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SOME QUANTITATIVE CHANGES IN THE BEHAVIOUR OF THE DOMESTIC  
CHICKEN IN THE FIRST SEVEN WEEKS AFTER HATCHING.

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A Thesis Presented in Partial Fulfilment  
of the Requirements for the Degree of  
Master of Science at Massey University.

by

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## CHAPTER I

### INTRODUCTION

The study, which was carried out at the Poultry Research Centre, at Massey University, was concerned with the behavioural development of the domestic chicken, and more specifically with the quantitative changes taking place in specific categories of behaviour from hatching to approximately two months after hatching. Observations for the study were carried out under laboratory conditions rather than in the field, for the following reasons.

- (i) some control of environmental variables could be achieved in the laboratory which could not be attained under field conditions.
- (ii) that the chicks could be kept in view to permit a detailed surveillance of their movements to be made for the duration of each observation period. This was necessary for a full quantification of the observations to be obtained, and for the data to be of use in statistical analyses.
- (iii) that a set number of chickens could be observed from the beginning to the end of each trial so that the data would be amenable to statistical treatment. Under field conditions it is doubtful if these requirements could have been met to the satisfaction of the observer. By the nature of the topic under study, quantitative techniques were essential, as was the use of statistical tools to extract sufficient information from the raw data to warrant the adoption of the quantitative approach.

Five separate trials were performed, using separate groups of newly-hatched chicks for each trial, and taking into account the time required for cleaning and disinfecting between trials, the total time taken for the observations and

experiments was approximately twelve months.

The first two trials performed were essentially exploratory in that the basic framework of later trials was formed here, and such problems as the duration of observation periods and of the categories of behaviour to be used were sorted out. The information gathered in these two trials was not presented in the thesis because the observation periods used were found to be too short to be representative of the total behaviour of the chicks. In later trials a fifty-minute observation period was settled on as a reasonable representation of the chicks' total behaviour during the day (detail on this is given in the section on "Techniques of Sampling and Analysis").

With the background of information gained in the first trials, it was decided that six categories of "maintenance behaviours" should form the units of measurement to be used in subsequent trials. These six categories were derived from three broad groupings of behaviour : feeding, non-feeding activity and resting. The major interest lay in the proportion of total day-time that the chicks spent performing each category of behaviour, and secondly in the changes in these proportions that occurred during development along with changes in food intake, growth and physiological changes in general.

The presentation of data was by two means - graphs and statistical tables. In both, mean figures derived from the total number of individuals in each experimental or trial group are used. Individual measurements are not dealt with anywhere in the thesis, these having been used in the early stages of collecting data together to provide the group means. This is in keeping with the quantitative approach to the study, where it is hoped that individual eccentricities are submerged in the production of a group mean having an approximation to the real mean of that population from which the sample group was drawn. The final results obtained are assumed to be valid generalizations

on behavioural development of the particular breeds of chicks used in the trials.

#### The Specific Aims of the Study

It will be obvious from the foregoing section that this study is not one of classical zoology for it deals with only a small section of the animal's life, and that by being a laboratory study it tends to be more closely allied to the physiological rather than to the naturalistic approach in research. The author does not view this as a criticism of the approach adopted, but on the other hand views it as a legitimate approach to a field of research which New Zealand Zoology has been slow to move into. The approach of interpreting the results in terms of physiology rather than against a background of ecology was partly dictated by the absence of ecological information on the ancestors and relatives of the domestic fowl, which might have given some basis for interpreting the results obtained in the present study. In the same way, interpretation of the results against a background of evolutionary concepts suffered from lack of information on the food preferences and supplies, and predators of the ancestors of the domestic fowl in their natural environment.

Consequently, the specific aim of the study was to demonstrate that quantitative changes do take place in the maintenance behaviours during the ontogeny of the chick, and where possible to draw upon the literature on developmental physiology to provide explanations or parallels to interpret the changes in behaviour which do take place. Other more direct measures of ontogenetic change - growth and food consumption were measured to provide further correlates for the measures of behavioural change.

