STUDIES ON FERTILITY AND HATCHABILITY IN RHODE ISLAND RED (RIR) AND RHODE ISLAND WHITE (RIW) CHICKENS

BY

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DECLARATION

I hereby declare that this Thesis has been written by me and is a product of research work executed by me. It has not been accepted in any previous application for higher degree. To the best of my knowledge, this Thesis contains no materials previously published or written by another person except were due, references have been made in the text.

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CERTIFICATION

The Thesis entitled:" Studies on Fertility and Hatchability in Rhode Island Red (RIR) and Rhode Island White (RIW) Chickens" by Morontoye, Mufutau Ola meets the regulation governing the award of the degree of Master of Science of the Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

For :- My loving FULL SIBS:

Ademola Tundun Tola

Lanre

Asimiyu Bolaji

- My beloved and darling MOTHER - Alhaja Rafiat Aduke Layonu (RAL), she is everything to me after my God .....

&

- My Sheikh's; Ahmada Tijjani (RTA), Alhaji Ibrahim Nyass Al-Kaolaq (RTA), Moh'd - Jamiu Shamsudeen-I-Islam (RTA); and to the entire lovers of Toriqas all over the World.

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ABSTRACT

Two experiments were conducted to determine the effect of season and age of hen on reproductive traits in the Rhode Island Red (RIR) and Rhode Island White (RIW) strains of chickens. In the two experiments, data were obtained from two hundred and fifty two (252) hens and twenty eight (28) cocks. The traits measured were fertility, hatchability of all eggs, hatchability of fertile eggs and chick weight at hatching. The percentages of the reproductive traits were transformed on arc sine scale.

The mean monthly/seasonal percent fertility, hatchability of all eggs and hatchability of fertile eggs were 87.83% and 85.03%, 71.57% and 71.06%, 81.25% and 84.35% respectively for the RIR and RIW strains. Those obtained on the transformed scale were 69.75% and 67.10%, 58.35% and 58.69%, 64 80% and 67.67% respectively for the RIR and RIW strains. The differences within and between the strains in this experiment for fertility, hatchability of all eggs and of fertile eggs were not significant ($P>0.05$) with respect to month and season, though S.E and coefficient of variability were slightly higher in the RIW strain than in the RIR strain.

The mean percent fertility, hatchability of all eggs and of fertile eggs at different ages were found not to be significantly different in the RIR strain. In the RIW strain, significant age difference was not observed in fertility, however, age of hen was found to have a significant effect ($P<0.001$) on the hatchability of all eggs and of fertile eggs. A negative and no significant relationship was obtained with Pearson corellation between age and percent

fertility, hatchability of all eggs, hatchability of fertile eggs and day old chick weight (ACW). The overall mean percent fertility, hatchability of all eggs and hatchability of fertile eggs over the age group studied (56 - 72) weeks were 80.89% and 89.93%, 43.97% and 53.95%, 49.00% and 57.45% respectively for the RIR and RIW strains on the untransformed scale. The values on the transformed scale were 71.80% and 79.46%, 39.15% and 47.98%, 43.48% and 51.14% respectively for the RIR and RIW strains. The differences between strains in this experiment for fertility, hatchability of all eggs and of fertile eggs were significant ($P<0.001$).

In the two strains, age of hen was found to have a significant effeet($P<0.001$) on the average day old chickweight. The over-all average day old chick weight (ACW) over the age group studied was 35.65g for the RIR chickens and 34.97g for the RIW chickens. Difference between the strains for ACW was found to be significant ($P<0.01$).

In the two experiments, fertility percentages obtained for the two strains were generally high and encouraging. Hatchability percentages as expressed to all and fertile eggs on the other hand were higher in experiment 1 (effect of season on fertility and hatchability) and lower in experiment 2 (effect of age of hen on hatchability and chickweight). Failure of fertile eggs to hatch or early embryonic death accounts for the low hatchability percentages obtained for the RIR and RIW strains in experiment 2 rather than infertility. Thus the overall management of the birds on the farm needs to be generally improved.

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CHAPTER ONE

1.0 INTRODUCTION

The Nigerian poultry industry as at today greatly rely on foreign sources for the supply of parent stocks for the production of commercial day old chicks.

The production of fertile eggs and the level of hatchability of eggs are among some of the indices for estimating the economic value of a commercial hatchery operation. Apart from the fact that poor hatchability and fertility prevent adequate supply of chicks, poults, ducklings and keets to farmers, it is a great loss to poultry breeders and commercial hatcheries in terms of materials, money and time (Mast, 1987).

Generally, more losses have been found to occur in chicken eggs during the incubation period either due to low fertility or low hatchability. It is very important to reduce these losses to a minimum in order to use a few number of eggs to produce the highest number of chicks possible. Therefore, the need to increase poultry production is an attempt to provide sufficient animal protein to meet the protein requirements and demand of our geometrically increasing population. The importance and concern calls for poultry breeding centres, that will supply Nigeria's own grandparent and parent stocks to the private hatchery operators, to be established in order to minimize the dependance on imported

chicks. This goal can not be fully realized without a more detailed and clear knowledge of fertility and hatchability and of factors influencing them.

The incubation of eggs is the vital link in the reproductive cycle of the fowl. The study of fertility, hatchability, viability and embryonic mortality of eggs are of great academic and economic importance for modern poultry industries(Hafez and Kamar, 1955).

In poultry, traits of importance that are improved upon are either productive or reproductive. Reproductive fitness is a composite trait determined in the fowl mainly by egg production, fertility, hatchability and adult viability. In order to obtain a high percentage of chicks from eggs set for hatching, good fertility and hatchability are necessary. Many factors have been found to influence fertility and hatchability. While environmental factors affect both, inheritance has been found to play a more role in hatchability differences.

The reproductive potentialities of the eggs are influenced by environmental, genetical and physiological factors of the hen. Other factors affecting these two indices of hatchery profitability include plane of nutrition, conditions and length of storage of eggs, strain, egg quality, mating ratio, diseases (Landauer, 1967; North, 1981; Pascal, 1981; Stahl et. al., 1986; Peebles and Brake, 1987).

Since the fertility, hatchability of all eggs and fertile eggs are influenced mainly by environment, it is important to determine how monthly and seasonal variation, and increase in age of hen affect fertility, hatchability and weight of chicks at hatching for use in the hatchery division of poultry industries to improve the breeding flock.

This study therefore was designed to determine:

i. The effect of monthly and seasonal variations on the fertility and hatchability of the Rhode Island Red (RIR) and Rhode Island White (RIW) strains of chickens.

ii. The effect of age at sexual maturity (ASM) on fertility, hatchability and the weight of chicks at hatching in the Rhode Island Red (RIR) and Rhode Island White (RIW) strains of chickens.

CHAPTER TWO

LITERATURE REVIEW

2.1 **Fertility**:-

Fertility is the proportion of number of eggs that are capable of developing into a chick over the total number laid or incubated. Determining fertility is mainly done by candling either on the 7th or 18th day of incubation. It is extremely difficult to establish between low fertilization and a high degree of early embryonic death. Thus errors are at times made in determining fertility in most hatcheries because fertility and hatchability of fertile eggs are frequently considered together as hatchability of all eggs set. Thus, Crittenden et. al. (1957) separated fertility and hatchability by examining unhatched eggs for evidence of embryonic death. They pointed out that if apparently infertile eggs were not broken out to determine fertility, early embryonic death could be wrongly classified as infertile. As most hatcheries rely on candling to identify 'infertile' eggs, this incorrect classification is probably quite common. If therefore there is a correlation between early and late embryo mortality, such incorrect classification could lead to the assumption of spurious correlations between infertility, as determined by candling and hatchability of fertile eggs. Fechheimer (1972) therefore

indicated that early undetected mortality may account for loss of upto 11.2% of fertile eggs in broiler populations.

If inheritance plays any part on fertility at all, it is probably too small to merit consideration in normal breeding practice, which should concentrate on correct management (Mann, 1960). Not only are the whole of the reproductive physiology systems of both the male and female domestic fowls involved in this character (normally traits are affected by the physiology of one individual), but it should be realized that fertility problems are also closely related to social and mating behaviour patterns and that data collected from birds which are flock mated may be very different from data collected on pair mated or artificially inseminated birds.

Mann (1960) also showed that there are several major gene effects which cause embryo abnormalities and death, and these can be easily eliminated provided there are no heterozygoic advantage effect which tend to maintain stable polymorphisms. Research by Morton et. al. (1965) on relationships between blood groups, transferins and albumen in adults and mortality of progeny during incubation and in the first two days post hatching, indicates extremely complex genetic relationships.

Several other factors which are mainly environmental have been found to either directly or indirectly affect fertility of the

domestic fowl e.g nutrition, management systems, disease infection, egg storage treatments etc (Stahl et. al., 1986; Peebles and Brake, 1987).

2.2 **Hatchability**:-

Hatchability refers to the percentage of eggs hatched in to viable chicks after 21 or 22 days of incubation. Hatchability is either determined on the basis of all eggs set or of fertile eggs set after candling on the 7th or 18th day of incubation.

Hatchability is not an easy trait to measure partly because of the considerable variation between eggs of different strains in the time required in the incubator for the chicks to hatch. The ability of the chick to hatch is superficially a simple characteristic, nevertheless in biological terms it is extremely complex. Alternatively, the zygote may have formed but failed to develop beyond a specific point for one of a variety of reasons (Hunton, 1969).

Hatchability however, presents an entirely different story for although it is governed to a considerable extent or degree by environmental influences which are themselves complex, the difference between good and bad hatchability is fundamentally one of inheritance (Mann, 1960). Thus, in practice, hatchability is usually defined as the percentage of all fertile eggs from a given mating which produce live chicks without artificial assistance at piping time. During recent years, there has been a tendency to

base this percentage on the total number of eggs set. It is being claimed that in practice almost all eggs from a healthy breeding pen are infact fertile and that what are commonly called infertile or clears are nearly always fertile but that embryonic development has stopped at a very early stage.

Hatchability and fertility are major reproductive parameters which are most sensitive to environmental and genetic influences (Stromberg, 1975). Thus, Hays and Sanborn (1924) adviced that in practice, one should employ for breeding only those birds which have attained at least 85% hatchability. It allows for a reasurable but not excessive amount (15 percent) of embryonic mortality arising from non-inherited conditions.

That hatchability is an inherited character was first demonstrated by Gowell (1903), and the genetics of the character have since been intensively studied by other breeders and researchers. From correlation studies based on a large flock of RIR's, Hays and Sanborn (1924) concluded that hatchability is determined mainly by a single autosomal incompletely dominant gene (H). They claimed that two doses of this gene (HH) endowed a bird with the genetic capacity for 85% hatchability or more; a single dose (Hh) corresponds to figures ranging from 55% to 84% while the homozygous recessive (hh) leads to a hatchability of under 55 percent. It should however be noted that hatchability of the egg is influenced mainly by enviromental factors. Genetical, physiological as well

constitutional physical and chemical factors of the eggs also affect hatchability to a considerable extent. Hatchability has been found to be binomially distributed (Hunton,1969; Chaudary et. al.,1984) and thus improvement of this trait would become progressively more difficult as the mean hatchability approached 100% (Hunton,1969). However, Chaudary et. al. (1984) transformed their data using arc sine scale, and thus the degree of non-normality is reduced considerably. It also avoided the characteristic association between mean and variance (Crittenden et. al.,1957). Therefore, arc sine scale is expected to fulfil the statistical requirements of analysis more appropriately.

