

## Influence of Age Combination and Protein Supplementation on the Rate of Lay, Egg Quality and Chick Viability<sup>1</sup>

Arthur R. Ylagan<sup>2</sup>

College of Agriculture, Fishery and Forestry  
dok\_art@yahoo.com

**Abstract** - Farm trial was conducted to determine the effect of short-term game fowl management interventions on egg production and chick viability. It involved two studies. In study 1, the experimental treatments were: a) brood cock x brood pullets, b) brood stag x brood hens, c) brood cock x brood hens, and d) brood stag x brood pullets. In Study 2, protein supplementation at different day intervals with different dosage (number of capsule) were used: a) zero supplementation, b) one capsule per week, c) two capsules per week, and d) three capsules per week.

Results showed that egg production, egg shape index, hatchability and chick viability were not influenced by age combination of brood fowls. Relatively, more males were produced by old-old and young-young combinations, although the differences were not significant. Short-term supplementation of brood fowls with high protein concentrate and energy utilization enhancer did not influence egg production and egg and chick viability. There were relative improvements in egg and chick viability, suggesting that those may be with long term supplementation.

It is recommended that a study for longer duration of time of pairing of the different combinations be conducted to further test the productive efficiency in terms of rate of lay, hatchability and chick viability, and supplementing brood fowl with energy utilization enhancer for a longer duration of time and with a bigger experimental bird population.

**Key Words** - age combination, brood fowl, chick viability, egg quality, fowl management, protein supplementation.

<sup>1</sup>Dissertation submitted to the Cavite State University in 2007; currently, the author is involved in animal nutrition specifically on feeds formulation for brood fowls.

<sup>2</sup>Vice President for Research, Extension and Training

## INTRODUCTION

The current status of the local game fowl industry is solely the result of the Filipinos' love for cockfighting. In fact, cockfighting is regarded by many as the Filipino's national sport, not just a pastime. Over the past several decades, it is the understanding of basic genetics that has helped the modern breeder maintain and improve some of the great families of game fowl that have been passed down through generations.

Maintaining and improving bloodlines is the primary goal of game fowl breeders. Breeding and selection are two very important aspects of game fowl production that spells the difference between success and failure (Bunan, Lorenzo & Gorgonia, 2002). Oftentimes, the knowledge that a particular pullet or hen belongs to a good bloodline is enough for it to be designated as a brood fowl. Hence, the importance of the brood hen should never be forgotten as it contributes to the genes of the progeny.

The hen is the other part of the entire equation in breeding gamecocks. It is important to be very choosy in buying pullets or hens. Some breeders prefer to buy hens instead of pullets because at least their bloodline has already been proven. However, throughout the history of game fowl breeding, the importance of the hen has been overlooked, even ignored. Any present day breeder competing in the fierce arena who ignores the importance of the hen is not only at his own peril, but also at the peril of his fowl's competitive success.

To preserve ideal bloodline, the mating must be made between ideal cock and hen. Thus, the mating will result in: Cock and Hen mating producing  $\frac{1}{2}$  cock,  $\frac{1}{2}$  hen (F1 or Filial Generation 1); Father to daughter, Mother to son (F2 or filial generation 2); Granddaughter to Grandfather, Grandmother to grandson (F3); Granddaughter to Great Grandfather, Great Grandmother to Grandson (F4) (Shy, 1982).

Game fowl breeding is a tedious and lengthy undertaking that requires fulltime attention. A strain that has been purebred for a number of years should be selected for crossing. It is usually more satisfactory to get a cock because one can select the best as seen in the battle (Bark, 1964). Troiano added that when breeding game fowl for their fighting characteristics, most cockers select and breed game fowl for their power, speed, cutting ability, brains, temperament, and heart, in other words, their "gameness" (2004).

Apart from adopting a good breeding program, proper management of the breeder flock is essential to produce good hatching eggs. The

vigor and health of a chick depends on the care of its parents before the egg is laid. All birds in a breeder flock should be reared with proper management practices. Birds in the breeding flock should be healthy and free of physical shortcomings that can interfere with proper mating and egg production. The potential parent birds must be able to produce fertile hatching eggs before chick quality can be improved.

