much must be received per pound to make it profitable to keep birds for a longer period, for example, toms from 24 to 26 weeks?

Example I

1. At 24 weeks, toms averaged 27.33 lb. each in OARDC test.

2. Assume can sell at 24 weeks for 23 cents a pound. 27.33 X $0.23 = $6.29 per bird.

3. Assume feed costs are $55 per ton and other added costs are 1 cent per bird per week.

4. From 24 to 26 weeks, feed consumption per bird was 17.37 lb.

5. $55 a ton is 2.75 cents a pound.

6. 17.37 X $0.0275 = $0.48 feed cost per bird for the 2 weeks.

7. $0.48 plus $0.01 per week of other added costs for 2 weeks equals $0.48 + $0.02 = $0.50 added cost per bird for the 2 weeks.

8. $6.29 + $0.50 = $6.79 must be received at 26 weeks to have equal net income at both periods.

9. $6.79 divided by 29.39 (the average weight at 26 weeks) = 23.10 cents per pound must have for equal net incomes. (If 2 1/2 cents per week were used as other added costs, $6.84 divided by 29.39 = 23.27 cents per pound needed for equal net incomes.)

Example II (Same as I except change in costs)

1-2. Same as above.

3. Assume feed costs are $65 per ton and other added costs are 3 cents per week per bird sold.

4. Same as above.

5. $65 a ton is 3.25 cents a pound.

6. 17.37 X $0.0325 = $0.56.

7. $0.56 plus $0.03 cents per week other added costs equals $0.56 + $0.06 = $0.62.

8. $6.29 + $0.62 = $6.91 (cost at 26 weeks).

9. $6.91 divided by 29.39 = 23.51 cents per pound must be received at 26 weeks to have equal income as selling for 23 cents a pound at 24 weeks.

<u>Example III</u> (Same as II except different price for 24-week-old toms)

1. Same as above.

2. Assume can sell at 24 weeks for 21 cents a pound. 27.33 X $0.21 = $5.74.

3-7. Same as above.

8. $5.74 + $0.62 = $6.36 must receive per bird at 26 weeks to have equal net incomes in both periods.

9. $6.36 divided by 29.39 = 21.64 cents per pound must be received at 26 weeks to have equal income as selling for 21 cents a pound at 24 weeks of age.

Obviously a price decline must be computed in the same way as a price increase. The decrease per pound must be multiplied by the total number of pounds produced to date. This will show that a small decrease in price per pound will result in a net loss compared to an earlier marketing time.

If possible, producers will want to use their own data in computing this kind of information. However, if none are available because of the problems in weighing birds and feed, the physical data presented by Dr. Touchburn can serve as relatively realistic guides. Actual feed prices and expected prices for the turkeys can be used at different ages in the same manner as the physical data are used here.

# EFFECTS OF AGE OF TURKEYS ON THE FLAVOR OF TURKEY MEAT

G. J. Mountney

New, rapid-growing strains of medium to large size turkeys have been developed so they can be marketed from 12 to 24 weeks of age and provide a range of different size turkeys for the consumer. Before such a system of rearing turkeys can be adopted by the industry, considerable information needs to be gathered to determine the costs, quality, and acceptance of turkeys produced in this age range. Flavor and consumer acceptance are probably the two most important characteristics, since the others become unimportant if consumers will not purchase the turkeys produced.

Considerable work has been done on the effects of rations and frozen storage on the flavor and acceptability of turkeys, Carlson et al (1957, 1962), Spencer et al (1956), Harkin et al (1958), Goertz et al (1955), and Swickard et al (1953). However, little information is available on preferences for turkeys from the same flock slaughtered at different ages.

Fry et al (1958), working with chicken broilers, reported that taste panels were unable to distinguish differences in chicken broth from 10- and 14-week-old birds but could distinguish differences between 6- and 10-week-old birds cooked by baking. Lineweaver (1961) reported that within the limits of experimental error, chicken flavor is essentially independent of age, sex, variety, and production conditions.

The object of the present experiment was to determine whether a taste panel could recognize differences in flavor of turkey hens of different ages from the same flock and whether they had a preference for birds of a particular age.

Turkey hens from the same flock reared at the Ohio Agricultural Research and Development Center were slaughtered at 12, 16, 20, and 24 weeks of age. They were scalded at 142° F., chilled in slush ice overnight, drained, packaged, frozen, and held at 0° F. until ready for cooking. At that time they were thawed for 18 hours at room temperature and then cooked in a rotating oven at 325° F. to an internal breast temperature of 90° C. Carcasses were wrapped in aluminum foil and held in the refrigerator for 1 - 2 days before slicing and serving.

Samples of white and dark meat at room temperature, consisting of two samples from the same bird and one from another, were presented to panel members in a manner so positional bias was eliminated. With this arrangement, each member tasted the same samples from the same carcass twice except that the order of presenting the samples in triangular form was reversed. The above procedure was repeated on 3 different days, using different turkeys each time for both white and dark meat from the several age groups. After members of the panel had made their decisions, they were asked to list their order of preference for the various samples.

The numbers of correct judgments for the various age groups among taste panel members are shown in Table 1. For white meat samples, significant differences were obtained between 16- and 24-week-old birds ($p < .05$) and 12- and 24-week-old birds ($p < .01$). No significant differences were obtained for dark meat, although the difference between 12- and 24-week-old birds approached significance ($p < .05$).

From these limited tests, it appears that panel members can discern a difference between 12- and 24-week-old turkeys and between 16- and 24-week-old turkeys.