In addition to conducting trials to record the outline of developmental changes, there were two problems in the literature of poultry science which interested the author and which, though they had been investigated, had not

been interpreted against a background of behavioural science; such an interpretation was attempted in two experiments. The problems investigated were :

- (i) that when two different forms of the same food type are fed to chicks, one form consistently gives a greater growth rate than the other. In this experiment the aim was to test if two groups of chicks, each fed on one of the food forms, showed any quantitative differences in the proportions of time spent feeding, active and resting.
- (ii) that chickens and adult fowl, when in the domestic environment (sheds, houses) often display a tendency to pull out each others feathers, and even to resort to cannibalism.

These two problems may seem more the province of agricultural science, but such a view is relevant only if it were possible to draw a line dividing research into two aspects - "pure" and "applied".

In the present study, the awareness of the problems arose from practical or applied aspects, while the approach to them was from a background of pure research. The aim was to understand the problems in terms of cause and effect relationships irrespective of whether any solution could be arrived at.

These last two trials are related to the main aim of the study in that the experiment in food forms was a direct follow on from the original trials on the maintenance behaviours - it occupied the same time duration, used the same categories of behaviour, the same sampling and analytical techniques, and the interpretation of results was against a similar background - that of physiology.

The trial on feather-pulling was a greater deviation from the original aim of the study, for it utilised a non-parametric statistical method and the activity recorded (feather-pulling) could not be directly classified as a

maintenance behaviour. However the trial was performed with the idea of interpreting the development of feather-pulling against a background of ontogenetic changes in the maintenance behaviours and to test the view that it might be related to nutrition. If feather-pulling was so related then there would probably be some parallel between it and feeding in ontogeny. Finally, the feather-pulling experiment was interpreted against the same basis of developmental physiology as the other two trials were; providing a direct connection between the three trials and the stated aims of the study.

## CHAPTER II

### REVIEW OF LITERATURE

In the fields of social behaviour and early learning the domestic chicken has received much attention since the first decade of this century. Even before this time however, Spalding (1873) had initiated studies on the early behaviour of chicks with particular reference to their social responses, but these studies were apparently not pursued again until the early 1900's. The maintenance behaviours, however, have not received much attention at all, apart from some experiments where they have figured in the early learning of the chicks.

In the field of early learning, the experiments of Breed (1911), Shepherd and Breed (1912), Bird (1933), and Cruze (1935), were early attempts to analyse the parts played by maturation and learning in the improvement in pecking at food that occurs in the first few days after hatching. The phenomenon of "imprinting" has received more attention than it possibly deserves, due mainly to the efforts of Lorenz (1935) to build a theoretical framework of behaviour mechanisms around it.

Social behaviour leading to the formation of the peck-order or social hierarchy has interested researchers since Schjelderup-Ebbe's early reports (1923) on the subject. Guhl (1958) provided an excellent summary of this field of research including the physiological basis of this behaviour. These studies are not really relevant to the present study and the short summary given in this review was intended only to place the study of maintenance behaviours into their context of where research has been carried out.

Kruijt's (1964) study of the Burmese Red Jungle-Fowl did include some information on the appearance of the maintenance behaviours in ontogeny. Although of a qualitative nature, the information is valuable because it establishes a base-line from which to begin interpreting quantitative results. Kruijt made the observation that walking was present from a few hours after hatching; that running was shown on the first or second day and was usually accompanied by wing-flapping by the fourth day; that jumping was shown on the second day, and hopping on the second and third days. Flying began on the twelfth day. Generally, the picture is one of an animal which becomes increasingly active over the first fortnight after hatching. This aspect of ontogeny figures strongly in the first two trials reported in the present study and provides material for interpreting the results presented there. With regard to feeding, Kruijt noted that his chicks began ground-pecking some hours after hatching - this aspect of feeding has received a great deal of attention, even in pre-hatching development. (Kuo, 1932). Ground-scratching was first shown in a complete form on the third day by Kruijt's chicks. These observations were useful to the present study in the aspect of the progression of various behaviours during the first fortnight after hatching.