Another concern of the local game fowl breeders is the hatchability of the eggs that their breeders produce. The eggs should have good hatchability, a problem under certain situations. Hens for egg production must have the ability to lay large numbers of eggs. Selection of hens based on the rate of lay is the primary objective of the poultry breeder. The traits considered to be of economic importance include rearing mortality, laying mortality, egg production, food consumed per dozen of eggs produced, and body weight, according to “Systems Used for Breeding – Incubation and Embryology” (n.d.).

There are criteria that need to be considered and followed in selecting eggs for hatching to ensure production of quality game chicks. These include size, weight, shape, eggshell quality (smoothness, shell thickness) and yolk quality. The viability of eggs developing to hatching stage is based on temperature (38 °C – 40 °C), humidity (60% to 65%), velocity and movement of air to supply the egg with oxygen in the incubator and stored energy within the egg (Boerjan, 2002).

The most important factor affecting hatchability is incubation temperature (Taylor, 1999). Variations in chick weight at hatch has also been attributed to the amount of water lost from the eggs laid by young breeders, as well as the thicker shell membranes, cuticle and more viscous albumen, act as a significant barrier to water vapor diffusion between the interior of the egg and of the incubator temperature (McLoughin and Gous, 1999).

Nutrition is another aspect of game fowl management that raisers have to contend with. Poultry and game bird feeds are referred to as “specially prepared” feeds. These are exclusively formulated to contain all the protein, energy, vitamins, minerals, and other nutrients necessary for proper growth, egg production and health of the birds.

Game fowl owners and breeders have the tendency to raise their game fowl quite extravagantly. Often, high-quality commercial game bird feeds are not available and feed substitutes are fed to the bird. More often than not, game fowls are given supplements and medicines that are either in excess of what they need, or not needed at all (Bunan et al., 2002).

The most convenient way of feeding chickens is with a pelleted ration, whether the birds are confined indoors or allowed to range outdoors. Most diets contain corn for energy, soybean meal for protein, and vitamin and mineral supplements. Commercial rations often contain antibiotics and arsenicals to promote health and improve growth, coccidiostats for combating coccidiosis, and sometimes mold inhibitors. However, it is possible to obtain unmedicated feed-check feed labels to see if they contain feed additives (Fanatico, 2003).

Nilipour (1997) pointed out that breeder feed and its micronutrient composition not only dramatically influence the production and health of breeders but also the production of high quality, fertile eggs able to nourish the developing embryos for 21 days. Bunan, et al. (2002) added that feeding game fowls with a 16 – 18 % crude protein (CP) ration appears to give them the best body conformation.

The concerns of game fowl raisers and breeders are: a) the proper selection and pairing of brood fowls to produce and develop bloodlines that are superior in all character traits; b) the quality and hatchability of eggs produced; c) correct and proper incubation management practices; and d) proper brooding and growing management of the chicks to produce excellent game birds in the future. This study was conducted to help solve the troubles encountered by most game fowl raisers and breeders. In general, this study aimed to determine certain aspects of game fowl management in relation to the rate of lay, egg quality, chick viability, and brooding performance of game chicks.

## **MATERIALS AND METHODS**

The component experiments of the study focused on and were limited to short-term management interventions aimed at enhancing the reproductive performance of brood fowl and egg and chick management in relation to the rate of lay, egg quality, chick viability, gender ratio, and their brooding performance. The study was conducted at El Dia Game Farm, San Mateo, Rizal from August to October 2007.

### **Experimental Design and Data Analysis**

All component studies were laid out following Completely Randomized Design. Data were analyzed using Analysis of Variance for completely randomized experiments. Difference among treatments means ascertained for significance using Duncan's Multiple Range Test (DMRT).

### **Study 1 - Age Combination of Brood Fowls and Egg and Chick Viability**

Brood fowls belonging to a single bloodline were used. They were either 1-year old or 3-years old or older, based on farm records kept. They were paired accordingly, and collection of hatching eggs from each pairing lasted for one month.