TABLE 1.--Number of Correct Judgments among Taste Panel Members Testing Turkey Meat from Birds of Different Ages.

| Age of Birds | Correctly Identified | | Not Correctly Identified | | No Difference Observed | |
|---|---|---|---|---|---|---|
| Weeks | Number | Percent | Number | Percent | Number | Percent |
| | | | DARK MEAT | | | |
| 20 and 24 | 12 | 35 | 18 | 53 | 4 | 12 |
| 16 and 24 | 11 | 32 | 20 | 59 | 3 | 9 |
| 12 and 24 | 16 | 47 | 15 | 44 | 3 | 9 |
| | | | WHITE MEAT | | | |
| 20 and 24 | 12 | 36 | 18 | 55 | 3 | 9 |
| 16 and 24 | 17* | 52 | 12 | 36 | 4 | 12 |
| 12 and 24 | 22** | 67 | 7 | 21 | 4 | 12 |

*$p < .05$

**$p < .01$

## References

Carlson, C. W., W. Kohlmeyer, E. B. Alsup, L. M. Burrill, and O. E. Olson. 1957. Chemical composition of turkeys as it affects palatability and keeping quality. South Dakota State College, Agri. Exp. Sta. Bull. 463.

Carlson, C. W., A. W. Adams, R. A. Wilcox, G. F. Gastler, and Lida M. Burrill. 1962. Dietary energy, sex, strain and storage as influencing composition and/or palatability of broad breasted bronze turkeys. Poultry Sci. 41:150-160.

Fry, J. L., G. Bennett, and W. J. Stadelman. 1958. The effect of age, sex, and hormonization on the flavor of chicken meat. Poultry Sci. 37:331-335.

Goertz, G. E., G. E. Vail, D. L. Harrison, and P. E. Sanford. 1955. Organoleptic and histological characteristics of fresh and frozen stored turkey fed high-density and low-density rations. Poultry Sci. 34:640.

Harkin, A. M., C. Kitzmiller, G. L. Gilpin, and G. G. Marsden. 1958. Quality of the cooked meat of turkeys fed animal or vegetable protein diets with vitamin and fat supplements. Poultry Sci. 37:1328-1339.

Lineweaver, H. and E. L. Pippen. 1961. Chicken flavor. Proc., Flavor Chem. Symp. 21-36. Campbell Soup Co., Camden, N. J.

Spencer, J. V., W. E. Watson, W. J. Stadelman, and M. C. Ahrens. 1956. Effect of cooling and freezing procedures on consumer acceptability factors of turkey meat. Food Technol. 10:16-18.

Swickard, M. T., A. M. Harkin, and S. J. Marsden. 1954. Palatability of turkeys fed experimental diets containing aureomycin and fish products. Poultry Sci. 32:726-729.

EARLY POULT MORTALITY

Karl E. Nestor and Philip A. Renner

A relatively large proportion of the total mortality in turkey flocks occurs within 2 weeks after hatching. Management and disease are among several factors which may be responsible for this high early mortality.

A series of tests were conducted to determine the influence on early poult mortality of length of time poults are held after hatching before placing on feed and water. In these tests, a control group was placed on feed and water immediately after hatching. Two other groups were held for periods of 24 and 48 hours before placing on feed and water. Some tests were conducted in batteries and others were conducted in floor pens.

The effect of holding time on poult mortality during the first 2 weeks after hatching is given in Table 1. Mortality of birds grown in floor pens was higher than those reared in batteries. Holding poults for 1 day after hatching resulted in an increase in mortality. The increased mortality in floor pens (3.2%) was greater than that in batteries (0.8%). The mortality of birds held 2 days before placing on feed and water was much greater than those placed on feed immediately or those held for 1 day prior to placing on feed. When all birds were considered, an increase in mortality of 1.7% was observed in birds held 1 day. The mortality of birds held 2 days was about four times as great as that of the control (0 hours) group.

The mortality differences between holding times and type of rearing and the interaction between treatment and type of rearing were all highly significant ($P < .01$). This means that there was less than one chance in 100 that the differences were due to chance.

Holding poults also seriously affected the body weights of poults at 14 days of age. The average body weights of the groups held 0, 24,

TABLE 1.--Effect of Holding Time After Hatching on Early Poult Mortality (0-2 wks. of age).

| Type of Rearing | 0 Hours | | 24 Hours | | 48 Hours | |
|---|---|---|---|---|---|---|
| | No. Poults | % Mort. | No. Poults | % Mort. | No. Poults | % Mort. |
| Floor | 241 | 4.6 | 244 | 7.8 | 248 | 14.9 |
| Batteries | 398 | 2.5 | 390 | 3.3 | 395 | 10.9 |
| Total and Average | 639 | 3.3 | 634 | 5.0 | 643 | 12.4 |

TABLE 2.--Effect of Holding Poults after Hatching on Early Growth Rate.

| Hours Held after Hatching | Age (wks.) 4 | 6 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|
| | | | Males | | | | |
| 0 | 473 | 910 | 3.54 | 5.62 | 8.01 | 10.4 | 12.3 |
| 24 | 430 | 833 | 3.34 | 5.41 | 7.64 | 9.9 | 11.6 |
| 48 | 423 | 884 | 3.50 | 5.63 | 7.97 | 10.4 | 12.3 |
| | | | Females | | | | |
| 0 | 411 | 758 | 2.86 | 4.34 | 6.00 | 7.60 | 8.70 |
| 24 | 383 | 723 | 2.80 | 4.30 | 5.96 | 7.62 | 8.80 |
| 48 | 355 | 717 | 2.76 | 4.22 | 5.89 | 7.50 | 8.67 |

and 48 hours were 163, 150, and 134 grams, respectively. These differences were highly significant ($P < .01$). The birds in two tests were reared until 16 weeks of age to determine the influence of holding poults on body weights at older ages. These data are presented in Table 2. Each average value in this table was based on the weights of 55 to 85 birds.

Holding poults for 24 and 48 hours reduced body weights in males at 4 and 6 weeks of age in comparison with the control (0 hours) group. These differences were highly significant statistically ($P < .01$). Body weights of males were also reduced in the 24-hour group at all of the older ages. The differences were statistically significant ($P < .05$).