2.3 Effect of Season on Fertility and Hatchability

During the course of domestication, there has been a tremendous redistribution in the improved breeds of hens throughout the two hemispheres. The tropical and sub-tropical zones are characterized by certain seasonal climatological changes, namely the big fluctuation in atmospheric temperature, relative humidity, rainfall and small variation in day length when compared with the temperate zone.

The major environmental factors which affect the reproductivity of fowl is the atmospheric temperature (Kamar, 1954). Fertility and hatchability are lowered when the chickens are kept under high (Heywang, 1944) or low (Payne and Ingram, 1927) environmental temperatures. Heywang (1944) also showed that chickens kept under

air temperatures of 60° to 66° F have a high fertility and hatchability. Thus, it seems that atmospheric temperature is the limiting factor which affects fertility and hatchability rather than relative humidity.

In the female chickens, Wilson (1949) found that fertility was not seriously affected by high environmental temperature. Other studies have shown that environmental temperature does affect the fertility in the female fowl (Huston and Carmon, 1958; Clark and Sarakoon, 1967).

In the male chickens, high temperatures and long days have been found to cause production of the highest quantities of sperm and semen, but also causes deterioration in semen qualities (Kamar and Badreldin, 1959), which in turn causes deterioration of fertility and hatchability during the summer (Hafez and Kamar, 1955; Kamar, 1960).

Huston and Carmon (1958) showed that the fertility of eggs from females held in a variable temperature environment was significantly higher than that of females held at high environmental temperature and that there was no significant difference in hatchability between eggs of females at high and variable temperatures. However, Martin and Wessels (1965) reported that fertility have a slight and hatchability a considerable decline towards the end of the laying season from a survey of the

possible fluctuations in fertility and hatchability of eggs produced by flock mated light Sussex and New Hampshire hens in their first laying season.

A survey of studies of the effect of season on fertility and hatchability include that of Hafez and Kamar (1955), in which they considered four seasonal variations as thus; Winter; December, January and February. Spring; March, April and May; Summer; June, July, August and Autum as September, October and November. They observed that during the hot summer months, the temperature of the holding room was 2 to 6°C lower than the out door temperature while relative humidity was 5 to 15% higher than the out door. During the winter months, the temperature and the relative humdity in the holding room was almost similar to that of the out doors. A total of 3,947 eggs obtained from mating Fayoumi hens with five fertile cocks were incubated throughout twelve months in 1952/53 to study seasonal variation on fertility and hatchability. They observed minimum fertility in August while the maximum was in April. The average seasonal fertility during spring, summer, autumn and winter was found to be 87%, 72%, 80% and 91% respectively. When all the months were included, the average percent fertility was found to be 83%. The percent hatchability was found to be at its minimum during June and maximum during July and December. Thus, hatchability percent on basis of fertile eggs and all eggs was found to be 61% and 52% respectively. Hatchability percentage

during June was 35% and during July and December, it was 75% and 71% respectively.

While some studies on seasonal variation in fertility and hatchability of fowl eggs reported no significant differences between seasons, others have shown that there are significant differences in fertility and hatchability between seasons, thus Jalaludeen et. al. (1980) analysed data on 212,719 White Leghorn eggs over a four year period and found mean fertility in cold, hot, SW-Mansoon and NE-Mansoon seasons to be 88.0%, 86.01%, 89.75% and 88.01% respectively, hatchability of fertile eggs were 78.35%, 71.83%, 75.67% and 73.42% respectively. Differences between seasons were therefore concluded not to be significant. Sreenivasaiah and Joshi (1980) found fertility percentages to be 83.21 and 83.49 and hatchability of fertile eggs to be 76.95% and 81.36% for the Mansoon and winter periods respectively for the Japanese quails. Differences in fertility was therefore shown not to be significant, while differences in hatchability was very significant ($P<0.01$). They however, obtained a similar result in 1987 where fertility was 83.2 ± 0.02% and 83.49 ± 0.07% and hatchability of fertile eggs to be 76.95 ± 0.01% and 83.36 ± 0.05% for the eggs hatched in August (monsoon period) and November (winter period) respectively.

In another study, Babb and Huston (1972) showed that there was a considerable variation between year, hatcheries and season of the

year on hatchability of eggs from commercial broiler flock in a three year study (1968 - 1970) involving millions of eggs in the U.S. For the three year period studied, the highest mean monthly hatchability was found to occur between December and March (83 - 87)%. The lowest mean monthly hatchability occured between June and October (80 - 83)%. When the hatchability records of all the hatcheries are averaged for the three year period, they found a definate decline of approximately 5% during the summer months.

Similarly, Ramakrishnan and Unni (1975) reported that the effects of month and season on fertility and hatchability of the White Leghorn were all significant. This they discovered from analysis of records of fertility and hatchability of 227,327 White Leghorn eggs set over a 3-year period. They found that for eggs laid in December - February, March - May, June - August and September - November, average fertility over the 3-year period was 89.09, 86.89, 88.91 and 89.66 percent and hatchability 66.43, 64.37, 71.52 and 80.78 percent respectively. However, El-Maghraby et. al. (1969) found no significant difference in hatchability between year or season, but there were significant differences in egg fertility between year or season in Fayoumi.

2.4 **Effect of Age of Hen on Fertility and Hachability**

Variations in fertility and hatchability of eggs with increasing age of dams have been observed in different avian species and conflicting reports have been made. Low fertility and hatchability

of eggs laid by pullets during their first few weeks of production has frequently been observed in commercial poultry operations. This phenomenon was observed and well documented up to 28 weeks of age by Sunde and Bird (1959) who were unable to improve hatchability of young pullets by any of several nutritional treatments. They showed that eggs laid by pullets which had just reached sexual maturity did not hatch as well as later eggs.

Crittenden and Boren (1962) observed older birds of 30 to 38 weeks of age and found only a slight effect of age on fertility and hatchability. Also Smith and Boren (1975) studied the effect of age of hen on hatchability in two different lines of chickens and found significant linear differences between age group of hen from 20 to 37 weeks. However, Susan et. al. (1979) observed eggs from a young flock (34 - 49) weeks and that from an older flock (51 - 61) weeks and found that in the two groups, fertility and hatchability were encouraging, but the differences in fertility and hatchability between the two groups were not significant. They found that fertility was virtually 100% at about 34 weeks of age,but declined to about 89% by 60 weeks of age. Maximum hatchability was 91% at 44 weeks of age but declined to 82% by 60 weeks of age. They therefore, concluded that failure of fertile eggs to hatch was a greater source of overall loss in hatchability than was infertility.

In another study, Garwood and Lowe (1982) showed that fertility and hatchability increased with chronological ages, reaching a maximum in the sixth week after maturity. The hatchability of fertile eggs for the first 6 weeks were 79, 78, 82, 84, 85 and 88 percent respectively. Thus, they found a slight effect of age upon hatchability. However, no significant difference was found to occur with increased age to 30, 35 and 40 weeks as hatchability were 88, 87 and 88 percent respectively.

Asuquo and Okon (1993) showed in another study that age in lay and egg size within the first 6- months in lay will not significantly affect fertility and hatchability in Hyperco white broiler breeders. They found an overall flock mean percentage fertility within the 6-months in lay to be 82.62%, while average percentage hatch of fertile eggs was 81.72%.

They therefore, suggested that differences in percentage hatch could be due to embryonic development differential rather than fertility. On the otherhand, Aqcanas and Bandong (1970) analysed data on 117 White Cornish hens, 170 White Cornish pullets, 120 White Rock hens and 220 White Rock pullets. The hens aged 10 months and 11 days, and the pullets 6 months and 13 days at the start of the study. All hens were in their 7-months of production and pullets in their 2nd month of production. On average, pullets were found to be superior to hens in percentage of fertile eggs (91.18 versus 87.18) percent, hatchability of all eggs (73.69 versus 67.9) and percent hatchability of fertile eggs (81.23 versus 78.32) percent.

On the effect of subsequent breeding years on fertility and hatchability, Moseley and Landauer (1949) after reviewing several reports on chickens and turkeys concluded that after a second breeding year, hatchability and fertility declined with increasing age of dam. Hays and Talmadge (1949) in observation of identical Rhode Island Red breeders found drops of 5.8 and 7.5 percent between pullets and yearling years, 4.2 and 6.0 percent between yearling and 2-years birds and a drop of 12.6% between second and third breeding years. Similarly, Tomhave (1956, 1958) reported drops of 8.5% (202 days) and 2.5% (315 days) among New Hampshire pullets.

2.5 Effect of Age at Sexual maturity on Day Old Chick Weight

Not much had been reported on the effect of age at sexual maturity (ASM) on the weight of the subsequent chick at hatching (day old chickweight). However, there had been reports on rate at which weights are gained as the birds aged. Generally, the importance of bodyweight in egg type chickens have been recognized by commercial breeders and producers as it is an important indicator of general good health in birds. It has been found to increase as the birds increase in age,reached a maximum at about 6 months and start declining again. Ramirez et. al. (1984) reported chickweight at hatching (day old chick weight) as influenced by age of hen at 36 weeks and 60 weeks respectively and showed that chick weight averaged 39.41 and 41.76 grammes respectively at hatching

(P<0.05), and 69.44 and 69.70 grammes at 7 days of age for age of hen at 36 weeks and 60 weeks respectively.

2.6 **Breed and Strain Effect on Fertility and Hatchability**

Differences in fertility and hatchability of fertile eggs in chickens have been found to be due mainly to breed (Avigdor et. al., 1986). Mishra et. al.(1990) also reported that strain differences affect hatchability. Thus hatching ability has been shown to be more heritable in the dam strain (line) than in the sire strain in white leghorns (Naidu, 1964). It is therefore necessary in a breeding programme to select the females with high hatchability and to mate them with cockerels from hens whose eggs hatched well.

Singh and Belsare (1991) showed that for crossbred White Leghorn fowls, Rhode Island Red and Karaknat fowls during different seasons, egg hatchability averaged 54.8 ± 0.53, 47.3 ± 0.98 and 32.5 ± 2.04 respectively. They showed that egg hatchability varied in the three fowl breeds and the difference was found to be significant. Huston and Carmon (1958) reported that in New Hampshire, White Plymouth Rock and White Leghorn chickens held at variable and controlled environmental temperatures, statistically significant differences in fertility and hatchability were found to exist between breeds. Eggs from White Leghorns had the highest fertility, those from the New Hamsphire had the lowest and those from White Plymouth Rocks had intermediate fertility.