While the present study was in progress, Dawson and Siegel (1967) published the results of a quantitative study of changes taking place in a wide range of behaviour patterns over a period of ten weeks from hatching. These investigators used a scoring method of recording data - they did not use time itself as a measure and their results cannot be used to give an estimate of the relative importance of these behaviour patterns in the day-time available to the chick. They provided graphs demonstrating that their chicks reached peak scores on various responses at different weeks.

<u>Response</u>	<u>Week</u>
Resting	
Running	1st
Frolicking	
Scratching	4th
Sparring	6th
Resting	7th (second peak)
Preening	A linear increase to 10th week.

Little interpretation of results was attempted by these authors - except for their data relating to peck-order formation. Their interpretation as to why chicks have a peak of resting in the first week (using the term "allelomimetic" as an explanation) was considered to be particularly lacking in substance. Generally, the scoring method did not appear to be well suited to describing the changes in maintenance behaviours, e.g. one unit of resting at one week does not necessarily equal one unit of resting at seven weeks after hatching.

An area of research which provided much material for interpretation of the results obtained in this study was that of the physiology of development of the chick. Most of this information is used in describing the general characteristics of the chicken and in the discussion section of the first trial reported in the study. Key references were those of Beattie and Freeman (1962) and Whittow (1965) on the changes in the metabolic rate of the chick during ontogeny; Lamoreux and Hutt (1939) and Freeman (1965) on the ontogenetic changes in the chick's deep body temperature. These references were particularly important for it is obvious that so much of the chick's behaviour over the first four weeks after hatching is directly influenced by these aspects of its physiology.

### Conclusions

The topic of quantitative changes in the maintenance behaviours during the ontogeny of the domestic chick has received little attention to date. The best



approach to such a study would appear to be the use of the literature on physiological development as a basis to work from in interpreting the results obtained.

CHAPTER IIITHE TAXONOMIC STATUS AND GENERAL CHARACTERISTICS OF THE  
DOMESTIC FOWLTaxonomy

The domestic chicken belongs to the Family Phasianidae within the Order Galliformes. This family includes the Japanese quail (Coturnix coturnix); the ring-necked pheasant (Phasianus colchicus); and the peafowl (Pavo cristatus).

The exact origin of the domestic fowl and its possible ancestors is lost in antiquity. Four species have been recognized (Beebe, 1926). The Red Jungle Fowl, Gallus gallus Linnaeus, sometimes referred to as G.ferrugineus, is widely distributed from north central and eastern India through Siam, Cochin China, Malay Peninsula to Sumatra, and is considered by Beebe to be the only species from which the domestic fowl arose. A grey species, G.sonneratii Temminck, is found in western, central and southern India; a red and yellow G.lafayetii Lesson inhabits Ceylon; and G.varius Shaw, called either the green or black species, is found in Java and adjacent islands.

There is evidence of a polyphyletic origin and Hutt (1949) suggests that those accepting the monophyletic theory should stick to G.gallus, whereas the familiar G.domesticus is probably permissible under the assumption that all domestic fowls were produced by hybridization from several wild species and have become distinct from any of them. The numerous breeds are classified according to place of origin, such as Asiatic, Mediterranean, English and American breeds.

## General Characteristics of the Domestic Fowl

G.gallus is a sexually dimorphic bird characterized by precocious or nidifigous development; that is it is capable of performing a wide range of the adult activities soon after hatching. These activities include walking, running, feeding, drinking, comfort movements and preening; all shown on the first day after hatching. Wing-flapping is present from the fourth day and flying begins on the twelfth day (Kruijt, 1964).

Even before hatching, developments take place resulting in the perfection of the pecking action. Kuo (1932) studied pre-hatching development and found that by the time the chick was ready to hatch, it possessed the head-lunging, bill opening and closing, and swallowing components of feeding, and that these were already co-ordinated into the pecking action of the hatched chick.

The primary need of newly-hatched chicks appears to be warmth. Collias (1952) noted that contact with a human hand within fifteen minutes after hatching diminished the distress calls. He also found that there were fewer distress calls from chicks hatched under a lamp than from chicks hatched at sub-normal temperatures.