From the results obtained with the 24-hour group, the 48-hour group should also show reduced growth rate at the older ages. Mortality prior to 4 weeks of age was much greater in the 48-hour group than in the other two groups. It is possible that the weaker poults, which would have grown more slowly, died prior to 4 weeks of age and, as a result, the average body weights at the older ages were greater than expected.

The results obtained with females were slightly different (Table 2). Both treated groups had lower body weights than the controls at 4 and 6 weeks of age ($P < .01$). The treated groups also had lower body weights at 8, 10, and 12 weeks of age but the differences were small and not significant. All three groups had essentially the same body weights at 16 weeks of age.

Since the body weights were generally reduced in the treated groups prior to 8 weeks of age, these groups probably would have lowered

TABLE 3.--Effect of Holding Temperature on Early Mortality and Body Weight.

| | No. Poults Started | | Percent Mortality | | | Body Weight (gm.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2 wks. of age | | 4 wks. of age | |
| Temp. | Trial 1 | Trial 2 | Trial 1 | Trial 2 | Av. | Trial 1 | Trial 2 | Trial 1 | Trial 2 |
| Control | 67 | 60 | 29.8 | 11.7 | 20.8 | 173 | 153 | 530 | 283 |
| 85° F.* | 67 | 60 | 20.0 | 11.7 | 15.8 | 157 | 125 | 511 | 232 |
| 95° F.* | 67 | 60 | 41.8 | 20.0 | 30.9 | 154 | 147 | 492 | 280 |
| 105° F.* | 67 | 60 | 28.4 | 53.3 | 40.8 | 156 | 132 | 522 | 242 |

*Held for 2 days without feed or water.

resistance to a disease outbreak. Such a disease outbreak did not occur during the experiment.

The poults in the previous experiments were held in chick boxes at room temperature. Two subsequent trials were conducted to determine the influence of holding temperature and holding time on early poult mortality. These two trials were conducted in battery brooders, with three treated groups in each trial. A control group was placed on feed and water immediately after hatching and brooded at 95° F.

All treated groups were held without feed and water for 2 days. Three holding temperatures (85°, 95°, and 105° F.) were tested. All treated groups were brooded under normal conditions after 2 days. The results are given in Table 3.

The mortality was extremely high in both trials. This was believed to be due to an unusually high level of N strain PPLO in the poults. In both trials, the control group and the group held at 95° F. without feed and water were in the same battery. In trial 1, the mortality in the controls was higher than that obtained in two treatment groups (85° and 105° F.). Since it has been shown previously that holding for 2 days increases mortality, it is unlikely that this result is typical of what is expected as all treated groups were held for 2 days. This result more likely represents differences between batteries. In the same battery, mortality was higher in the 105° group than in the 85° group and higher in the 95° group than in the control group.

The results obtained in trial 2 indicate that mortality increases as the holding temperature increases (Table 3). Holding poults for 2 days at 85° F. did not seem to have a harmful effect on livability. Since the number of birds in each group was small, the results obtained will have to be confirmed by further testing. They indicate, however, that lower temperatures are desirable when holding or transporting poults.

Different lines were used in the two trials. Large weight birds were used in trial 1 and medium weight birds were used in trial 2.

The treated groups were consistently reduced in body weights at 2 and 4 weeks of age but there were no noticeable differences between the various holding temperatures in trial 1. When the medium type birds were used in trial 2, the body weights were reduced to a greater extent at the 85° and 105° holding temperatures.

It is commonly believed that a large part of early poult mortality is due to starvation because some poults do not eat. These poults which die early are termed "starveouts". Recent evidence indicates that most poults which die early have eaten some food and die for some reason other than not learning to eat.

The birds which died during the holding temperature trials were examined for the presence of N strain PPLO organisms. This organism was present in most of the dead poults and lesions were noted in the air sacs in many poults. It is possible that much of the early mortality is due to the PPLO organism which may produce more mortality when stress, such as holding poults before placing on feed, occurs.

# AIRSACCULITIS IN TURKEYS

Y. S. Mohamed and E. H. Bohl

The turkey industry has done a commendable job in reducing the number of flocks infected with *Mycoplasma gallisepticum* (also known as the S6 strain of PPLO) which causes airsacculitis and infectious sinusitis of turkeys. Unfortunately, the problem of airsacculitis in poults still exists.

Another member of the PPLO family of organisms is now recognized as the main cause of airsacculitis in poults, with sinusitis occurring only rarely. This organism is known as *Mycoplasma meleagridis* and is often referred to as "H" serotype or "N" strain.

Research has shown that this organism is very widespread in Ohio turkey flocks. Similar reports have been received from other mid-western states and California.

Studies have been underway in the last few years at the Research Center to study the significance of this infection and to develop methods for diagnosis. The mode of transmission of this organism and possible control measures are also being studied.

The following is a brief summary of the results of work in these areas.

## Significance of the Infection

*M. meleagridis* by itself is capable of producing airsacculitis in turkeys. Airsacculitis due to this organism has been detected in unhatched embryos, day-old poults, and turkeys of different ages. The disease is prevalent in turkey flocks and could account for condemnations at packing plants. The disease sometimes is present in apparently healthy birds, which show evidence of disease (airsacculitis) only on slaughter. This is especially true under good management and sanitation.

Ohio experiments and observations have shown that stress may have an important role in this disease. Stress caused by holding poults without food or water for varying lengths of time has an effect on early poult mortality. Varying the brooding temperatures also has an effect. Ohio experiments show that these increased early mortalities can be correlated with natural infection of poults with *M. meleagridis*.

This infection also is believed to contribute to the death of embryos at the time of hatching.

In summary, this infection is believed to contribute mainly to low hatchability, early poult mortality, and some condemnations at the packing plant.

## Diagnosis

A serum plate test (SPT) and a tube agglutination test (TAT) have been developed at the Research Center. These are satisfactory for the diagnosis of this infection.

Media for isolation and techniques for identification are under constant study at the Center.

## Transmission

Considerable research has been done at the Research Center to determine this particular aspect of the disease. The organism has been recovered from a high percentage of semen samples and vaginas of turkeys. This is a venereal disease and can be transmitted either by artificial insemination or during natural breeding.