The following pairings (treatments) were made:

Treatment 1 – Brood Cock x Brood Pullets

Treatment 2 – Brood Stag x Brood Hens

Treatment 3 – Brood Cock x Brood Hens

Treatment 4 – Brood Stag x Brood Pullets

Each treatment had one brood stag (male chicken less than 1 year old) or brood cock (male chicken more than 1 year old) paired with five brood hens (female chickens more than 1 year old) or brood pullets (female chicken less than 1 year old), each female comprising one replication. The birds in this pairing were housed in a 3 m x 3 m x 5m breeding pens with steel framing, nylon mesh walls and roof with earthen floors. Trap nests were placed in each breeding pen to facilitate recording of individual egg production.

### **Brood Fowl Management**

*Feeding.* Farm-formulated breeder feed consisting of 60% concentrate feed and 40% duck layer pellet was fed to the experimental birds throughout the study. Each brood fowl was given 40 grams of this feed every feeding time. Feeding times were 7:00 a.m. and 4:00 p.m. Water was added with *adlibitum*. The breeder ration was mixed prior to feeding. The concentrate feed was soaked for 12 hours prior to mixing to remove toxic materials, foreign objects, and to facilitate digestion and utilization of nutrients by the brood fowls.

*Egg collection and recording.* Egg collection started three days after pairing, when the eggs laid by brood hens or brood pullets were already expected to be fertile. Eggs were collected three times a day just before feeding in the morning, 12:00 noon, and just before feeding in the afternoon. Using a pencil, each egg collected was marked with the leg band number of the brood hen or brood pullet, the wing band number of the brood cock or brood stag, and the date it was laid. The collected eggs were stored for a maximum of 4 days under room temperature (around

27°C) before incubation.

*Egg incubation.* The collected eggs were set in a forced draft electric incubator with automatic egg turning mechanism. They were candled after 18 days of incubation, just before they were transferred to the hatcher incubator with pedigree trays. Non-viable eggs were counted and taken out. The chicks that hatched were counted, weighed, and wing banded for identification.

*Chick brooding.* After wing banding and weighing, the chicks that hatched were immediately placed in battery brooders, each with a 25-watt incandescent bulb to provide the brooding temperature required.

*Chick feeding.* The chicks were group-fed twice a day; the amount of feed given per feeding time gradually increased as they grew older.

## Data Collection

While not really an indicator of the influence of age gap on egg viability, egg production of the brood hens and brood pullets was recorded and compared for possible differences. Each egg laid during the experiment period was weighed and its length and width were taken using a Vermeer caliper. Egg shape index was taken as:

$$\text{Egg shape Index} = \frac{\text{Egg width (mm)}}{\text{Egg length (mm)}}$$

Eggs representing each replication were sampled for shell thickness, which was taken using a micro-caliper. The remaining eggs were artificially incubated and their hatchability was taken as:

$$\% \text{ Hatchability} = \frac{\text{No. of Chicks Hatched}}{\text{Total No. of Eggs Set}} \times 100$$

Chick weight was taken as soon as it was taken out of the incubator. The male-to-female ratio was taken as soon as genders were already discernible.

## Study 2 – Energy Utilization Enhancer Supplementation of Brood Fowls and Egg and Chick Viability

One of the main ingredients of a commercially available energy utilization enhancer is L-carnitine, which is known in media advertisement as the fat burner. Its effectiveness in reducing “sapola” or gut fat

has been proven in game fowls being conditioned for fighting. Practical tests that prove its effectivity is a reduction in body weight and the thin feeling whenever the vent of the chicken is pinched after supplementation, which is an indication that it has utilized its fat deposits (Bunan, et al., 2002). It would be interesting to know whether the ability of this product to mobilize fat deposits of the chicken would have profound effects on egg and chick viability if given to brood fowls. Hence, this study was conducted.

## **Treatments**

Brood fowls of the same age group or body weight category were subjected to a month-long commercially available energy utilization enhancer supplementation program to determine its influence on egg and chick viability, including chick gender ratio.