2.7 Other Factors Influencing Fertility and Hatchability

2.7.1. Genetic

Fertility and hatchability are major parameters of reproductive performance which are most sensitive to environmental and genetic influence (Stromberg, 1975). North (1978) reported that fertility is inherited to some extent as securing good hatchability seems to depend more on the breeders than the incubator. Thus, hatchability has been found to be determined by a very large number of genes (Byerly et. al., 1934) and could be improved upon by selective breeding (Wilson and Johnson, 1946). However, genetic analyses which have been reported indicated that the heritability of fertility as a compound character is low, probably of the order of 0.05 and that improvement by selection would be difficult. It is thus, not suprising that reported estimate heritability of fertile eggs and of all eggs set have been about 0.10 - 0.15 (Johannson and Rendel, 1968).

2.7.2 Nutrition

While some studies have revealed that fertility and hatchability were not improved in young pullets by any of the several nutritional treatments (Sunde and Bird, 1959), other investigations have shown that the traits could be improved by nutrition (Stahl et. al.,1986; Peebles and Brake,1987).

Feeding for maximum egg production of market eggs does not insure adequate feeding for high levels of embryonic development and hatchability. Reproduction imposes increased needs for certain vitamins and trace minerals on chicken female breeders that are not required for egg formation and as a consequence egg production.

Naber (1975) observed from the National Research Council (NRC) recommendations that the needs for riboflavins, pantothenic acid, pyridoxine and folacin are all increased for the breeders by 45 - 50 percent. On the other hand, requirements for vitamin A, D, Niacin, calcium, phosphorus, sodium and iodine are not increased in the breeders diet. Hence, good fertility and hatchability of eggs means that the breeder ration must be fortified to a greater extent for many but not all nutrients. Thus, Asuquo and Okon (1993) formulated their breeders ration for the Hyperco White broiler breeders to contain 2.95 Mcal M.E/kg and 16.25% crude protein (CP), and water was fed ad. lib. throughout their period of study on effect of age in lay and egg sizeon fertility and hatchability of the Hyperco White broilers and they obtained a generally high fertility and hatchability percentages.

2.7.3 Mating Ratio

It has actually been established that mating ratio affects fertility of poultry eggs (Landauer,1967; North,1981) . Some of the different mating ratios used in the determination of age and seasonal influence on fertility and hatchability of fowl eggs

included that of Garwood and Lowe (1982) in which the ratio of males to females was 1:9 within each pen for a total of 13 floor pens (with each pen measuring 3.00* 1.10 metres). The pullets were trapnested 7 days a week and mean percent hatchability for the study period was 84.3 percent.

Asuquo and Okon (1993) managed the Hyperco White broiler breeders in four replicate breeding floor pens measuring a 2.95* 1.05 metres with ratio of cock to hen being 1:7. Each Pen thus provided an average floor spaceof 0.26M^2 per bird. The overall flock mean percent fertility and hatchability were found to be 82.62 and 81.72 percent respectively. However, Sreenivasaiah and Joshi (1980) maintained a mating ratio of 1:19 for eggs laid between 60 to 120 days of age for 2-monsoon and 2-winter hatches and they obtained high fertility and hatchability percentages.

2.7.4 Diseases

Seneviratna (1969) and Okaeme (1983) reported that clear or infertile eggs or lowered hatchability may probably occur due to salmonellosis. Many dead in shell or piped eggs had been accredited to Salmonella and Malcoplasma infected flock. Most diseases have adverse effect on ultimate viability of the eggs and chicks that may emerge. Thus, fertility and hatchability will therefore be reduced if the breeding flock is unhealthy. Proper attention to health management on breeding farms will eliminate chances of disease interfering with fertility and hatchability.

Therefore, healthy stocks are essential for the production of sound hatching eggs.

2.7.5 **Hatching Egg Condition**

Improper care of hatching eggs can greatly reduce hatchability and fertility (Esminger,1983). Hatching eggs are more frequently collected than those of the table eggs. Under normal temperature, four times daily, but under extreme temperatures every 1 hour collection is recommended and must be stored at temperatures of below 50 - 60°F with relative humidity of about 70 - 80%. Storage effect play an important role in fertility and hatchability. It is well documented that the longer the eggs are stored before incubation the lower will be the hatchability. For good hatchability, eggs should not be stored for more than 7-days(Altabari and Kunodi,1989), as moistore loss from the eggs would be greater than 1% (Ahmed et. al.,1983).

North (1972,1978) reported that age of hatching eggs affect day old chicks quality. He reported that shell quality, over storage, shape of egg, size of eggs and variance in incubator temperature are physical differences that could affect hatchability.

Oluyemi and Roberts (1979) reported that extreme porosity of egg shell can allow spoilage organisms to enter the eggs and would also cause excessive loss of moisture from the eggs, hence shell texture

must be good and egg surface smooth. Soiled eggs are usually not set in the incubator as well as cracked eggs.

2.8 **Incubators/Incubator Problems**

Incubator simply refers to where eggs are hatched to chicks, poults, keets, etc by artificial means. Eggs have been incubated for thousands of years by artificial means. Over the years, incubators have been developed and refined to the point where they are almost completely automatic. Modern commercial incubators are heated by electricity, have automatic egg turning devices and are equiped with automatic controls to maintain proper levels of heat, humidity and air exchange and today, they vary in capacity from a few thousands to many thousands of eggs.

Many symptoms of trouble such as clear with blood rings (blood spots), dead germs, abnormal keets/chicks formation, draggy hatch or delayed hatch are caused by too high or too low temperatures and humidity during incubation, which in turn would result in poor hatchability. Morgan (1985) advised that eggs should be checked at least twice daily to be certain that the incubation temperature is right and must be turned at least 3-times daily after the first 24 hours. Therefore, a good hatchery manager must not toy with the hatchery machines and must have supplementary power supply incase of power failure from the main supply line because of danger of suffocation to the developing embryos during power failure.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Site

The study was conducted in Shika, Zaria (Kaduna State), in the subhumid zone. Shika is located in the northern guinea savannah, about 650 metres above sea level. It lies between latitude 10°North and longitude 7° East. The average annual rainfall is 1,100mm and this spread from late April or early May to late October. The mean minimum and maximum temperature vary from 20°C to 36°C depending on the season. Relative humidity during the wet season is about 76% and 30% during the dry season.

3.2 Experimental Site and Materials

The experiment was carried out at the National Animal Production Research Institute (NAPRI), Shika, which is located in about 22km Northwest of Zaria. The poultry breeding unit of the Institute serves as the experimental site, using the Rhode Island Red (RIR) and Rhode Island White (RIW) strains of chickens as the experimental materials.

The Rhode Island Red and Rhode Island White chickens are American breeds of chicken, dual purposed and well adapted to tropical environment. They are medium sized and are one of the most popular breeds of poultry in Africa. Large number of birds were imported ten years ago (1985), acclamatized and bred for a number of

generations. Selection of the birds for increased egg production (egg number) over successive generations for production of a commercial hybrid that have high egg producing capacity and intensity have been achieved by NAPRI. The birds are now in their 6th generation of selection for egg number. Mature weights for birds are 3.0kg for cocks, 2.5kg for hens and between (1.5 and 2.2)kg for cockerels and pullets depending on their ages.

3.3 **Mating**

The selected birds for the experiment were brought down from the cage and transferred to deep litter floor pen houses. Two hundred and fifty two (252) hens and twenty eight cocks of the RIR and RIW layer breeders aged (56 - 60) weeks old from five different hatches raised on the farm were used. The birds were managed in twenty eight replicate breeding floor pens with ten (10) birds (1cock and 9 hens per pen. Each pen measured 3.04* 1.14 metres with the floor covered with a 3cm layer of wood shavings. Thus, floor space allowed per bird varied from 0.15 to 0.50m^2 depending on the age of bird.

The birds were earlier wing and leg tagged. Collection of fertile eggs started three weeks after mating. Trapnest were placed in each pen so that accurate records of the eggs will be maintained. On each egg laid, the strain, pen number and hen's tag number were recorded. Trapnests were checked hourly. Egg laid on the floor

were regarded as common pen and were thus not used for the experiment.

The fertile eggs that were collected were stored in a cooler in the hatchery egg holding room at between 10 - 14°C and set on a weekly basis for thirteen consecutive weeks.

3.4 **Hatching**

The fertile eggs were set every week in a large egg capacity western air type incubator that turns egg automatically four times a day. Eggs were selected against dirt, various deformities and cracks. They were seperated according to age of hen laying them and arranged on trays according to pen. The eggs were fumigated with potassium permanganate (KM_nO_4) and hydrogen peroxide (H_2O_2) in the Fumigation room against hatchery diseases (Salmonella and Malcoplasma). They were left for thirty minutes before being transferred in to a combined setter-hatcher incubator which was set at 36.5° - 38.5°C and a relative humidity of 60 - 65%.

On the 18th day of incubation, the eggs were candled using bright electric bulbs/fluorescent tubes. The number of infertile eggs were noted, recorded and then removed. Eggs containing live embryos were transferred in to the hatcher for 3-days during which the chicks hatched and were properly dried, tagged and weighed. The number of chicks hatched were recorded and were later taken to the brooding houses.

3.5 **Brooding and Rearing**

This is the period when chicks were taken care of from day old to about eight weeks of age. It mainly involved the provision of heat, water and feed. The chicks were artificially brooded (supply of heat by electric bulbs, lanterns, and stoves to ensure the temperature is adequate for the chicks, (about 35°C)). Balanced ration and water were offered ad. libitum from day old. Initially, feed was spread on newspapers from which the chicks fed for a few days until they were able to reach for food from the low feeding troughs provided in the brooding house.

The chicks were vaccinated against marek's disease in the brooding house on day 1 while newcastle and infectious bronchitis vaccines, coccidostat, antistress, dewormer etc were also administered (as shown in Table 2).

At about eight weeks, chicks were debeaked and transferred to deep litter floor pen rearing houses. Their ration was changed from chick mash to growers mash, and the feeding trough were replaced with appropriate ones.

At about twenty weeks of age, the birds were transferred to their laying cages to monitor their egg production potentials for the normal selection (for egg number) practice of NAPRI. At this stage, their ration was changed to breeders mash (as shown in Table 1). This study thus cover the brooding, rearing, laying and

hatching phases with more emphasis on the laying and hatching phases.