In female turkeys, the organism tends to localize in the uterus and vagina, which can be the source of egg transmission of the organism. The egg gets infected in the uterus and the embryo in turn becomes infected. Correlations have been made between the vaginal carrier state and isolations from non-hatched fertile eggs and day-old poults with lesions. These results emphasize the importance of egg transmission of this infection.

## Possible Control Measures

1. By the use of serum tests (SPT and TAT), it is hoped that a breeding flock of males and females which are free of this infection can be selected and raised under strict isolation conditions. The antigens used for these tests are not available commercially but are made at the Center for research purposes.

2. Kumar et al at Minnesota reported that dipping of eggs in tylosin reduced the incidence of airsacculitis in day-old poults and also reduced the egg transmission of *Mycoplasma*. This may be another means of controlling this condition.

## Specific Pathogen Free (SPF) Flock

The Departments of Veterinary Science and Poultry Science at the Research Center are attempting to establish an SPF flock. Special emphasis is to obtain turkeys free of *M. meleagridis*.

This flock is intended to be free also of the other common pathogens of poultry, such as *M. gallisepticum*, Newcastle disease, fowl pox, pullorum, typhoid, paratyphoid, paracolon, and other diseases which can be readily diagnosed.

Some progress has been made along this line. More studies are needed in this area and to determine the feasibility of such programs under commercial conditions in Ohio.

## Reference

Kumar et al. 1966. Airsacculitis in turkeys (II). Avian Dis. 10:194-198.

# SOME OBSERVATIONS ON WING NOTCHING OF TURKEYS

V. D. Chamberlin

Wing clipping of turkeys to prevent flight has been practiced at the Research Center for several years. Poults were wing clipped by the removal of the phalanges or wing tips slightly beyond the outer joint toward the tip of the wing's last section. This operation was performed by using surgical shears or an electric debeaker on turkeys from 1 day old to 3 or 4 weeks of age. This prevented the birds from flying over fences and becoming mixed in various experiments.

A large percentage of wing-clipped turkeys were downgraded at market time because of injured and bruised wing stubs. The stubs do not heal properly on experimental birds which must be caught frequently during the growing season for taking weights and various operations. With many toms and heavier birds, the wounds remain open to bruises and infection.

Formerly the range birds were wing clipped by cutting the larger flight feathers or primaries and part of the secondaries of one wing to prevent extensive flying. Heavy shears, tin snips, and sheep shears have been used for this purpose. The birds were usually clipped at 8 weeks, or at the time they went to range, and again at 12 and 16 weeks, or when the feathers grew out. This did a fairly good job but added an extra time-consuming chore which was necessary to repeat at least once or twice during the range season.

Wing notching has been tried on a small scale on previous occasions and was not a perfect solution to the problem. Using an electric debeaker with a notching blade, the tendon over the last joint of one wing is severed. The tip of the wing is grasped in one hand, held horizontally, and flexed toward the body of the bird to make the tendon taut. The notch is located with the index finger. Then the tendon is cut and cauterized with the electric blade. Relaxing of the wing joint indicates that the tendon has been cut.

During this past season, trials were made of wing notching poults 1 day old or as they were taken from the incubator. The poults were sexed and wing banded. Half of the birds of each sex were wing notched and grown intermingled with poults of the same sex. Individual weights were taken at 2-week intervals.

The data presented in Table 1 give the weights and mortality to 6 weeks of age. The average weights of the three groups of normal males is slightly heavier than the three groups of notched males. The average weights of the notched females is slightly heavier. Mortality was slightly more in females than in males. The differences in values are probably not statistically significant. Examination of the notched poults at the end of 6 weeks showed complete healing of wings. A sample of the birds tossed in the air indicated inability to fly.

From the preliminary results, it was decided to notch all pedigreed poults hatched, which involved several thousand birds. When these birds were weighed at 8 and 16 weeks, their wings were healed and good control of flight was observed. However, at the 24-week weighing it was observed that many of the larger hens and toms had open sores where the wings were notched. The open sores were severe enough to cause some downgrading at the processing plant. Thus it was concluded that wing notching to control flight should not be used for large, broad-breasted turkeys.

TABLE 1.--Six Week Body Weights and Mortality of Normal vs. Wing-Notched Poults.

| | Normal Males | | Notched Males | | |
|---|---|---|---|---|---|
| | Body Weight | Mortality | Body Weight | Mortality | Pen |
| | 2.49 | 0 | 2.32 | 0 | 1 |
| | 2.45 | 0 | 2.34 | 0 | 2 |
| | 2.24 | 0 | 2.27 | 1 | 3 |
| Av. | 2.39 | 0 | 2.31 | 0.33 | |
| | Normal Females | | Notched Females | | |
| | 1.96 | 1 | 2.03 | 2 | 4 |
| | 2.05 | 1 | 2.09 | 1 | 5 |
| | 1.98 | 1 | 1.98 | 1 | 6 |
| Av. | 1.99 | 1 | 2.03 | 1.3 | |

# TURKEYS SELECTED FOR RESISTANCE TO STRESS

Keith I. Brown

When noxious stimuli are applied in turkeys, the animals are apparently relatively successful in maintaining physiological balance by means of internal changes. Research suggests that any condition which causes an increased release of hormones from the pituitary-adrenal system is potentially damaging to the animal. The sum of all non-specific responses to a systemic stressor is called the General Adaption Syndrone (G.A.S.). The most prominent physiological and functional changes in the G.A.S. in poultry are: (1) enlargement of the pituitary, probably due to the increased production and output of adrenocorticotrophic hormone (ACTH); (2) adrenal enlargement; (3) cholesterol depletion of the adrenals, together with an increased output of corticosterone; (4) atrophy of thymus, bursa, and spleen; (5) a decrease of lymphocytes and an increase of heterophils; (6) retardation of growth or loss of weight, evidenced by an increased excretion of sodium, potassium, total nitrogen, and uric acid.