The product is in capsule form, hence given orally. The following supplementation schemes were followed, representing the treatments. In the absence of a recommended dosage and mode of supplementation, these schemes were arbitrarily assigned:

Treatment 1 – No supplementation (control)

Treatment 2 – 1 capsule (250mg) per week

Treatment 3 – 2 capsule (250mg) per week

Treatment 4 – 3 capsule (250mg) per week

One brood cock was assigned to 5 brood hens and housed in a breeding pen earlier described in Study 1. Each brood hen represents 1 replication. Trap nests were placed in each cage to facilitate records of egg production. The energy utilization enhancer capsules were given in the morning right after the brood hens' forced feeding with it.

## **Brood Fowl Management**

Feeding, egg collection and recording, incubation and chick management were similar to those described in Study 1.

## Data Collection

*Feed consumption.* Individual feed consumption was recorded by noting the number of times each brood fowl was given its 40-gram ration. Total feed consumption was taken as the sum of all 40-gram feeds given over the one-month period of experiment. It was noted that the amount of feed was just enough for the daily ration of the entire number of flock per cage and no leftovers were noticed.

*Egg production.* Data on egg production were taken as all eggs laid 3 days after supplementation started up to a month thereafter.

*Egg attributes.* Data on egg dimension, hatchability were taken as described in Study 1.

*Chick data.* The initial weight of each chick that hatched was taken. The male-to-male ratio of the brood from each mating combination was determined as soon as gender was discernible.

## RESULTS AND DISCUSSION

### Study 1 – Age Combination of Brood Fowls and Egg Viability

Brood Fowls belonging to a single blood line were used. They were either 1 year old or 3 years old or older, based on farm records kept. They were paired accordingly, and collection of hatching eggs from each pairing lasted for one month.

The influence of age combination of brood fowls on egg characteristics and viability is presented in Table 1.



**Table 1.** Effect of age combinations of brood fowls on egg and chick viability

Treatment	Hen Housed Egg Production	Egg Shape Index	Egg Weight (g)	Shell Thickness (mm)	% Hatchability	Chick Weight (g)	Chick Gender Ratio
T1: Brood Cock x Brood Pullets	11	0.78	47	0.024	55	26	1.08
T2: Brood Stag x Brood Hens	5	0.78	47	0.024	60	19	1.00
T3: Brood Cock x Brood Hens	8	0.79	39	0.020	50	26	1.22
T4: Brood Stag x Brood Pullets	8	0.78	39	0.021	26	26	1.74

### Egg Production

The one-month egg production in all treatments was generally low, the highest being only 11 eggs and the lowest is five (5) eggs. In spite of what appeared to be a considerable difference (11 vs 5 eggs), the difference between any two treatments was not significant.

The data on egg production appear to represent the typical rate of egg laying in game fowls. Game fowls are generally poor egg producers, partly because such chickens are usually selected for pugnacity and fighting style, with the rate of egg production usually not being part of the selection program.

Age grouping of brood fowls did not show any influence on rate of lay. This is expected since egg laying is solely a hen's function and, thus, entirely depends upon its body condition and genetic potential.

While brood pullets laid more eggs than brood hens, their rate of egg production was unexpectedly low as to be just similar to that of brood hens. To some extent, though, relative performance of the brood hens used in the study conforms to the observation of Bunan, et al. (2002) that the ability of the brood hen to reproduce declines with age.

### Egg Shape Index

The shape of the eggs laid by brood fowls of different age combinations ranged from 0.78 to 0.79, indicating that pairing of brood cocks with

brood pullets does not alter egg shape.

Like egg production, egg shape is a trait that entirely depends upon the phenotype and genotype of the brood hen, hence, is not expected to be influenced by the brood cocks regardless of its age. The result shows that egg shape is more or less consistent in game fowls, and their age is not a factor that alters it.

Egg weight was similar among all treatments. Brood fowls in Treatments 1 and 2 laid eggs that were on average, eight (8) grams heavier than those in Treatments 3 and 4. However, it may probably be due to factors that include body size of the brood pullets and brood hens, this difference was not significant. While the body weight of the brood fowls was not taken, its effect on egg weight was evident if the egg weights in Treatments 1 and 2 were compared. The females in Treatment 1 were pullets, while those in Treatment 2 were hens.