Table 1: Composition of feed

Ingredients	Chick mash	Growers mash	Breeder mash
Maize	54.2	43.0	49.0
Rice offal	10.0	20.0	12.0
Groundnut cake	23.5	12.5	20.2
Soyabean meal	-	20.0	10.0
Limestone	1.5	1.5	7.5
Bone meal	2.75	2.75	2.75
Salt	0.3	0.3	0.3
Vitamin premix	0.25	0.25	0.25
Total (%)	100.00	100.00	100.00
Calculated Analysis			
Total phosphorus %	0.73	0.7	0.6
Lysine %	1.0	0.8	1.0
Methionine %	0.7	0.8	0.7
Calcium %	1.0	1.0	4.0
Crude protein %	19.25	17.0	16.0
Energy K cal	2,800	2,400	2,400

Table 2: Vaccination/Medication Schedule

Age of bird	Vaccination/medication
Day 1	NDV(1/o) + Mareks
Day 1 - 15	Anti stress
Day 10	IBDV - First dose
Day 24	IBDV - second dose
Week 3 (for 5 days)	Coccidiostat
Week 4	NDI (1)
Week 6 (for 5 days)	Coccidiostat
Week 7	NDV(k) First dose + FPV
Week 8	Dewormer
Week 9 (For 5 days)	Coccidiostat
Week 12 (For 5 days)	Coccidiostat
Week 16	NDV(k) second dose
Week 17 (For 1 day)	Dewormer

* NDV (1/o) - Newcastle disease vaccine (intra occular)
* NDV (L) - Newcastle disease vaccine (Losota)
* NDV (K) - Newcastle disease vaccine (Kumarov)
* IBDV - Infectious Bursal disease Vaccine (Gumboro)
* FPV - Fowl pox vaccine

3.6 Measurement of Reproductive Traits (Fertility and Hatchability) and Day Old Chickweight

Two experiments were carried out to determine the influence of season on fertility and hatchability, and the effect of age of hen on hatchability and the subsequent chickweight at hatching in the Rhode Island Red and Rhode Island White strains of chickens.

3.6.1 Seasonal Variations Effect on the Fertility and Hatchability of Eggs

For this experiment, data was obtained between 1991 and 1995 from the Poultry Research Programme unit of the National Animal Production Research Institute, Shika - Zaria, compiled and analysed for monthly and seasonal effect on fertility and hatchability in the RIR and RIW chickens.

For this study, seasonal variation was broadly classified as follows:-

i. Dry cold period - November to January

ii. Dry hot period - February to April

iii. Rainy period - May to October

3.6.2 Effect of Age of Hen on Hatchability and Day Old Chickweight

The birds of the selection lines of the two strains of chickens (RIR and RIW) under consideration for this experiment were obtained from five different hatches and their ages ranged from 56 - 60 weeks old as at when the experiment actually commenced. Fertile eggs from the hens were separated according to the five different hatches of birds laying them and thus to the respective ages of

hens laying them with the aid of the list of selected birds from the computer. The list included the followings: the chick number, pen number, date of hatch, hatch number, strain. The chick number, pen number and strain were thus recorded on every trapnested fertile eggs and these assisted in separating them according to the ages of hens laying them. The trapnested fertile eggs were set in the incubator according to pens on a weekly basis and the subsequent chick emerging upon hatching were tagged for ease of identification to the ages of hen producing them and also for their weighing. The emerging chicks were thus weighed individually directly from the hatch tray to the nearest gram using an electronic scale.

Number of eggs set, number of fertile eggs, number of eggs hatched in to viable chicks and the weight of chicks upon hatching were recorded. Percent fertility, hatchability of all egg set, hatchability of fertile eggs and the average day old chickweight (ACW) for the hens aged from 56 - 72 weeks were obtained for the two strains and used for statistical analysis. Strain comparison on the birds in terms of semen quality revealed that volume of semen in RIW chickens is higher than that of RIR, while sperm concentration in RIR is higher than that of RIW. Age on the other hand had no effect on semen quality while season has no effect on volume of semen but has effect on sperm concentration (i.e sperm concentration during cold weather are normaly higher than during the hot seasons.

3.7 **Data Analysis**

Data collected during the study were entered into the computer using Dbase IV programme. Analysis of the data was carried out with System Analytical Statistics (SAS) Statistical Package (SAS, 1985).

The following traits were measured:

i. Fertility
ii. Hatchability of all eggs set
iii. Hatchability of fertile eggs
iv. Age at sexual maturity (ASM)
v. Day old chick weight

Percent fertility, percent hatch and hatchability percent were calculated as follows:

$$\text{Percent fertility} = \frac{\text{Total number of fertile eggs}}{\text{Total number of eggs set}} \times 100$$

$$\text{Percent hatch} = \frac{\text{Total number of chicks hatched}}{\text{Total number of eggs set}} \times 100$$

$$\text{Percent hatchability} = \frac{\text{Total number of chicks hatched}}{\text{Total number of fertile eggs}} \times 100$$

Percent fertility, percent hatchability of all eggs and percent hatchability of fertile eggs were transformed on arc sine scale (Snedecor and Cochran, 1980) using Systat (Wilkinson, 1988).

3.7.1 Statistical Analysis

i. Experiment A: Effect of Seasonal Variation on Fertility and Hatchability

A one way analysis of variance was carried out with season and month as the main effect (independent variable). Fertility and hatchability were analysed using the model;

$$Y_{ij} = \mu + A_i + e_{ij}$$

where

μ = the overall mean

A_i = season of the year or month

e_{ij} = the error term

The assumptions are;

The A's and e's are identical and independently distributed, IID with means and variances equal to zero. A's and e's are mutually uncorrelated. Treatment means were separated using Duncan's Multiple Range Test, DMRT (Steel and Torrie, 1980).

ii. Experiment B: Effect of Age of Hen on Hatchability and Day Old Chickweight

A one way analysis of variance was also carried out with age at sexual maturity (ASM) as the main effect (independent variable). Fertility, hatchability and day old chickweight were analysed using the model;

$$Y_{ij} = \mu + B_i + e_{ij}$$

where,

μ = the overall mean

B_i = Age of hen at which eggs were obtained

e_{ij} = the error term

It is also assumed that the B's and e's are identical and independently distributed, IID with means and variances equal to zero. The B's and e's are mutually uncorrelated.

Treatment means were separated using least square means/pairwise difference (PDIFF).

Analysis of variance was also carried out on the fertility, hatchability of all eggs and of fertile eggs, ACW with strain as main effect to compare the two strains in the two experiments.

Pearsons correlation analysis was obtained to determine the relationship between age and fertility, hatchability of all eggs, hatchability of fertile eggs and day old chick weight (ACW)

4.0 CHAPTER FOUR

RESULTS

4.1 Effect of Season on Fertility and Hatchability

Table 4 - 7 show the effect of month and season on the percent fertility, percent hatchability of all eggs and percent hatchability of fertile eggs(untransformed and transformed scale)for the RIR and RIW strains of chickens respectively.

Monthly and seasonal variations have no significant effect (P>0.05) on the reproductive traits for the untransformed and transformed scales in the two strains of chickens.The mean seasonal/monthly percent fertility, hatchability of all eggs and of fertile eggs were found to be 87.83%, 71.57% and 81.25% respectively for the RIR on the untransformed scale while on the transformed scale 69.25%, 58.35% and 64.8% respectively were obtained. similarly, the mean seasonal/monthly percentages for the respective traits in the RIW strain on the untransformed scale were 85.63%, 71.06% and 84.35%. Values obtained on the transformed scale for the RIW strain were 67.10%, 58.69% and 67.67% respectively.

The S.E and coefficient of variability are higher in the RIW strains than the RIR strain, though there was no significant difference (P>0.05) in the mean seasonal percent fertility, hatchability of all eggs and hatchability of fertile eggs on the untransformed and transformed scale between the two strains (Table 8). However, the RIR strain had slightly higher percent fertility, hatchabilty of all eggs and of fertile eggs than the RIW strain.

In the RIR strain, minimum fertility was in April while the maximum was in February. Low fertility was maintained during April, May, July and August when the average atmospheric temperature was 32.3°C with a relative humidity of 45.7% to 82.9%. High fertility levels were maintained during September, December, January, February and March when the average atmospheric temperature was 29.5°C. The relative humidity during this period ranged from 18% to 78% (Table 3). The average seasonal fertility was 88.61% during the dry cold, 87.70% during the dry hot and 87.29% during the Rainy period on the untransformed scale. Values obtained on the transformed scale were 70.58% during the dry cold, 69.67% during the dry hot and 69.22% during the rainy period (Table 6). The percent hatchability of all eggs set and of fertile eggs was at minimum during April and maximum during December. The percent hatchability of all eggs and of fertile eggs decreased in April and July when the average atmospheric temperature was about 33°C and relative humidity of 45.7% and 81.2% respectively. Meanwhile, it increased between December, February and March at an average atmospheric temperature of about 30°C and a relative humidity ranging from 18% to 28.1%. The respective average seasonal percent hatchability of all eggs and of fertile eggs were 73.04% and 81.97% during the dry cold period, 72.24% and 82.04% during the dry hot period and 69.91% and 80.07% during the rainy period on the untransformed scale. Values obtained on the transformed scale were 59.11% and 65.60% during the dry cold period, 59.57% and 65.80% during the dry hot period and 56.76% and 63.37% during the rainy period respectively (Table 6).

In the RIW strain, minimum fertility was in November, while the maximum was in February. Low fertility was maintained during November, April, May, July and August when the average atmospheric temperature was 32.3°C with a relative humidity ranging from 29.9% to 82.9%. High fertility levels were maintained during September, December, January, February and March when the average atmospheric temperature was 30°C. The relative humidity during that period ranged from 18% to 78% (Table 3). The average seasonal fertility was 83.46% during the dry cold period, 87.44% during the dry hot period and 85.57% during the rainy period on the untransformed scale. Values obtained on the transformed scale were 66.87% during the dry cold period, 69.35% during the dry hot period and 65.23% during the rainy period (Table 7). The percent hatchability as expressed to all eggs and to fertile eggs was at minimum during april and maximum during February. The percent hatchabilty of all eggs and of fertile eggs decreased in April, May and December when the average atmospheric temperature was ranging from 29.5°C to 36.1°C and relative humidity of 28.1% to 69.1%. It however, increased in February and March at average atmospheric temperatures of 31.6°C and 35.1°C, and relative humidity of 18% and 22.9%. The average seasonal percent hatchability of all eggs and of fertile eggs was 66.05% and 85.34% during the dry cold period, 73.49% and 83.37% during the dry hot period and 72.38% and 84.51% during the rainy period respectively on the untransformed scale. Values obtained on the transformed scale were 57.96% and 68.98% during the dry cold period, 59.54% and 67.15% during the dry hot period and 58.48% and 67.24% during the rainy period respectively (Table 7).

4.2 Effect of Age of Hen on Fertility and Hatchability

Table 9 - 12 show the mean percent fertility, percent hatchability of all eggs and of fertile eggs on the untransformed and transformed scales by age of hen in the RIR and RIW strains of chickens. No significant differences ($P>0.05$) in the percent fertility, percent hatchability of all eggs and of fertile eggs due to age were obtained in the RIR strain on the untransformed and transformed scale. In the RIW strain, significant differences were not observed in the percent fertility due to age. However, age of hen was found to have a significant effect ($P<0.001$) on the percent hatchability of all eggs and of fertile eggs on the untransformed and transformed scales.