Studies of the pecking responses were carried out by Lloyd Morgan (1896) who observed that chicks never pecked at a sheet of water even if they were thirsty and were standing in it. They would, however, peck at any material or bubbles in the water and as soon as the beak was wetted they commenced the drinking response.

On the first day the chick begins to peck clumsily and at random at bright objects, such as the eyes of other chicks, drops of water, spots on the wall of the pen and the like. The ability to peck at food soon develops (Wood-Gush, 1955) and improves as a result of maturation and experience (Cruze, 1935).

The development of fear responses occurs at 33 to 36 hours after hatching (Hess, 1959) and this terminates the so-called "critical period" for the attachment of the chicks' social responses to an animal or an object which it has experienced during this time. Of course, in the natural situation it is towards the hen and towards other chicks that the social responses are directed, and fear responses are given to any animals not experienced prior to the onset of fear.

Since Schjelderup-Ebbe's early reports (1923) on the existence of a social hierarchy in chickens, many observers have substantiated his descriptions. It is now recognized that the peck order forms the basis of all group behaviour in adult chickens and immediately after a meeting between strange hens, the contests begin.

Guhl (1958) found that there is a general sequence in which the aggressive patterns appear : escape or fear responses, frolicking, sparring, aggressive pecking, avoidance and fighting. Males show aggressive behaviour earlier than females and in small unisexual groups, males form a peck-order by 6-8 weeks; females by 8-10 weeks.

In their physiology, chickens are characterized by an early poikilothermic condition which gives way to a homeothermic condition sometimes between one and three weeks after hatching. Lamoreux and Hutt (1939) found that adult levels of body temperature ( $41^{\circ}\text{C}$ - $42^{\circ}\text{C}$ ) were not reached until approximately twenty days after hatching. Freeman (1965) found that body temperature became constant on the sixth day after hatching - a considerable difference to the figure quoted by Lamoreux and Hutt.

The metabolic rate of the hatched chick is lower than that of the adult. The metabolism increases during the first four weeks after hatching to reach a

level considerably higher than the adult level. It then decreases until the adult level is reached. This ontogenetic variation in metabolic rate must be recognized as important a characteristic of the domestic fowl as is the existence of the early poikilothermic state.

Finally, the contagious nature of most chicken behaviour should be noted; if one chick begins performing an action it usually stimulates other chicks into joining it in that activity. By stimulating each other in this manner, chickens produce the phenomenon of social facilitation, defined as "any increment of activity resulting from the presence of another individual" (Crawford, 1939).

#### Summary

This completes one section of the study - that introducing :

- (i) the study itself;
- (ii) the literature pertinent to the study;
- (iii) and finally the animal used for the observations.

The next section of the work describes the categories of behaviour used and how they were arrived at; the practical aspects of sampling and analysis of data, and finally a short chapter on the room used in the trials.

## CHAPTER IV

### THE CATEGORIES OF BEHAVIOUR USED IN THE STUDY

Six categories of behaviour were chosen as units to form the basis of the measurement of quantitative changes occurring in the ontogeny of the chick. These categories are listed below.

1. Feeding
2. Walking, pecking and running.
3. Scratching and pecking.
4. Sitting
5. Standing
6. Preening

These categories were chosen partly on the basis of the function they fulfilled and partly on their relationships with one another in time. The idea of using the temporal associations of behaviour as a guide to study was advocated by Marler and Hamilton (1966). The present study utilized that concept, because in the behaviour dealt with, discrete units could not always be arrived at on a purely functional basis. The significance of this as a factor is brought out strongly in the section dealing with the category of walking, pecking and running, where several actions were combined together essentially on temporal associations rather than on functions.

In terms of function, the six categories used could be placed into two groups revolving around energy expenditure and energy conservation :

- (i) those behaviours in which the chick was resting, sitting, standing and preening.

- (ii) those behaviours in which the chick was obviously not resting; feeding, walking, pecking and running, and scratching and pecking.