Normally pullets and hens lay similar eggs. As the birds grow older, the size of its egg also increases, oftentimes with a corresponding decrease in egg production. This is because egg size is nearly related to the age of the female breeder (McLoughlin & Gous, 1999).

It is interesting to note that the brood fowls of similar ages (brood cock x brood hen; brood stag x brood pullets) laid lighter, thus similar eggs than the pairings of varying age combination. However, it is difficult to account this result to age combination, since egg weight is entirely dependent upon the pullet or the hen.

### **Shell Thickness**

Eggs laid by birds in Treatments 1 and 2 had slightly, but not significantly thicker shell than those laid by birds in Treatments 3 and 4.

While the results are not significant, the data on shell thickness appear to go with egg weight. In fact, the slight difference in egg weight could have been due partly to shell thickness. While not really a major concern of the study, it is worth noting that the thickness of the shell of the eggs laid by all the brood fowls used was just half as that of the commercial birds, which was about 0.40 cm. understandably, smaller eggs have thinner shells. What is interesting is that the size of the eggs laid by the game fowls was about 3/4 that of the commercial chickens, but their shell was half as thick. This could mean that game fowl eggs have characteristically thinner shells.

## Egg Hatchability

Hatchability of eggs ranged from 50% to 75%, with brood pullets paired with brood stags having the highest hatchability and brood hens paired with brood cocks, the lowest. However, it may probably be due to small sample size, the differences among treatments were not significant.

While not significant, the difference in hatchability is worth considering. It appears to conform with the mating combination, with brood pullets paired with brood stags attaining the highest hatchability while the brood hens paired with brood cocks, the lowest. In a way, this result is a contradiction of the common belief of some game fowl breeders who wait until their brood stocks is at least two years old before using them for breeding purposes. With chickens sexually maturing at six months of age, 8-month old brood fowls should be in their prime and, thus, should be able to produce healthy progeny.

The result strengthens game fowl breeders' practice of pairing old brood fowls with younger ones to attempt to produce healthy progeny from superior but aging game fowl. To a certain extent, the result also confirms that pairing old brood fowls results in problems in hatchability and chick quality, a reason for the limit of about five (5) years for brood cocks and four (4) years for brood hens as recommended by Bunan, et al.(2002).

## Chick Weight

Except in Treatment 2 where the chicks produced were lighter (19 g vs 26 g), all treatments produced day-old game chicks with similar body weight (26 g). The 7-gram difference, though, was not enough to yield any significant result.

If results are to be considered minus their non-significance, these appear to contradict the fact that chick size depends on egg size, the eggs produced by the brood hens in Treatment 2 being heavier and thus bigger than those laid by the brood fowls in Treatments 3 and 4. It is generally accepted that there is a positive correlation between pre-incubation egg weight and chick weight at hatching. The embryonic growth over time, within the differently sized eggs was exponential, and the growth is limited by the space within the eggshell, thus the development of the embryos within the small eggs lagged behind that of the embryos from bigger eggs from the eight (8) days of incubation (McLoughlin & Gous, 1999).

It appears that in case of the eggs in Treatment 2, the growth of the embryos was somewhat restricted as shown by their relatively lighter

weight at hatching. A consequence of selection of high yield breeds is an increasing variability in hatchability of eggs from flocks of different ages. Eggs from young and old breeders differ significantly with respect to size, eggshell conductance and heat production (Boerjan, 2002).

In the present study, however, the result was the opposite, suggesting that as brood hens grow older, they become less able to deposit more of the nutrients needed for embryonic development. It could be that the brood fowls used were already past their prime, with their reproduction ability already diminishing. Such reason though, is purely theoretical, since brood hens in Treatment 3 produced heavier chicks from relatively lighter eggs.

### **Gender Ratio**

The gender ratio of the eggs hatched by brood fowls of different age combinations ranged from 1.00 to 1.74 but showed no trend, indicating that pairing brood cocks with brood pullets does not alter chick gender ratio.