Overall, mean percent fertility, hatchability of all eggs and of fertile eggs over the age group studied was 80.89%, 43.87% and 49.00% respectively for the RIR on the untransformed scale, while on the transformed scale 71.80%, 39.15% and 43.48% respectively were obtained (Table 9 and 10). Similarly, the overall mean percentages for the respective traits in the RIW strain on the untransformed scale were 89.93%, 53.95% and 57.45%. Values obtained on the transformed scale were 79.46%, 47.98% and 51.14% respectively (Table 11 and 12).

The S.E and coefficient of variability are lower in th W strain than those of the RIR strain. significant strain ferences ($P<0.001$) existed in the overall mean percent rtility, hatchability of all eggs and of fertile eggs on the untransformed

and transformed scale over the age group studied. The RIW strain had significantly higher overall mean percentages of reproductive traits than the RIR strain (Table 14).

In the RIR strain, maximum fertility of 92.31% on untransformed scale and 81.95% on the transformed scale were obtained at 62 weeks of age and minimum of 67.96% and 69.25% on the untransformed scale and 60.10% and 60.38% on the transformed scale were obtained at 68 and 72 weeks of age respectively. Minimum percent hatchability as expressed to all eggs and to fertile eggs obtained were 28.92% and 30.42% on the untransformed scale and 27.03% and 2[illegible]2% on the transformed scale at 68weeks of age and maximum percent hatchability of all eggs and of fertile eggs were 54.40% and 58.36% on the untransformed scale and 49.06% and 52.77% on the transformed scale at 62 week of age respectively (Table 9 and 10). There is however a decrease in percent fertility, percent hatchability of all eggs and percent hatchability of fertile eggs with increasing age of hen as there are variations or fluctuations (increasing and decreasing trend) between age groups.

In the RIW strain, maximum fertility of 97.80% on the untransformed scale and 82.87% on the transformed scale at 60 weeks of age was obtained and minimum of 78.64% on the untransformed scale and 68.86% on the transformed scale was obtained at 70 week of age. The minimum percent hatchability as expressed to all [illegible]gs and to fertile eggs obtained was 21.82% and 23.26% on the u[illegible]ansformed scale and 21.50% and 22.38% on the transformed scale at 64 weeks of

age and a maximum of 71.81% and 71.56% on the untransformed scale and 64.19% and 67.12% on the transformed scale was obtained at 61 weeks of age respectively (Table 11 and 12). Decrease in percent fertility, percent hatchability of all eggs and percent hatchability of fertile eggs with increasing age of hen also occur in this strain with variations or fluctuations (increasing and decreasing trend) between age groups. Thus hatchability percentages between 56 and 63 weeks of age in RIW were significantly higher than the hatchability percentages between 64 and 72 weeks of age except the hatchability percentages obtained at 69 weeks of age (Table 12). Simple Pearson's correlation was computed for age and a pair of characters in the two strains and these are presented in (Table 15 and 16). There was a negative relationship between age and percent fertility, hatchability of all eggs and hatchability of fertile eggs.

4.3 **Effect of Age of Hen on Day Old Chickweight**

Table 13 shows the average day old chickweight with increasing age of hen in the RIR and RIW strains of chickens. Age of hen was observed to have a significant effect ($P<0.001$) on the average day old chickweight in the RIR and RIW strains respectively. The overall average day old chickweight over the age group studied was 35.65g for the RIR strain and 34.97g for the RIW strain. Analysis of variance shows that the overall average day old chickweight in RIR strain was significantly higher ($P<0.01$) than those of the RIW strain . Highest average day old chickweight of 37.56g at 65 weeks of age and 37.38g at 71 weeks of age were obtained for the RIR and

RIW strains respectively, while the lowest average day old chickweight for the RIR was 33.79g at 62 weeks of age and 33.33g at 57 week of age for the RIW strain. In the RIR and RIW strains, chickweight at hatching could be said to increase as birds increase in age, and day old chickweight between/from 64 and 72 weeks of age are slightly significantly higher than those obtained between/from 56 and 63 weeks of age with increasing and decreasing trend noticed between age groups in the 2 strains. A no significant positive relationship was obtained between age and day old body weight of chickens. Though, values obtained for the RIR chickens were higher statistically than those obtained for RIW as in (Table 15 and 16).

4.4 Effect of Transformation

Transformation had no significant effect ($P>0.05$) on the reproductive traits with respect to season and age of hen in the two experiments, although the percentages of the reproductive traits on the transformed scale were lower compared to the untransformed scale in the two strains. However, the transformed percentages for the reproductive traits had a generally lower root mean square error (RMSE) or standard error (S.E) and higher coeffficient of determination (R^2) as shown in the analysis of variance tables (Tables A-dd and a-u) when compared to the untransformed data, indicating that the transformed scale has better Statistical goodness of fit than the untransformed scale.

Table 3: Average climatological conditions (meteoroligcal data) during the period of study

Month	Rain-fall (mm)	Temperature (°C) S_{max}	S_{min}	Relative humidity (%) 0900 gmt	1500 gmt	Sunshine (Hrs)
Nov.	0.52	31.8	14.1	39.9	29.2	8.6
Dec.	1.00	29.5	13.0	28.1	22.5	7.4
Jan.	NIL	28.6	15.3	18.0	17.5	6.5
Feb.	NIl	31.6	15.3	18.0	14.4	7.5
March	7.5	35.1	19.2	22.9	21.4	6.9
April	29.9	36.1	22.3	45.7	31.2	7.5
May	123.1	33.7	21.0	69.1	48.8	7.4
June	163.3	30.8	19.8	76.1	56.5	6.4
July	218.7	28.7	20.0	81.2	64.9	6.2
Aug.	274.4	28.5	19.8	82.9	71.7	5.1
Sept.	139.3	30.1	19.8	78.0	64.8	6.4
Oct.	40.4	32.2	18.5	66.6	49.3	8.2

i = mean of day S_{max} = Screen maximum S_{min} Screen minimum

Source: Institute for Agricultural Research Climatological data, Meteorological Department, Samaru - Zaria

Table 4: Effect of month on percent fertility, percent hatchability of all eggs and of fertile eggs in strain 1 (RIR)

Treatment (Month)	PF	PHA	PHF	TPF	TPHA	TPHF
November	87.525	68.275	77.100	69.800	56.275	62.325
December	89.633	79.900	89.133	71.627	63.400	70.933
January	89.250	72.300	80.950	71.100	58.350	64.150
February	90.000	79.350	88.200	71.600	63.050	69.750
March	89.725	77.575	86.500	71.125	64.500	69.950
April	84.700	63.350	74.500	67.250	52.900	59.675
May	87.675	70.975	80.950	69.350	57.575	64.500
July	87.350	65.750	75.250	69.300	54.000	60.050
August	85.050	69.000	81.150	67.200	56.150	62.650
September	88.000	71.375	81.050	70.50	57.625	64.250
Mean	87.829	71.571	81.255	69.758	58.348	64.802
SE±	14.428	89.201	76.901	9.308	29.537	43.691
C.V	4.32	13.196	10.792	4.37	9.26	10.20
Significance	NS	NS	NS	NS	NS	NS

ACW = Average day old chickweight
S.E = Standard error
C.V. = Coefficient of variability
Significance = Significance level
S.D = Standard deviation
PF = Percent Fertility
PHA = Percent Hatchability of all eggs
PHF = Percent Hatchability of fertile eggs
TPF = Transformed percent fertility
TPHA = Transformed percent hatchability of all eggs
TPHF = Transformed percent hatchability of fertile eggs
RIR = Rhode Island Red
RIW = Rhode Island White

Table 5: Effect of month on percent fertility, percent hatchability of all eggs and of fertile eggs in strain 2 (RIW)

Treatment (Month)	* PF	* PHA	* PHF	* TPF	* TPHA	* TPHF
November	77.000	63.35	85.100	62.875	54.625	70.075
December	90.950	61.85	89.800	72.050	64.550	71.600
January	88.050	71.65	81.350	69.700	58.050	64.150
February	91.950	85.10	92.550	73.050	67.300	74.350
March	88.750	81.55	91.925	70.550	64.575	73.625
April	83.875	59.63	70.225	66.750	50.625	57.075
May	81.600	65.30	80.175	64.525	53.950	64.500
July	86.950	75.20	86.500	53.450	60.350	68.500
August	85150	76.80	89.100	68.050	61.350	70.600
September	88.550	75.85	85.550	70.400	60.625	67.675
Mean	85.639	71.063	84.35	67.10	58.693	67.673
SE±	74.7	155.28	88.158	57.34	43.301	53.773
C.V	10.09	17.53	11.13	11.28	11.21	10.83
Significance	NS	NS	NS	NS	NS	NS

* as in Table 4

Table 6: Effect of season on percent fertility, percent hatchability of all eggs and of fertile eggs in strain 1 (RIR)

Treatment (Season)	* PF	* PHA	* PHF	* TPF	* TPHA	* TPHF
Dry Cold	88.611	73.044	81.967	70.578	59.11	65.600
Dry Hot	87.770	72.240	82.040	69.670	59.570	65.800
Rainy	87.292	69.908	80.067	69.217	56.758	63.367
Mean	87.82	71.570	81.255	69.758	58.348	64.800
S.E±	13.82	95.97	82.301	8.936	36.55	47.549
C.V	4.23	13.68	11.16	4.28	10.36	10.64
Significance	NS	NS	NS	NS	NS	NS

* as in Table 4

Table 7: Effect of season on percent fertility, percent hatchability of all eggs and of fertile eggs in strain 2 (RIW)

Treatment (Season)	* PF	* PHA	* PHF	* TPF	* TPHA	* TPHF
Dry Cold	83.463	66.050	85.337	66.875	57.962	68.975
Dry Hot	87.440	73.490	83.370	69.530	59.540	67.150
Rainy	85.567	72.383	84.508	65.225	58.475	67.242
Mean	85.63	71.063	84.360	67.108	58.693	67.673
S.E±	73.905	178.062	115.445	64.538	61.52	69.428
C.V	10.03	18.77	12.73	11.97	13.36	12.31
Significance	NS	NS	NS	NS	NS	NS

* as in Table 4

Table 8: Effect of strain on mean seasonal percent fertility, percent hatchability of all eggs and of fertile eggs

Treament (Strain)	*PF ± SD	*PHA ± SD	* PHF ± SD	* TPF ± SD	*TPHA ± SD	*TPHF ± SD
RIR (1)	87.829± 3.634	71.570± 9.564	81.255 ± 8.817	69.758± 2.943	58.348± 5.983	64.808± 6.762
RIW (2)	85.63± 8.44	71.063± 13.24	84.350± 10.391	67.100± 7.974	58.693± 7.595	67.673± 8.079
C.V	7.44	16.15	11.62	8.72	11.66	11.23
Significance	NS	NS	NS	NS	NS	NS

* as in Table 4

Table 9: Effect of Age of hen on percent fertility, percent hatchability of all eggs and of fertile eggs on straint 1 (RIR)