It is now known that any systemic stressor acts via the central nervous system on the hypothalamus (mid-brain). Neurosecretory cells of this region then produce corticotrophin releasing factor (CRF), which travels via the hypothalamic capillaries into the portal veins of the pituitary. The anterior pituitary responds with an increased output of ACTH, which in turn causes the adrenal cortex to release higher amounts of corticosterone. This steroid then induces changes in the lymphoid system, loss in weight, etc.

It should be noted that the hypothalamus is activated to release CRF by an extremely large and diverse group of stimuli generally lumped together under the term "stress." Such a list would include otherwise unrelated items which range from excitement, anxiety, fear, apprehension, cold, heat, physical trauma, tranquilizing drugs, excessive exercise, etc. Thus, "stress" is a term for immensely dissimilar stimuli which have in common the experimentally proved property of stimulating ACTH secretion.

There is no doubt that ACTH and corticosterone are necessary for protection against stressful stimuli. However, cortical steroids (corticosterone in fowl) produce several undesirable side effects. The catabolic response, i.e. loss in weight, is certainly not desirable if rapid growth and efficient feed utilization are desired. Secondly, ACTH and the glucocorticoids (corticosterone in birds) are known to interfere with immune responses in several species of animals. An adequate dose of ACTH or cortisone has been shown to inhibit antibody formation in rabbits, rats, and mice. In addition, it has been shown by a number of workers that glucocorticoids cause involution by the bursa in the young bird and that the bursa is involved in the production of antibodies in birds.

Since the G.A.S. always induces catabolic processes and since ACTH and glucocorticoids are known to interfere with immune responses in several species of animals, it is postulated that the animal which is capable of adapting to a stressor without bringing the G.A.S. into play (low response animal) would be the superior animal. Such an animal should grow faster, have a better feed conversion, have a greater reproductive efficiency, and a greater resistance to a wide variety of stress and disease conditions. If high and low response lines can be selected, they should be invaluable animals for studies by stress physiologists. The animals should be particularly useful in determining the relationship of adrenal response to resistance to a wide variety of environmental stress and disease conditions. For these reasons, a study was initiated to select a high and low stress response line of turkeys.

To develop a high and low stress response line, a reliable routine measurement or criterion for stress must be available. As can be seen from the review, a number of physiological measurements can be used as indicators of ACTH and glucocorticoid secretion. However, it seems wise in genetic selection to select for the particular trait in question rather than correlated traits. This means selection for either ACTH secretion or for corticosterone level in the turkey. Since there are procedures of a fairly routine nature available for corticosterone analysis, it was decided to use plasma corticosterone levels following a standard stress as the selection criteria.

The procedure used is suitable for the measurement of corticosterone in the turkey, regardless of the age or degree of sexual maturity. This procedure has been used on thousands of samples of turkey and chicken blood.

## Validation of the Procedure

The validity of this procedure has been verified by measuring plasma corticosterone in 4-week-old turkeys, laying turkeys, and 4-week-old chickens both before and after injection with ACTH and after cold stress.

The data in Table 1 shows that there was a highly significant increase within 3 to 6 hours after a single injection of ACTH and that the plasma corticosterone returned to the pre-injection level at 12 hours. There was also a significant increase in plasma corticosterone in the 4-week-old turkey after 3 hours in the cold room at 4° C. Thus, this procedure can be used to measure the increase in plasma corticosterone resulting from a systemic stressor or from ACTH injections.

## Method of Genetic Selection

In 1963, 48 hens and 48 toms from the Ohio randombred turkey strain were mated at random except that full sib mating was avoided. Four weekly hatches were grown from this line. At 4 weeks of age, the poults were placed in a cold room at 4° C. for 4 hours. At the end of the cold stress, 5 ml. of heparinized blood was drawn from each bird by cardiac puncture. The plasma was frozen for later analysis.

During the following months, the plasma samples were analyzed for corticosterone and these values were used to select 32 hens and 32 toms with a high response to stress and the same number with a low response to stress. Thirty-two toms and 32 hens were selected, one from each family, at random to continue the randombred control line.

TABLE 1.--Effect of ACTH and/or Cold Stress on Plasma Corticosterone of Turkeys and Chickens.

| Type of Bird | Treatment | No. Birds | Hrs following ACTH inject. or stress | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0 | 3 | 6 | 12 | 24 |
| Laying turkeys | 24 U. ACTH | 13 | 4.6 | 11.8* | 9.8* | 4.6 | 4.2 |
| 4 Wk. old turkeys | 8 U. ACTH | 12 | 6.2 | 19.8* | 17.8* | | |
| 4 Wk. old chickens | 8 U. ACTH | 15 | 1.05 | | 6.07* | 2.59 | 0.87 |
| 4 Wk. old turkeys stressed at 4°C | | 15 | 6.2 | 12.7* | | | |

*P < .01 when compared to the corticosterone level at 0 hours.

TABLE 2.--Reproductive Performance of Selected Lines (12 weeks production).

| Line | % Egg Production | % Fert. | % Hatch of Fertile Eggs |
|---|---|---|---|
| 1964 | | | |
| R. B. Control | 50.1 | 76.1 | 75.5 |
| High Line | 47.8 | 83.9 | 78.2 |
| Low Line | 48.4 | 85.5 | 81.3 |
| 1965 | | | |
| R. B. Control | 60.8 | 75.6 | 80.7 |
| High Line | 60.6 | 86.3 | 79.3 |
| Low Line | 62.1 | 83.0 | 81.6 |
| 1966 | | | |
| R. B. Control | 62.6 | 95.5 | 81.3 |
| High Line | 62.3 | 92.5 | 73.3 |
| Low Line | 65.3 | 89.1 | 79.4 |

Note: Only trap nested eggs were recorded. Approximately 3% of all eggs are floor eggs.