Like egg production, chick gender ratio entirely depends upon the phenotype and genotype of the hen and roosters; hence, it is not expected to be influenced by the brood cocks regardless of its age. The result shows that chick gender ratio is more or less consistent in game fowls, and their age is not a factor that alters it.

### **Chick Mortality**

No mortality was recorded. The chicks were raised only for one week and were alert at hatching, hence, the good viability.

### **Study 2 – Energy Utilization Enhancer Supplementation of Brood Fowls and Egg and Viability of Chicks**

The effect of energy booster supplementation of brood fowls on egg production, egg shape index, egg weight, shell thickness, egg hatchability, chick weight and gender ratio is presented in Table 2.

**Table 2.** Effect of energy utilization enhancer supplementation on egg and chick viability

Treatment	Hen Housed Egg Production	Egg Shape Index	Egg Weight (g)	Shell Thickness (mm)	% Hatchability	Chick Weight (g)	Chick Gender Ratio
T1: Control (none)	8	0.77	39	0.200	62	26	1.27
T2: 1 capsule /week	8	0.77	47	0.025	62	26	1.17
T3: 2 capsules/week	8	0.78	37	0.021	75	19	1.00
T4: 3 capsules/week	9	0.78	47	0.023	66	27	1.08

## Egg Production

Egg production of brood fowls supplemented with varying dosages of energy booster capsules was similar to those of the control. L-carnitine, the active component of the energy booster, was supposed to enhance fat mobilization to allow the body to use it more efficiently, in the process reducing the body fat reserves. Apparently, short term supplementation did not readily improve egg produced. The seemingly low production with or without energy booster capsule supplementation may also mean that brood fowls were already optimally laying, only that they were limited by their genetic potential; or, the addition of concentrate in their diet may have significantly altered its nutrient composition. The alteration resulted in nutrient imbalance, one that was not able to support egg production at an acceptable rate. The diet given to the brood fowls was a combination of breeder pellet (40%) and concentrates (60%).

## Egg Shape Index

Egg shape index was essentially the same among all the treatments, indicating that this was not influenced by the energy booster supplementation. The similarity of indexes with those in Study 1 indicated that game fowl eggs had a characteristic shape, the index of which ranged from 0.77 to 0.79.

## Egg Weight

Contrary to expectations, egg weight was not influenced by energy booster supplementation. With enhanced energy utilization as a result of

supplementation, there should have been an improvement in the energy-to-protein ratio that was available for utilization. However, this did not happen, with the energy-to-protein ratio of the diet already altered because of the addition of concentrate mix. It may have been the effect of using booster supplement was more readily seen if brood fowls and brood pullets were given plain breeder diet.

### **Shell Thickness**

While not significant, the results in shell thickness were more a reflection of egg size than those in Study 1. The smaller the eggs tended to have thinner shells than the bigger counterparts. However, while the control group eggs had the thinnest shell, it was not clear whether the relative increase in egg shell thickness with energy booster supplementation was treatment-related or not because of inconsistencies in egg size.

### **Egg Hatchability**

There were no significant differences in egg hatchability. The variations were considerable, but were not enough to elicit good statistical results probably because of small sample size. Egg hatchability seemed to favor energy booster supplementation, being higher in treatments where brood fowls were given higher doses of the supplement. This could be because the role of L-carnitine in the energy booster supplement was not just confined to energy mobilization.

### **Chick Weight**

Chick weight was not significant by energy booster supplementation of brood fowls. At any rate, it appeared to be a reflection of egg weight, since the bigger eggs produced the heavier game chicks.

Although not analyzed, what was interesting to note was that if the weight of the day-old chicks was taken relative to egg weight, only those in Treatment 1 fell within the acceptable range of 65% to 68% as proposed by Deeming (1995) as an alternative way of assessing chick quality. Since the eggs were incubated in a single forced draft incubator, still unknown was the cause for the chicks in the treatments where brood fowls were supplemented with energy booster capsules tended to be drier than those in the control (55%, 51%, and 59%, respectively vs 67%), .