Age (Weeks)	* PF ± S.E	* PHA ± S.E	* PHF ± S.E
56	82.66 ± 3.78	50.62 ± 4.68	57.30 ± 4.98
57	85.66 ± 5.05	50.43 ± 6.25	57.00 ± 6.65
58	73.71 ± 5.19	46.14 ± 6.42	49.00 ± 6.84
59	88.48 ± 5.91	46.62 ± 7.32	52.14 ± 7.79
60	83.59 ± 5.91	42.51 ± 7.32	44.88 ± 7.79
61	76.93 ± 5.35	48.96 ± 6.62	53.24 ± 7.24
62	92.31 ± 6.55	54.40 ± 8.10	58.36 ± 8.63
63	81.36 ± 6.14	46.32 ± 7.60	52.32 ± 8.09
64	80.16 ± 4.00	38.83 ± 4.95	41.57 ± 5.27
65	89.97 ± 4.98	45.07 ± 6.17	47.92 ± 6.56
66	83.74 ± 5.52	36.77 ± 6.83	41.80 ± 7.27
67	87.34 ± 6.4	34.08 ± 7.93	39.69 ± 8.44
68	67.96 ± 5.8	28.92 ± 7.18	30.42 ± 7.65
69	77.47 ± 5.1	41.77 ± 6.33	51.27 ± 6.74
70	75.93 ± 5.3	46.42 ± 6.62	54.36 ± 7.04
71	82.90 ± 6.7	38.85 ± 8.30	46.52 ± 8.83
72	69.25 ± 5.4	42.15 ± 6.72	48.54 ± 7.51
Mean	80.89	43.87	49.00
C.V	37.99	86.7	82.6
Significance	NS	NS	NS

* as in Table 4

Table 10: Effect of Age on Transformed percent fertility, percent hatchability of all eggs and of fertile eggs in strain 1 (RIR)

Age (Weeks)	* TPF±S.E	* TPHA±S.E	* TPHF±S.E
56	74.15 ± 3.40	45.19 ± 4.04	50.99 ± 4.36
57	75.94 ± 4.54	45.04 ± 5.39	51.21 ± 5.82
58	66.09 ± 4.67	40.97 ± 5.55	43.54 ± 5.99
59	78.19 ± 5.31	41.34 ± 6.32	45.74 ± 6.82
60	74.59 ± 5.31	37.77 ± 6.32	39.70 ± 6.82
61	68.43 ± 4.80	43.49 ± 5.71	46.94 ± 6.17
62	81.95 ± 5.89	49.06 ± 7.00	52.77 ± 7.56
63	72.19 ± 5.52	41.60 ± 6.56	46.40 ± 7.09
64	71.26 ± 3.59	32.73 ± 4.27	35.13 ± 4.61
65	79.7 ± 4.48	40.81 ± 5.32	42.94 ± 5.75
66	74.97 ± 4.96	33.18 ± 5.89	37.13 ± 6.36
67	76.55 ± 5.76	29.55 ± 6.84	34.93 ± 7.39
68	60.10 ± 5.22	27.03 ± 6.02	27.92 ± 6.70
69	67.80 ± 4.60	38.81 ± 5.47	46.17 ± 5.91
70	67.43 ± 4.80	41.03 ± 5.71	47.59 ± 6.17
71	73.27 ± 6.02	36.03 ± 7.16	42.86 ± 7.73
72	60.38 ± 4.88	37.46 ± 5.8	43..14 ± 6.62
Mean	71.80	39.15	43.48
C.V	38.47	83.87	81.55
Significance	NS	NS	NS

* as in Table 4

Table 11: Effect of age of hen on percent fertility, percent hatchability of all eggs and of fertile eggs in strain 2 (RIW)

Age (Weeks)	* PF ± S.E	* PHA ± S.E	* PHF ± S.E
56	91.40 ± 4.06	71.56 ± 6.58	72.70 ± 6.80
57	93.38 ± 3.00	66.63 ± 4.86	70.00 ± 5.02
58	90.94 ± 3.14	68.32 ± 5.10	71.52 ± 5.27
59	88.74 ± 3.39	56.81 ± 5.50	60.09 ± 5.68
60	97.80 ± 3.99	66.74 ± 6.47	68.35 ± 6.69
61	92.72 ± 3.35	71.81 ± 5.43	75.56 ± 5.62
62	90.73 ± 3.47	56.80 ± 5.63	59.29 ± 5.82
63	87.37 ± 4.13	62.65 ± 6.69	67.55 ± 6.92
64	85.17 ± 4.63	21.82 ± 7.52	23.26 ± 7.77
65	98.75 ± 3.11	35.98 ± 5.05	39.41 ± 5.22
66	91.78 ± 3.28	50.17 ± 5.31	52.28 ± 5.49
67	86.54 ± 3.43	35.73 ± 5.56	38.90 ± 5.75
68	86.45 ± 3.99	30.74 ± 6.47	35.54 ± 6.69
69	93.19 ± 3.28	59.95 ± 5.31	63.52 ± 5.49
70	78.64 ± 3.31	44.28 ± 5.37	52.68 ± 5.55
71	90.06 ± 3.87	53.33 ± 6.27	56.78 ± 6.43
72	90.75± 3.84	50.12 ± 6.27	54.06 ± 6.49
Mean	89.93	53.95	57.45
C.V	24.73	66.86	64.91
Significance	NS	***P<0.001	***P<0.001

* as in Table 4

Table 12: Effect of age of hen on Transformed percent fertility, percent hatchability of all eggs and of fertile eggs in strain 2 (RIW)

Age (Weeks)	* TPF ± S.E	* TPHA ± S.E	* TPHF ± S.E
56	81.83 ± 3.87	62.47 ± 5.74^{ab}	63.62 ± 6.00^{ab}
57	83.30 ± 2.86	59.62 ± 4.24^{ab}	62.72 ± 4.43^{ab}
58	78.56 ± 3.00	60.52 ± 4.45^{ab}	63.04 ± 4.65^{ab}
59	79.04 ± 3.24	50.44 ± 4.80^{bcd}	53.47 ± 5.01^{abc}
60	82.87 ± 3.81	54.08 ± 5.65^{abc}	59.89 ± 5.91^{abc}
61	85.57 ± 3.20	64.19 ± 4.74^{a}	67.12 ± 4.96^{a}
62	81.16 ± 3.31	60.60 ± 4.91^{bcd}	52.45 ± 5.14^{bc}
63	77.23 ± 3.94	56.20 ± 5.84^{abc}	60.68 ± 6.01^{abc}
64	75.20 ± 4.43	21.50 ± 6.56^{g}	22.38 ± 6.86^{f}
65	79.47 ± 2.97	32.46 ± 4.40^{efg}	35.40 ± 4.60^{ef}
66	81.51 ± 3.13	44.49 ± 4.64^{cde}	46.72 ± 4.85^{cde}
67	76.89 ± 3.27	32.88 ± 4.85^{efg}	35.85 ± 5.07d^{ef}
68	76.10 ± 3.81	27.65 ± 5.65^{fg}	31.95 ± 5.91^{ef}
69	82.98 ± 3.13	53.91 ± 4.64^{abc}	56.70 ± 4.85^{abc}
70	68.86 ± 3.16	39.62 ± 4.69^{def}	46.27 ± 4.90^{cde}
71	79.94 ± 3.69	47.91 ± 5.48^{bcd}	50.40 ± 5.73^{bcd}
72	80.89 ± 3.69	44.61 ± 5.48^{cde}	47.44 ± 5.73^{bcde}
Mean	79.46	47.98	51.14
C.V	26.74	65.61	64.36
Significance	Non	***P<0.001	***P<0.001

* as in Table 4

Means within column with different superscripts differ significantly (P<0.001)

Table 13: Effect of Age of hen on average day old chickweight, ACW (g) in RIR and RIW strains

Age (Weeks)	* ACW in RIR ± S.E	* ACW in RIW ± S.E
56	36.52 ± 0.55^{ab}	34.52 ± 0.66^{cd}
57	34.64 ± 0.76^{bc}	33.33 ± 0.49^{d}
58	34.89 ± 0.81^{bc}	34.27 ± 0.51^{cd}
59	33.96 ± 0.87^{c}	36.78 ± 0.59^{ab}
60	36.25 ± 0.92^{abc}	34.47 ± 0.67^{cd}
61	34.12 ± 0.81^{c}	33.42 ± 0.54^{d}
62	33.72 ± 0.94^{c}	34.40 ± 0.59^{cd}
63	34.40 ± 0.94^{bc}	35.32 ± 0.71^{bc}
64	37.41 ± 0.67^{a}	34.87 ± 0.99^{bcd}
65	37.56± 0.76^{a}	35.24 ± 0.61^{bc}
66	36.96 ± 0.92^{ab}	34.66 ± 0.59^{cd}
67	34.02 ± 1.12^{c}	36.70 ± 0.68^{ab}
68	35.64 ± 1.00^{abc}	36.03 ± 0.85^{abc}
69	36.82 ± 0.72^{ab}	35.45 ± 0.54^{bc}
70	34.13 ± 0.79^{c}	34.59 ± 0.50^{cd}
71	35.28 ± 1.00^{abc}	37.38 ± 0.67^{a}
72	35.89 ± 0.85^{abc}	35.76 ± 0.68^{abc}
Mean	35.65	34.97
C.V.	10.97	9.81
Significance	*** P < 0.001	*** P < 0.001

* as in Table 4

Means within column with different superscripts differ significantly (P < 0.001)

Table 14: Effect of strain on mean age percent fertility, percent hatchability of all eggs, percent hatchability of fertile and ACW

Treat-ment (Strain)	*PF±SE	*PHA±SE	*PHF±SE	*TPF±SE	*TPHA±SE	*TPHF±SE	*ACW±SE
RIR(1)	80.89±1.11^{b}	43.87±1.59^{b}	49.00±1.66^{b}	71.82±1.02^{b}	39.15±1.38^{b}	43.48±1.46^{b}	35.64±0.19^{a}
RIW(2)	89.93±1.02^{a}	53.95±1.46^{a}	57.44±1.53^{a}	79.45±0.94^{a}	47.98±1.27^{a}	51.13±1.53^{a}	34.97±0.16^{b}
C.V	31.07	77.29	74.41	32.29	75.29	73.55	10.70
Signi-ficance	***P<0.001	***P<0.001	***P<0.001	***P<0.001	***P<0.001	***P<0.001	**P<0.01

* as in Table 4

Means within column with different superscripts differ significantly (P<0.001)

Table 15: Estimates of Pearsons Correlation between Age and Percent Fertility, Hatchability of all eggs, Hatchability of Fertile egg and ACW in RIR Strain

	Age	Fertility	Hatchabiility of All Eggs	Hatchability of Fertile egg	ACW
Age	1.00				
Fertility	-0.0893	1.00			
Hatchability Of All Eggs	-0.0961	0.459	1.00		
Hatchability Of Fertile Eggs	-0.0810	0.328	0.9482	1.00	
ACW	0.0317	-0.057	-0.169	-0.152	1.00

Table 16: Estimates of Pearsons Correlation between Age and Percent Fertility, Hatchability of all eggs, Hatchability of Fertile egg and ACW in RIW Strain

	Age	Fertility	Hatchabiility of All Eggs	Hatchability of Fertile egg	ACW
Age	1.00				
Fertility	-0.067	1.00			
Hatchability Of All Eggs	-0.210	0.375	1.00		
Hatchability Of Fertile Eggs	-0.191	0.288	0.951	1.00	
ACW	0.174	-0.046	-0.127	-0.101	1.00

5.0 CHAPTER FIVE

DISCUSSION

5.1 Effect of Season on Fertility and Hatchability

In the RIR and RIW strains of chickens studied, season was found to have no significant effect on the fertility percentages obtained. This is in agreement with the reports made by Jalaludeen et. al. (1980), Huston and Carmon (1958) and Sreenivasaiah and Joshi (1980). The result is however, contrary to those reported by Ramakrishnan and Unni (1975) and El-Maghraby et. al. (1969). The mean seasonal percent fertility obtained in the RIR and RIW chickens were similar to those reported by Hafez and Kamar (1955), Jalaludeen et. al. (1980), Sreenivasaiah and Joshi (1981) and Ramakrishran and Unni (1975), though those reported by the latter were slightly higher than was obtained in this study.