In February 1964, these three selected lines were mated, using the procedure listed above. Egg production, fertility, and hatchability were determined for a 12-week period. The first two hatches were grown and were stressed at 4 weeks of age and the same measurements were taken as in 1963.

In February 1965, the selected lines were again mated and the reproductive data gathered. This year enough technical help was available to stress all the poults from four hatches and to analyze all the samples for corticosterone. This represents approximately 1100 samples from all three lines. Each year the poults were grown to 24 weeks of age. Mortality and body weights were measured at 4, 16, and 24 weeks of age.

**TABLE 3.--Corticosterone Level and Growth Performance of Selected Lines. ($F_2$ Generation).**

| Line | ug % Corti-costerone | Body Wts., Kg. 4 Wk. | 16 Wk. F | 16 Wk. M | 24 Wk. F | 24 Wk. M |
|---|---|---|---|---|---|---|
| R. B. Control | 12.7 | 0.417 | 4.19 | 5.72 | 5.77 | 9.40 |
| High Line | 13.5 | 0.403 | 4.19 | 5.81 | 5.81 | 9.35 |
| Low Line | 11.1 | 0.440 | 4.22 | 5.94 | 5.94 | 9.85 |
| | | | Analysis of Variance | | | |
| Line | 19.9** | 16.1** | 16.6** | | 10.9** | |
| Sex | 4.13* | 70.6** | 2031.2** | | 3746.0** | |
| Hatch | 2.91* | 14.2** | 1.95 | | 0.98 | |
| L X S | 0.65 | 0.93 | 2.85 | | 4.01* | |
| L X H | 2.45* | 1.48 | 1.12 | | 1.81 | |
| S X H | 1.78 | 0.40 | 0.78 | | 1.16 | |

*P <.05
**P <.01

## Results and Discussion

The reproductive data on the selected lines for 1964, 1965, and 1966 ($F_1$, $F_2$, and $F_3$ generations) are shown in Table 2. There are no significant differences. In 1965, however, it may be noted that the hatchability of fertile eggs tends to be high in the low line and reduced in the high line. This approached significance at the 5% level. If this trend is real, there should be a significant difference in the next generation.

In Table 3, the growth data and the plasma corticosterone levels are shown for the $F_2$ generation. The 2.4 ug% difference in plasma corticosterone in the high and low lines is highly significant. A preliminary study of this data from the first hatch in 1966 ($F_3$) indicates this spread is approaching 4 ug%. It is also apparent that the low line birds are significantly heavier at all ages. This was predicted by the author, based on the catabolic action of corticosterone.

In Table 4, the heritability of corticosterone level after stress is shown to be 0.309. As each year's data becomes available, a more accurate estimate of the heritability can be obtained.

The poults hatched and being grown in 1966 provided an excellent opportunity to test the livability of the three lines under disease conditions. The H strain of PPLO was found to be present in all lines. Because of this, mortality during the first 4 weeks post hatching is of particular interest (Table 5). The mortality due to natural death was 5.0%, 12.8%, and 15.2% in the low line, randombred line, and high line, respectively. Likewise, the mortality was 12.7%, 13.9%, and 21.1% in the same lines due to cold stress and collection of blood by cardiac puncture. It appears that the low line is more resistant to cold stress and to H strain PPLO than the high line. Thus, these data lend some validity to the original hypothesis.

Because of the high mortality resulting from cold stress and blood collection in 1966 ($F_3$), the stressing will be done at 5 weeks of age in 1967 with the $F_4$ generation. With the loss due to stress at 4 weeks of age, it is probable that many of the high line birds which should be selected are lost at this age.

It is quite probable that the mortality due to cold stressing of the birds is shifting the randombred control to a more resistant bird. If this is true, the level of plasma corticosterone will tend to decrease somewhat with each generation. Progress toward increasing the plasma corticosterone in the high line will also be retarded somewhat. By increasing the age of stressing to 5 weeks of age, the loss of birds from cold stressing and blood collection should be reduced.

The Ohio randombred line is also being maintained in connection with the genetic studies. A comparison of the randombred control which has undergone cold stress at 4 weeks and the other randombred control will be made at some future time to determine how much the stress has influenced selection. It may be that some of the improvement in egg production in all lines from 1964 through 1966 (Table 2) may be due to the selection resulting from loss of the low-resistance

TABLE 4.--Heritability of Corticosterone Level

| Line | |
|---|---|
| High Line | 0.330 |
| Low Line | 0.515 |
| R. B. Control | 0.083 |
| Ave. | 0.309 |

TABLE 5.--Four Week Mortality ($F_3$ generation) (H strain of PPLO diagnosed).

| Line | Hatch 1 | 2 | 3 | 4 | Ave. |
|---|---|---|---|---|---|
| | Natural Mortality | | | | |
| R. B. Control | 2.5 | 7.5 | 25.9 | 16.3 | 12.8 |
| Low Line | 3.4 | 1.7 | 10.3 | 5.7 | 5.0 |
| High Line | 10.6 | 13.0 | 19.5 | 18.4 | 15.2 |
| | Mortality Due to Cold Stress | | | | |
| R. B. Control | 6.8 | 16.3 | 14.4 | 20.8 | 13.9 |
| Low Line | 10.6 | 16.1 | 12.5 | 12.0 | 12.7 |
| High Line | 14.5 | 23.0 | 18.4 | 32.4 | 21.1 |
| | All Mortality | | | | |
| R. B. Control | 6.7 | 22.6 | 36.6 | 33.7 | 24.9 |
| Low Line | 13.6 | 17.5 | 21.5 | 17.0 | 17.1 |
| High Line | 23.6 | 33.0 | 34.4 | 44.8 | 33.1 |

birds due to stress. However, it is reasonably certain that most of this improvement is due to improved trap nesting techniques and better broody management.

## Summary

It was postulated that the animal (turkey) which can adapt to stress conditions without initiating the G.A.S. or at least has a low response should be the superior animal from the standpoint of economic traits. Such an animal should grow faster, have better feed utilization, greater reproductive efficiency, and greater resistance to a wide variety of stress conditions.