### **Chick Gender Ratio**

Chick gender ratio was essentially the same among all the treat-

ments, indicating that this was not influenced by energy booster supplementation. Although the control produced the highest ratio, it was encouraging to note that the least ratio was 50:50, which was better than what is considered norm in the industry where female chicks outnumber males. However, apart from this, results being non-significant, there could be other factors like season of the year and health of the brood fowls that also influence chick gender ratio.

### **Chick Mortality**

There were no mortalities in the one-week period that the game chicks were raised. Hence, the data on chick mortality was no longer presented.

## **SUMMARY AND CONCLUSIONS**

### *STUDY 1.*

Age grouping of brood fowls did not show any influence on rate of lay. While pullets laid more eggs than hens, their rate of egg production was unexpectedly low as to be just similar to that of hens. Like egg production, egg shape is a trait that entirely depends upon the phenotype and genotype of the hen, hence, is not expected to be influenced by the brood cocks regardless of its age. Therefore, it was concluded that egg shape is more or less consistent in game fowls, and their age is not a factor that alters it.

Because brood fowls of similar ages (brood cock and brood hen; brood stag and brood pullets) laid lighter, thus smaller eggs than the pairings of varying ages, it is difficult to account this result to age pairing, since egg weight is entirely dependent upon the pullet or the hen. Thickness of the shell of the eggs laid by all the brood fowls used was just half of that of the commercial birds, which was about 0.40 cm. It is therefore concluded that game fowl eggs have characteristically thinner shells. Hatchability of eggs appeared to conform with the mating combination, to the brood pullets paired with brood stags attaining the highest hatchability while the brood hens paired with brood cocks, the lowest. Therefore, in attaining high hatchability, brood pullets may be paired with brood stags.

### *STUDY 2.*

Egg production of brood fowls supplemented with varying dosages of energy booster capsules was similar to those of the control. Short term supplementation did not readily improve egg production in game fowls.

Egg shape index was essentially the same among all the treatments, indicating that this was not influenced by energy booster supplementation. Game fowl eggs appeared to have a characteristic shape, the index of which ranged from 0.77 to 0.79. Contrary to expectations, egg weight was not influenced by energy booster supplementation because the energy to protein ratio of the diet may already have been altered by the addition of concentrate mix in the regular feed given to the brood fowls. Shell thickness was more a reflection of egg size in Study 1. The smaller the eggs the more they tended to have thinner shells than their bigger counterparts. However, it was not clear whether the relative increase in egg shell thickness with energy booster supplementation was treatment-related or not because of inconsistencies in egg size. Egg hatchability seemed to favor energy booster supplementation being higher in treatments where brood fowls were given higher doses of the supplement. Therefore it is concluded that the role of L-carnitine in the energy booster supplement is not just confined to energy mobilization. Egg weight was not influenced by energy utilization enhancer supplementation of brood fowls. It appeared to be a reflection of egg weight, since the bigger eggs produced the heavier game chicks.

## RECOMMENDATIONS

Based on the findings, the following are recommended:

A further study on pairing of the brood pullets paired with brood stags for a longer duration of time may have to be conducted to further test their productive efficiency in terms of rate of lay, hatchability and chick viability. A further experiment may have to be conducted on supplementing brood fowl with energy utilization enhancer for a longer duration of time and with a bigger experimental bird population. Moreover, further study on brood fowls supplemented with 10% HPS using pure breeder feed (with no concentrate) has to be conducted to test the rate of lay, percent hatch and viable chicks produced.

A further study on the brooding performance of male game chicks supplemented with of 10% HPS – without antibiotics or with 15% HPS + antibiotics could be coupled with a study on the same aspects of game fowl management on rate of lay, egg quality and chick viability during summer months.

The use of protein concentrate and energy utilization enhancer for brood fowls and game chicks is recommended, since there is an apparent improvement in performance despite the shortcomings like small sample size at the time the studies were conducted. And, the use of medications



following a veterinarian-prepared health program is essential because of the improvement in game chick performance.

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