Low percent fertility in the RIR and high percent fertility in the RIW chickens were maintained when the average atmospheric temperature was about 32.3°C with relative humidity of about 82.9% and 29.5°C with humidity of about 78% . Thus, low fertility were maintained when the average atmospheric temperature was slightly higher and this is in line with the report of Hafez and Kamar (1955) and Huston and Carmon (1958). This further confirms the report of Heywang (1944) that fertility and hatchability are lowered when the chickens are kept under high environmental temperatures. The low fertility percentages obtained when the

relative humidity was lower further shows that atmospheric temperature is a more limiting factor which affects fertility and hatchability rather than relative humidity (Heywang, 1944). This result also confirms the findings of Kamar (1954) that the major environmental factor which affects the reproductivity of the fowl is the atmospheric temperature.

The no significant difference in mean seasonal hatchability of all eggs and of fertile eggs obtained in this study for the RIR and RIW chickens is also similar to the results reported by Jalaludeen et. al. (1980) and El-Maghraby et. al. (1969), but is contrary to the reports made by Babb and Huston (1972), Ramakrishnan and Unni (1975) and Sreenivasaiah and Joshi (1980).

The mean seasonal percent hatchability of all eggs and of fertile eggs reported by Hafez and Kamar (1955), Ramakrishnan and Unni (1975) and Jalaludeen et. al. (1980) were slightly lower than those obtained in this study while that of Babb and Huston (1972) was slightly higher and that of Sreenivasaiah and Joshi (1980) was close to the percentages obtained in this study.

Hatchability percentages obtained in this study when the average atmospheric temperature is low and high is in line with the reports of Hafez and Kamar (1955), Jaluladeen et. al. (1980), Babb and Huston (1972) and Ramakrishnan and Unni (1975). It is also in agreement with the reports of Heywang (1944) and Kamar (1954).

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5.2 Effect of Age of Hen on Fertility and Hatchability

Fertility percentages were found not to be significantly different between ages within the age group studied in the RIR and RIW chickens. This observation agrees with those of Susan et. al. (1979), Garwood and Lowe (1982) and Asuquo and Okon (1993). On the other hand, the findings of this study is contrary to those of Sunde and Bird (1989), Crittenden and Boren (1962) and Smith and Boren (1975) who showed that age of hen had a significant effect on fertility and hatchability.

The mean overall fertility with respect to age of hen obtained in this study for the RIR strain are similar to that reported by Asuquo and Okon (1993) and Aqcanas and Bandong (1970) while that obtained for the RIW chickens are similar to the findings of Susan et. al. (1979) and Garwood and Lowe (1982). The fluctuations between age groups could be as a result of many factors of which activity of the cocks, prefential mating, physiology of the hen and management problems are probable factors.

Percent hatchability of all eggs set and of fertile eggs were not significantly different as the hens aged in RIR which is similar to the reports of Susan et. al. (1979), Garwood and Lowe (1982) and Asuquo and Okon (1995) while in the RIW strain, percent hatchability as expressed to all eggs and to fertile eggs was found to significantly differ as the hens advanced in age in line with

the reports made by Sunde and Bird (1959), Crittenden and Boren (1962) and Smith and Boren (1975). The mean weekly and overall mean hatchability of all eggs and of fertile eggs with respect to age of hen obtained in this study for the RIR and RIW chickens were generally lower when compared to those reported by Susan et. al. (1979), Garwood and Lowe (1982) and Asuquo and Okon (1993). The generally low percent hatchability of all eggs and of fertile eggs obtained for the RIR and RIW chickens could be said to arise as a result of failure of fertile eggs to hatch or early embryonic deaths rather than infertility. The fluctautions (increasing trend) in hatchability percentages between age groups could also be as a result of many factors as listed above under fertility.

The significant difference that occured in reproductive traits percentages between the two strains as the hens aged agreed with the findings of Avigdor et. al. (1986) and Mishra et. al. (1990). This significance is however, contrary to the observation made by Smith and Boren (1975).

5.3 Effect of Age of Hen on Day Old Chickweight

Age of hen was observed to have a significant effect on the average day old chickweight in the RIR and RIW chickens and this conforms with the reports of Ramirez et. al. (1984). The overall average day old chickweight for the RIR and RIW chickens over the age group studied were slightly lower compared to the values obtained by Ramirez et. al. (1984).

5.4 Effect of Transformation

The percentages of the reproductive traits on the transformed scale for the RIR and RIW in the two experiments were found to be lower than those from the untransformed data, though transformation had no effect on the significance of the reproductive traits with respect to season and age of hen in the two experiments. It appears that transformation narrows down the variance. This might be the reason for the lower values on the transformed scale than the untransformed scale. Thus, the arc sine transformation normalises the distribution of these traits and also avoid the characteristic association between the mean and variance. Transformation appropriately fulfilled the statistical requirements for analysis as shown by its having a generally lower RMSE/SE than the untransformed data, thus confirming the reports of Chaudary et. al. (1984) and Crittenden et. al. (1957). The relatively lower coefficient of variability for the transformed data in this study, shows that a reasonably high degree of reliance could be placed on these estimates.

SUMMARY AND CONCLUSION

In the RIR and RIW strains of chickens, percent fertility, percent hatchability of all eggs and percent hatchability of fertile eggs had no significant monthly/seasonal variations. Significant differences were also not observed in the average seasonal fertility, hatchability of all eggs and of fertile eggs between the two strains, though the RIW strain had slightly higher S.E± and C.V than the RIR strain.

The mean monthly and seasonal percent fertility, percent hatchability of all eggs and of fertile eggs obtained were generally higher and encouraging for both strains, though slight drops were noticed during the months when the average atmospheric temperature were slightly high. This therefore suggests that the normal breeding programme of the selection lines for the two strains could be arranged to fall to any of the season or month but preferably season or month when the average atmospheric temperatures are low.

The effect of age of hen on fertility, hatchability and day old chickweight were also studied in the RIR and RIW chickens. Differences in fertility percentages were found not to be significant ($P>0.05$) as the hens aged and a generally high mean percent fertility were obtained for the RIR and RIW chickens over the age group studied. However, significant difference ($P<0.001$) was observed in the mean percent fertility over the age group

studied between the two strains. Thus the RIW had higher fertility percentages than the RIR chickens.

In the RIR chickens, no significant effect ($P>0.05$) of age was observed on the percent hatchability of all eggs and of fertile eggs while in the RIW strain, significant difference ($P<0.001$) was observed over the age group studied. The RIW strain however, had significantly higher percentages of the reproductive traits than the RIR strain. When the two strains were compared in terms of day old chickweight with respect to hen's ages, the RIR strain was found to have a significantly higher ($P>0.01$) average day old chickweight than the RIW strain.

The low percent hatchability of all eggs and of fertile eggs observed in this study indicate that failure of fertile eggs to hatch or early embryo mortality are the likely causes rather than infertility. Thus, this is pointing out that the overall management of the birds needs to be generally improved.

In view of the above, the mating programmes for the production of parents of next generation for the selection line of the RIR and RIW chickens which normally commences from 40 weeks of age and above should be maintained, and that under no condition should the mating be postponed to a second breeding season or year as serious drops in fertility and hatchability are likely.

Analysis of Variance Tables for Effect of Season on Reproductive Traits (Tables A-DD)

Table A: Analysis of variance for monthly percent fertility in strain 1(RIR)

Source	DF	MS	F-value	Pr
Month	9	10.362	0.72^{NS}	0.6871
Error	21	14.427		
Total	30			

R^2 = 0.23536 C.V = 4.3248 RMSE = 3.798

Table B: Analysis of Variance for monthly percent hatchability of all eggs in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Month	9	96.750	1.08^{NS}	0.4136
Error	21	89.201		
Total	30			

R^2 = 0.3173 C.V = 13.176 RMSE = 9.445

Table C: Analysis of variance for monthly percent hatchability of fertile eggs in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Month	9	79.684	1.04^{NS}	0.4451
Error	21	76.902		
Total	30			

R^2 = 0.3075 C.V = 10.792 RMSE = 8.769

NS = Not significant

R^2 = Coefficient of determination

RMSE = Root mean square error/standard error

** = Significant

Table D: Analysis of variance for Transformed monthly percent fertility in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Month	9	7.152	0.77^{NS}	0.6462
Error	21	9.308		
Total	30			

R^2 = 0.2477 C.V = 4.3737 RMSE = 3.0510

Table E: Analysis of variance for Transformed monthly percent hatchability of all eggs in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Month	9	51.115	1.75^{NS}	0.1398
Error	21	29.237		
Total	30			

R^2 = 0.4283 C.V = 9.2671 RMSE = 5.407

Table F: Analysis of variance for Transformed monthly percent hatchability of fertile eggs in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Month	9	50.47	1.16^{NS}	0.3707
Error	21	43.69		
Total	30			

R^2 = 0.33117 C.V = 10.2004 RMSE = 6.6099

Table G: Analysis of variance for monthly percent fertility in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Month	9	63.538	0.85^{NS}	0.5810
Error	20	74.700		
Total	29			

R^2 = 0.27680 C.V = 10.0933 RMSE = 8.6429

Table H: Analysis of variance for monthly percent hatchability of all eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Month	9	220.318	1.42^{NS}	0.2452
Error	20	152.84		
Total	29			

R^2 = 0.3897 C.V = 17.535 RMSE = 12.4613

Table I: Analsysis of variance for monthly percent hatchability of fertile eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Month	9	152.397	1.73^{NS}	0.1475
Error	20	88.158		
Total	29			