To test this hypothesis, high and low stress response lines are being selected from the Ohio randombred turkey. The criterion or measurement of stress used for selection is plasma corticosterone concentration in the 4-week-old poult following 4 hours of stress in the cold room at 4° C.

Estimates indicate heritability of this trait to be about 0.309. In the $F_3$ generation the plasma corticosterone after stress was 13.5 ug%, 12.7 ug%, and 11.1 ug% in the high line, randombred control, and low line respectively. These differences are highly significant. Validity is lent to the above hypothesis by the fact that the low line birds were significantly heavier at 4, 16, and 24 weeks of age than the high line birds. The livability after stress and during the first 4 weeks of life when H strain PPLO was diagnosed was significantly better in the low line birds than in the high line birds. Although there were no significant differences in the reproductive traits measured, the hatchability of fertile eggs was higher in the low line and this approached significance at the 5% level.

These data lend support to the hypothesis that animals which have low stress response will be superior with respect to desirable economic traits such as growth rate, feed conversion, and reproductive efficiency.

# GENETICS OF GROWTH AND REPRODUCTION

Karl E. Nestor

The major emphasis of turkey breeders has been placed on improving growth rate, with little importance given to reproductive traits. The objective of the turkey breeder should be to obtain a fast-growing turkey which will reproduce well. Obtaining this ideal depends on where emphasis is placed in selection, the heritability of traits being selected, and the genetic relationship (genetic correlation) between traits. With a positive genetic correlation between body weight and egg production, selecting only for body weight would result in improvement in egg production. A negative genetic correlation would result in a loss in egg production as a result of improvement in growth rate.

Selection studies in which selection is based on a single trait and several traits are measured provide estimates of realized heritabilities as well as allow evaluation of the genetic relationship between traits.

A randombred control in which no selection is practiced is required in selection experiments. The randombred control should remain genetically constant over several generations. Differences occurring in the randombred control between generations or years are primarily due to environmental differences. Such differences can then be removed from the selected lines by expressing the values for the selected lines as deviations from the randombred control. Randombred controls also measure intra-year differences such as those occurring between hatches.

A selection experiment conducted for four generations was completed in 1965. In this experiment, lines were selected for increased 8-week body weight (8-week line), increased 24-week body weight (24-week line), and increased egg production (egg line). A randombred population established in 1955 from four strains of white turkeys served as the base and control for this selection study.

Selection was effective in increasing body weight at both ages in the growth lines. After four generations of selection, the 8-week line had gains in 8-week body weight of 1.03 and 0.85, respectively, in males and females (Table 1). The 24-week line gained 4.05 and 2.95 lbs. in 24-week body weight. The realized heritability determined from response to selection was relatively high for body weight at both ages, averaging .45 for 8-week weight, and .48 for 24-week weight.

Selection for body weight at both 8 and 24 weeks of age resulted in an increase in shank length, keel length, body depth, and breast width at 24 weeks of age (Table 1). Selection for increased body weight at either age resulted in an increase in body weight at all ages, including adult body weight. Selection for egg production resulted in a slight decrease in body weight at 24 weeks of age and a decrease in adult body weight. Body depth in males was increased by selection for egg production.

TABLE 1.--Response of Selected Lines for Growth and Conformation Expressed as the Deviation from the Control Line. (4th generation).

| Trait | Lines | | | |
|---|---|---|---|---|
| | Control | 8 wk. wt. | 24 wk. wt. | Egg |
| | | Males | | |
| 8 Wk. Wt., lbs. | 4.23 | +1.03** | +0.69** | -0.04 |
| 16 Wk. Wt., lbs. | 13.07 | +2.17** | +2.24** | -0.15 |
| 24 Wk. Wt., lbs. | 21.17 | +2.92** | +4.05** | -0.20 |
| 24 Wk. Shank, in. | 7.36 | +0.14** | +0.26** | -0.05 |
| 24 Wk. Keel, in. | 7.03 | +0.28** | +0.48** | -0.04 |
| 24 Wk. Depth, cm. | 22.23 | +0.95** | +1.71** | +0.40** |
| 24 Wk. ½ Breast Width, cm. | 5.54 | +0.46** | +0.40** | 0.00 |
| Adult Body Wt. | 32.3 | +3.5 ** | +3.7 ** | -0.3 * |
| | | Females | | |
| 8 Wk. Wt., lbs. | 3.31 | +0.35** | +0.74** | +0.05 |
| 16 Wk. Wt., lbs. | 9.27 | +1.65** | +1.95** | -0.03 |
| 24 Wk. Wt., lbs. | 13.21 | +2.00** | +2.95** | -0.33* |
| 24 Wk. Shank, in. | 5.38 | +0.14** | +0.19** | -0.08* |
| 24 Wk. Keel, in. | 5.98 | +0.26** | +0.11** | -0.08* |
| 24 Wk. Depth, cm. | 17.46 | +0.62** | +1.07** | -0.01 |
| 24 Wk. ½ Breast Width, cm. | 4.99 | +0.32** | +0.29** | +0.05 |
| Adult Body Wt. | 17.2 | +2.6 ** | +3.9** | -0.9 ** |

*P <.05
**P <.01

Reproductive data obtained in the selected lines is presented in Table 2. The values for the selected lines are expressed as deviations from the randombred control. The numbers in parenthesis in 1965 represent the total amount gained or lost over the four generations of selection. The 84-day egg production of the growth-selected lines varied from year to year and did not show any trends with years, indicating that selection for growth rate had no influence on egg production. Such a trend was not observed in the other years and it is doubtful if selection was responsible for the reduction in fertility in 1965. Likewise, no trend was apparent in the values for hatchability of fertile eggs or numbers of poults produced in the growth-selected lines. Egg weight increased in the growth-selected lines.