In terms of biological function, the categories fall into three groups :

- (i) Feeding, consisting of food intake with a resultant energy expenditure.
- (ii) Non-feeding activity, consisting of : random movements in the environment (walking, pecking and running); exploration of the environment; the performance of play, leading to adult forms of behaviour. For instance, sparring leads to fighting; scratching and pecking in the litter, which probably belongs to the feeding system in a neurological consideration, but which has become separated from feeding in both a temporal and a spatial sense.
- (iii) Resting, consisting of : those states of inactivity leading to recovery from fatigue; conservation of heat and energy; care of the body surface.

A more detailed treatment of each category of behaviour is given in succeeding sections along with some general observations derived from the early trials and, where appropriate, physiological data are provided to give a broader understanding of each category.

### Feeding Behaviour

The feeding action consists of the chick pecking at and picking up food particles with the bill. The food is mixed with saliva in the mouth and swallowed. In chickens, geese and ducks, the bolus is forced downward by gravity and negative pressure in the oesophagus as the bird raises its head and extends the neck.

Food intake is affected by a number of factors, the most important of which are contained in the list below :

- (i) the energy value of the food.
- (ii) the protein value of the food.
- (iii) the temperature of the environment.
- (iv) palatability of the food.
- (v) social factors (social facilitation of feeding).
- (vi) conditions of management (husbandry).
- (vii) amount of energy expended or lost by the animal.
- (viii) the energy and protein requirements of the animal for processes of growth, activity and for maintenance of the living processes of the body.

These factors interact to determine the hunger and the appetite of the individual, resulting in food intake - one of the factors measured in the study. As most of these factors remained constant throughout the trials, there are only two which need be considered to explain changes in food intake and changes in the amount of time spent feeding. Those two factors are : the amount of energy expended or lost by the animal; and the energy and protein requirements of the animal for processes of growth, activity and for maintenance of the living processes of the body.

In an ontogenetic study, growth is an obvious feature, and it is reasonable to expect increases of food intake with time; also the energy expenditure of the animal is very likely to change and this will bring with it changes in the food intake of the individual.

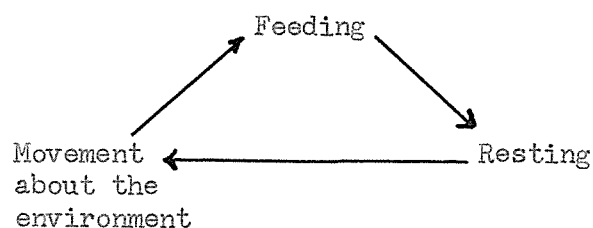
#### General Observations of Feeding

A few hours after hatching, chickens begin to peck at almost everything in their immediate environment : the eyes, bills, feathers and toes of other chicks; at their own bodies; at spots on the walls of their pens; at particles in the



litter, and so on. This random pecking, when coupled with the random walking movements of the chicks around their pen, must sooner or later bring it in contact with the food and water containers in the pen. When this occurs, the chicks very quickly establish these containers as sources of food and water. The actual commencement of feeding and drinking may not take place until late in the first day after hatching for the chicks tended to cluster under the heating lamps, and it was some hours before they began their movements about the environment. Observations of chickens raised with a hen indicated that the delay in the onset of feeding noticed in the laboratory set-up may have been due to the lack of a parent to lead the chicks to food and so initiate their feeding.

Once feeding had become established, the chicks settled into a cyclic sequence of behaviour :



During the first week after hatching, because they were forced to spend a good deal of time under the heating lamps, the chicks did not have a well-defined activity phase; in fact, activity consisted of many short bursts of running around the pen and relatively few instances of sustained walking occurred at all.

Feeding was well defined as a phase of behaviour - the chicks went to the feed tray, fed, and then usually returned to stand or sit under the heat lamp. It was quite obvious that the chicks were feeding when they were at the food

tray - this activity could not be mistaken for any other form of activity and so presented no problem in defining this category of behaviour to be used for measurement.