R^2 = 0.4375 C.V = 11.1313 RMSE = 9.389

Table J: Analysis of variance for Transformed monthly percent fertility in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Month	9	77.485	1.35^{NS}	0.2735
Error	20	57.340		
Total	29			

R^2 = 0.3781 C.V = 11.2853 RMSE = 7.5724

Table K: Analysis of variance for Transformed monthly percent hatchability of all eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Month	9	89.6754	2.07^{NS}	0.0841
Error	20	43.301		
Total	29			

R^2 = 0.4824 C.V = 11.2114 RMSE = 6.58

Table L: Analysis of variance for Transformed monthly percent hatchability of fertile eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Month	9	90.8509	1.69^{NS}	0.1573
Error	20	53.77		
Total	29			

R^2 = 0.4319 C.V = 10.8357 RMSE = 7.332

Table O: Analysis of variance for season percent hatchability of fertile egg in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Season	2	13.833	0.17^{NS}	0.8461
Error	28	82.301		
Total	30			

R^2 = 0.4319 C.V = 10.8357 RMSE = 7.332

Table P: Analysis of variance for Transformed seasonal percent fertility in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Season	2	4.8211	0.54^{NS}	0.5890
Error	28	8.9362		
Total	30			

R^2 = 0.03711 C.V = 4.2853 RMSE = 2.9894

Table Q: Analysis of variance for Transformed seasonal percent hatchability of all eggs in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Season	2	25.249	0.59^{NS}	0.5096
Error	28	36.554		
Total	30			

R^2 = 0.04702 C.V = 10.362 RMSE = 6.046

Table R: Analysis of variance for Transformed seasonal percent hatchability of fertile eggs in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Season	2	20.2067	0.42^{NS}	0.6579
Error	28	47.5495		
Total	30			

R^2 = 0.02946 C.V = 10.64138 RMSE = 6.8956

Table S: Analysis of variance for seasonal percent fertility in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Season	2	35.1967	0.48^{NS}	0.6262
Error	27	73.9055		
Total	29			

R^2 = 0.034075 C.V = 10.03951 RMSE = 8.5968

Table T: Analysis of variance for seasonal percent hatchability of all eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Season	2	140.432	0.79^{NS}	0.4046
Error	27	178.062		
Total	29			

R^2 = 0.055195 C.V = 18.7776 RMSE = 13.3440

Table U: Analysis of variance for seasonal percent hatchability of fertile eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Season	2	8.853	0.08^{NS}	0.9264
Error	27	115.445		
Total	29			

R^2 = 0.005648 C.V = 12.7381 RMSE = 10.7446

Table V: Analysis of variance for Transformed seasonal percent fertility in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Season	2	50.8207	0.79^{NS}	0.4652
Error	27	64.5384		
Total	29			

R^2 = 0.055115 C.V = 11.9725 RMSE = 8.03358

Table W: Analysis of variance for Transformed seasonal percent hatchability of all eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Season	2	6.0067	0.10^{NS}	0.9073
Error	27	61.522		
Total	29			

R^2 = 0.00718 C.V = 13.36366 RMSE = 7.84358

Table X: Analysis of variance for Transformed seasonal percent hatchability of fertile eggs ins train 2 (RIW)

Source	DF	MS	F-value	Pr
Season	2	9.2648	0.13^{NS}	0.8757
Error	27	69.4285		
Total	29			

R^2 = 0.009788 C.V = 12.31264 RMSE = 8.3324

Table Y: Analysis of variance for effect of strain on fertility percent

Source	DF	MS	F-value	Pr
Season	1	73.7252	1.77^{NS}	0.1889
Error	59	41.7303		
Total	60			

R^2 = 0.029074 C.V = 7.4468 RMSE = 6.4599

Table Z: Analysis of variance for effect of strain on hatchability of all eggs

Source	DF	MS	F-value	Pr
Season	1	3.9287	0.03^{NS}	0.8640
Error	59	132.754		
Total	60			

R^2 = 0.000501 C.V = 16.1549 RMSE = 11.5219

Table AA: Analysis of variance for effect of strain on hatchability of fertile eggs

Source	DF	MS	F-value	Pr
Season	1	146.056	1.58^{NS}	0.2142
Error	59	92.658		
Total	60			

R^2 = 0.005648 C.V = 12.7381 RMSE = 10.7446

Table BB: Analysis of variance for effect of strain on transformed percent fertility

Source	DF	MS	F-value	Pr
Season	1	107.717	3.02^{NS}	0.0874
Error	59	35.66		
Total	60			

R^2 = 0.0048702 C.V = 8.72413 RMSE = 5.9717

Table CC: Analysis of variance for effect of strain on transformed percent hatchability of all eggs

Source	DF	MS	F-value	Pr
Season	1	1.814	0.04^{NS}	0.8442
Error	59	46.561		
Total	60			

R^2 = 0.0006 C.V = 11.66 RMSE = 6.8236

Table DD: Analysis of variance for effect of strain on transformed percent hatchability of fertile eggs

Source	DF	MS	F-value	Pr
Season	1	125.87	2.27^{NS}	0.1368
Error	59	55.337		
Total	60			

R^2 = 0.03712 C.V = 11.234 RMSE = 7.4389

Analysis of Variance Tables for Effect of Age of Hen on Reproductive Traits (Tables a - u)

Table a: Analysis of variance for effect of age of hen on percent fertility in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Season	16	1413.04	1.50^{NS}	0.0957
Error	556	944.69		
Total	572			

R^2 = 0.041267 C.V = 37.993 RMSE = 30.1359

Table b: Analysis of variance for effect of age of hen on percent hatchability of all eggs in strain (RIR)

Source	DF	MS	F-value	Pr
Season	16	1315.67	0.91^{NS}	0.5584
Error	556	1446.87		
Total	572			

R^2 = 0.0255 C.V = 86.70 RMSE = 38.037

Table c: Analysis of variance for effect of age of hen on percent hatchability of fertile eggs ins train 1 (RIR)

Source	DF	MS	F-value	Pr
Season	16	1766.34	1.08^{NS}	0.3737
Error	556	1639.88		
Total	572			

R^2 = 0.03006 C.V = 82.638 RMSE = 40.495

Table d: Analysis of variance for effect of age of hen on transformed percent fertility in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Season	16	1161.056	1.52^{NS}	0.0870
Error	556	763.408		
Total	572			

R^2 = 0.04193 C.V = 38.4764 RMSE = 27.629

Table e: Analysis of variance for effect of age of hen on transformed percent hatchability of all eggs in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Season	16	1080.906	1.00^{NS}	0.4527
Error	556	1078.703		
Total	572			

R^2 = 0.028028 C.V = 83.8777 RMSE = 32.844

Table f: Analysis of variance for effect of age of hen on transformed percent hatchability of fertile eggs in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Season	16	1476.45	1.17^{NS}	0.2842
Error	556	1257.585		
Total	572			

R^2 = 0.03268 C.V = 81.551 RMSE = 35.462

Table g: Analysis of variance for effect of age on percent fertility in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Season	16	695.635	1.41^{NS}	0.1325
Error	656	495.047		
Total	672			

R^2 = 0.033137 C.V = 24.739 RMSE = 22.249

Table l: Analysis of variance for effect of age on percent hatchability of all eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Season	16	8020.910	6.16***	0.0001
Error	656	1301.268		
Total	672			

R^2 = 0.13069 C.V = 66.8609 RMSE = 26.073

Table i: Analysis of variance for effect of age on percent hatchability of fertile eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Season	16	7762.406	5.58***	0.001
Error	656	1390.591		
Total	672			

R^2 = 0.1198 C.V = 64.9128 RMSE = 37.2906

Table j: Analysis of variance for effect of age on transformed percent fertility in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Age	16	563.0515	1.25^{NS}	0.2265
Error	656	4510.559		
Total	672			

R^2 = 0.029515 C.V = 26.7431 RMSE = 21.249

Table k: Analysis of variance for effect of age on transformed percent hatchability of all eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Age	16	5839.767	5.89***	0.001
Error	656	991.193		
Total	672			

R^2 = 0.1256 C.V = 65.6142 RMSE = 31.483

Table l: Analysis of variance for effect of age on transformed percent hatchability of fertile eggs in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Age	16	5774.128	5.33***	0.001
Error	556	1083.493		
Total	672			

R^2 = 0.115029 C.V = 64.3673 RMSE = 32.917

Table m: Analysis of variance for effect of age of hen on ACW in strain 1 (RIR)

Source	DF	MS	F-value	Pr
Age	16	40.409	2.64***	0.0006
Error	370	15.294		
Total	386			

R^2 = 0.10254 C.V = 10.9709 RMSE = 3.91076

Table n: Analysis of variance for effect of age of hen on ACW in strain 2 (RIW)

Source	DF	MS	F-value	Pr
Age	16	41.294	3.51***	0.0001
Error	497	11.775		
Total	513			

R^2 = 0.101446 C.V = 9.812577 RMSE = 3.43148

Table 0: Analysis of variance for effect of strain on percent fertility

Source	DF	MS	F-value	Pr
Strain	1	25278.815	35.38***	0.0001
Error	1244	710.4036		
Total	1245			

R^2 = 0.027809 C.V = 31.07235 RMSE = 26.6534

Table p: Analysis of variance for effect of strain on transformed percent fertility

Source	DF	MS	F-value	Pr
Strain	16	18110.738	2.64***	0.0001
Error	1244	601.493		
Total	1245			

R^2 = 0.02363 C.V = 32.295 RMSE = 24.5255

Table q: Analysis of variance for effect of strain on percent hatchability of all eggs

Source	DF	MS	F-value	Pr
Strain	1	31445.601	21.64***	0.0001
Error	1244	14529.958		
Total	1254			

R^2 = 0.01710 C.V = 77.2911 RMSE = 38.117

Table r: Analysis of variance for effect of strain on transformed percent hatchability of all eggs

Source	DF	MS	F-value	Pr
Strain	1	21407.77	22.04***	0.0061
Error	1244	1093.820		
Total	1245			

R^2 = 0.017409 C.V = 75.296 RMSE = 33.0730

Table s: Analysis of variance for effect of strain on percent hatchability of fertile eggs

Source	DF	MS	F-value	Pr
Strain	1	22005.993	13.89***	0.0002
Error	1244	1588.797		
Total	1245			

R^2 = 0.011041 C.V = 74.4148 RMSE = 39.859

Table t: Analysis of variance for effect of strain on transformed percent hatchability of fertile eggs

Source	DF	MS	F-value	Pr
Strain	1	18128.822	14.78***	0.0001
Error	1244	1226.686		
Total	1245			

R^2 = 0.011741 C.V = 73.5508 RMSE = 35.0241

Table u: Analysis of variance for effect of strain on day old chick weight average (ACW)

Source	DF	MS	F-value	Pr
Strain	1	101.0489	7.09**	0.0079
Error	899	14.258		
Total	900			

R^2 = 0.007822 C.V = 10.70884 RMSE = 3.77602

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