Selection for egg number was very effective. The 180-day egg production of the egg line was more than twice that of the randombred control. The realized heritability obtained with the method of selection used averaged 0.23 for the first four generations of selection. Since selection in this line was based on the production of the dam, the actual heritability would be about twice the heritability observed or .46. Selection for egg production increased the number of poults produced and decreased egg weight.

TABLE 2.--Response of Lines for Reproductive Traits by Year.

| Line | Year | No. Eggs (84 days) | 180 Days | % Fert. | % Hatch F.E. | No. Poults (56 days) | Egg Wt. (gms.) |
|---|---|---|---|---|---|---|---|
| C | 1961 | 43 | -- | 86 | 84 | 18 | 83 |
| | 1962 | 44 | -- | 89 | 83 | 20 | 85 |
| | 1963 | 42 | -- | 86 | 84 | 18 | 82 |
| | 1964 | 44 | -- | 70 | 81 | 16 | 85 |
| | 1965 | 38 | 57 | 88 | 82 | 27 | 84 |
| 8 | 1961 | - 2 | ---- | - 2 | -6 | -3 | -1 |
| | 1962 | + 4 | ---- | + 3 | +6 | +6 | +3 |
| | 1963 | + 3 | ---- | - 6 | -3 | -1 | +3 |
| | 1964 | - 5 | ---- | + 4 | -6 | -2 | -0 |
| | 1965 | + 6(+6) | ---- | -20(-21) | +2(-7) | -5(-5) | -0(+5) |
| 24 | 1961 | + 2 | ---- | - 5 | -4 | -3 | +6 |
| | 1962 | - 6 | ---- | + 3 | +7 | +4 | -4 |
| | 1963 | + 4 | ---- | + 1 | -7 | -2 | +5 |
| | 1964 | - 1 | ---- | + 4 | -2 | +2 | -1 |
| | 1965 | - 4(-.5) | ---- | -12(-9) | 0(-6) | -6(-5) | +1(+7) |
| E | 1961 | + 3 | ---- | + 2 | -2 | -1 | -0 |
| | 1962 | + 3 | ---- | - 4 | +6 | +5 | -3 |
| | 1963 | + 3 | ---- | - 4 | -8 | -3 | +3 |
| | 1964 | + 2 | ---- | +16 | +8 | +9 | -3 |
| | 1965 | +10(+21) | + 59 | -18(-8) | -7(-3) | +3(+13) | -3(-6) |

TABLE 3.--Heritabilities of Various Semen Measurements

| Trait | Heritability | |
|---|---|---|
| | Randombred Control | Egg Line |
| Semen Yield (cc) | .64±.08 | .16±.03 |
| Sperm Concentration | .16±.03 | .22±.06 |
| % Bent Sperm | .18±.03 | .00±.04 |
| | Genetic Correlation | |
| | Randombred Control | Egg Line |
| Yield X Concentration | .11 | 1.48 |
| Yield X Bent Sperm | -.48 | ---- |
| Concentration X Bent Sperm | -.26 | ---- |

The results of the selection study indicated very little genetic relationship between growth rate and egg production. However, 24-week body weight in the egg line was reduced slightly by changing the egg production greatly.

A new selection experiment was initiated in 1966. The randombred control and egg lines were continued in this experiment to determine if further increases in egg production would reduce growth rate. A third line selected for increased semen yield was also started.

The randombred control used in the 1965 experiment was established in 1955. As a result it was much smaller in body weight than present commercial strains. It was decided, therefore, to establish a new randombred control population from two large commercial strains of white turkeys. Two lines will be developed from the new randombred control. One line will be selected for increased 16-week body weight and the other line will be selected for both increased 16-week body weight and increased egg production by the use of an index.

Heritability estimates were made for semen yield, sperm concentration, and percent bent sperm in the randombred control and egg lines. Semen yield was highly heritable in the randombred control line (Table 3). Sperm concentration and percent bent sperm had similar heritabilities in the control population. The estimates obtained in the egg line were lower for semen yield and percent bent sperm. Estimates of the genetic relationship among these traits were also obtained. In general, selection for increased semen yield should increase the sperm concentration and reduce the percentage of bent sperm. The percent bent sperm is negatively correlated with fertility. In other words, a decrease in percent bent sperm results in an increase in fertility.

TABLE 4.--Reproductive Data Obtained in 1966.

| Line | Egg Production (no.) | | | Adult body wt. lb. | | Semen Yield (cc) | | |
|---|---|---|---|---|---|---|---|---|
| | 84 days | 120 days | 180 days | males | females | Jan. | Mar. | June |
| Control | 41 | 56 | 69 | 34.6 | 18.5 | .166 | .141 | .155 |
| Egg | 55 | 77 | 104 | 33.7 | 16.9 | .150 | .147 | .171 |
| Semen | 45 | 60 | 77 | 35.4 | 18.2 | .245 | .204 | .195 |
| Commercial A | 45 | 60 | 71 | 43.4 | 23.7 | ---- | .132 | ---- |
| Commercial B | 47 | 65 | 77 | 41.3 | 22.2 | ---- | .196 | ---- |

Reproductive data were obtained in 1966 for the randombred control line, egg line, semen line, and the two commercial strains used in forming the new randombred control. These data are shown in Table 4.

The egg production of the egg line was greater than the randombred control at all lengths of lay. However, the egg production of the randombred control increased and that of the egg line decreased relative to 1965 (Table 2). So the difference between lines was not as great as in 1965. The breeder hens were housed in a different house and a different broody management was used in 1966. These factors could be responsible for smaller differences between the lines.

The egg production of the semen line was greater than that of the control, possibly indicating that selection for semen yield may increase egg production. The commercial strains produced better than the randombred control, which means that the commercial breeders have improved egg production since 1955. The semen yield of selected males was much greater in the semen line than in the other lines. The semen yield in one commercial strain (B) was also greater than the control.

The new selection study should provide further information on the genetic relationship between egg production and growth rate of turkeys. In addition, knowledge of the genetics of semen yield will be obtained.