The rate of pecking at food does not appear to vary greatly with age; during the first week the chicks were capable of pecking at a rate of 90-100 pecks per minute. Observations taken at six weeks after hatching showed that the chicks rarely exceeded the rate attained in the first week. There was, however, a great amount of variation evident in the rate of pecking shown by any one chick during the course of any one day. When the chicks were obviously hungry, they would peck at a high rate (70-100 pecks per minute); whereas at other times they might peck at the rate of 20-40 pecks per minute.

The mean duration of feeding bouts and the changes which occurred with age were recorded, as an additional method of describing feeding - time was the main measure used in the study and consequently most descriptions were related to time itself. Table 1 gives details of the characteristic duration of the feeding bout.

TABLE 1.                    CHANGES IN TIME SPENT FEEDING AND IN INTERVALS BETWEEN BOUTS  
(Data from twenty-four White Leghorns, fed on crumbles).

(Figures in minutes)

Time after hatching	4th Day	1 Week	2 Weeks	3 Weeks	4 Weeks	5 Weeks
Mean duration of feeding bouts	2.0	2.5	3.7	4.5	4.9	5.0
Mean interval between bouts	40	32	21	16	14	14

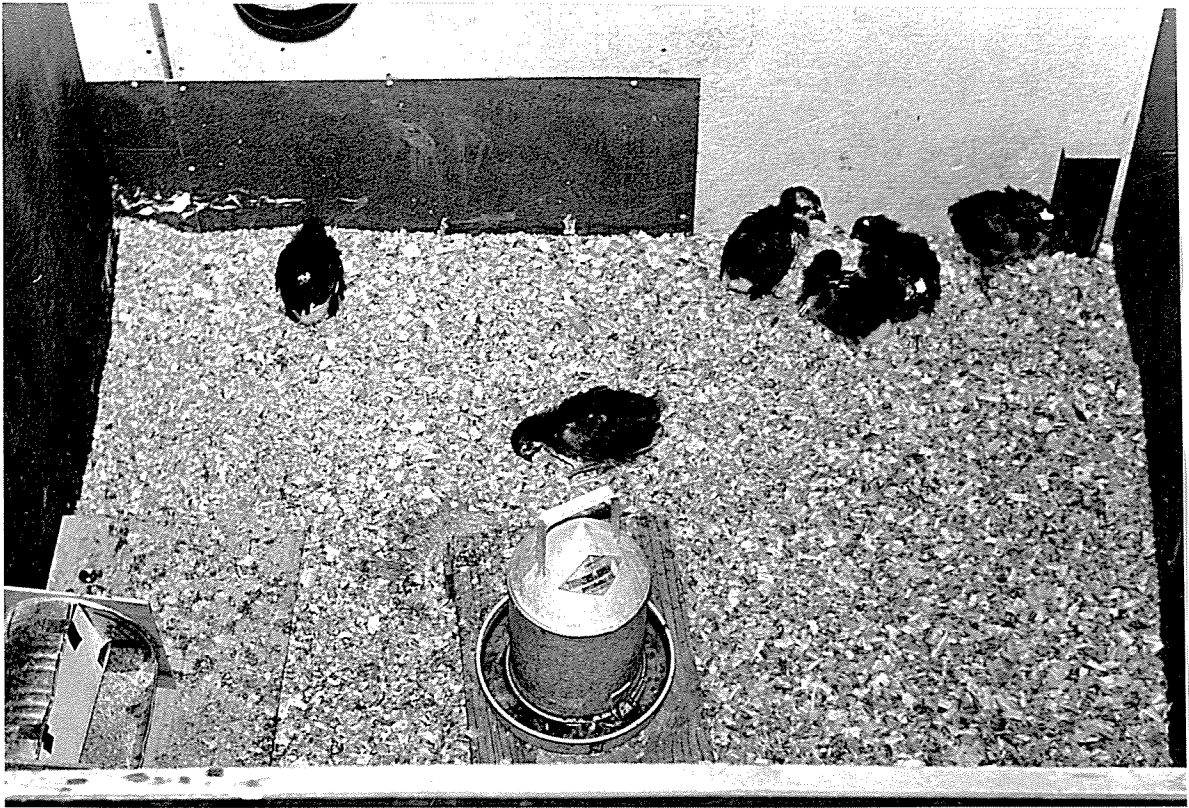


Plate 1. An experimental pen. The view shows a feeder, a waterer  
six Australorp chicks and a portion of the infra-red  
lamp (top left hand of plate)



Plate 2. Activity. Six White Leghorn chicks engaged in walking  
and pecking at particles in the litter.

## Conclusions

Feeding occurs as a fairly discrete activity - it is not easily confused with other behaviour patterns and so is easily defined as a unit or category for use in a study such as the present one.

## Non-Feeding Activity

The two categories of behaviour comprising this grouping together of activities were defined essentially on the basis of exclusion; that is they were not directly involved with or connected with the intake of food, thus they could be excluded from that category of behaviour; and secondly they were composed of actions which were not shown by the animal in its resting state.

Additional evidence for setting up these two categories came from their temporal associations with each other, and their temporal isolation from feeding and resting. That is, because these two categories of activity tended to be incompatible with resting and feeding in their performance, they were also separated from resting and feeding in time.

## Scratching and Pecking

Scratching in the litter consists of the chick in a standing position with the body bending forward and making one to four backward strokes with one leg, followed by one to four with the other. It seems that scratching is automatically coupled with the pecking action - chicks rarely scratch without also delivering a peck at the litter or food.

In older chickens (6-7 weeks), scratching and pecking were observed to continue for twenty minutes or more at a time, but such occurrences were rare and the scratching sessions were usually of much shorter duration. (See Table 2).

TABLE 2.

DURATION OF SCRATCHING SESSIONS  
(Data from 24 White Leghorns)

Age	2 days	4 days	1 week	2 weeks	3 weeks
Mean duration of scratching sessions	1.0	1.5	2.7	2.8	5.0

During the first week there was a noticeable tendency for the chicks to perform some scratching actions while feeding, but in later weeks the scratching became completely separated, both temporally and spatially from feeding.

It was also noted that on two occasions when the chickens ran out of food, they performed a great amount of scratching, leaving some areas of the pen bare of litter in the process. This would indicate that hunger and the feeding mechanisms in general have an intimate connection with scratching. The same view was put forward by Breland and Breland (1966) who noted that : "throwing any sort of delay into a food-getting sequence almost invariably brings out the chicken's scratching pattern, a prominent part of the behaviour with which the gallinaceous birds make their living in the wild - the tendency of the scratch pattern to emerge is so strong that the chickens do not have to be specifically trained to scratch. The pattern generally comes out willy-nilly and chickens have been known to make as many as 10,000 unnecessary responses in a day - if you consider each cycle of the typical foot-scratching movements as a response". Guhl (1962) described scratching in the litter as a "displacement activity", presumably on the grounds that it was no longer displayed in its functional context. However the concept of "displacement activity" has been somewhat modified since 1962. Kruijt (1964) in a critical discussion of the "displacement" concept made it clear that there is, as yet, no common opinion on what

constitutes a displacement activity, and that this was partly due to the fact that function and causation had not been sharply distinguished.

The writer is of the opinion that the term "displacement activity" occupies a similar state to the term "instinct" and that both have proved of little value in the analysis of cause and effect relationships in behaviour studies, for by providing a convenient descriptive "cloak", they tend to preclude or inhibit detailed analysis of behaviour patterns. Consequently the terms "displacement activity" and "instinct" have been avoided in this study.

#### The Walking-Pecking-Running Category of Behaviour

This category is the most heterogenous of all the categories, containing as it does walking, running, pecking, (apart from that pecking done when scratching or feeding) and also diverse other activities such as sparring, fighting and prolicking.

These varied behaviours were placed in the one category on two grounds :

- (a) they are not performed while the animal is resting, feeding or scratching, thus they form a group of activities on the basis of exclusion from the other behaviour categories; and secondly
- (b) they are related in a temporal sense; for instance, walking may develop into running, or walking combined with pecking, or flying, or fighting, and so on.

Activities such as frolicking, fighting or running are rarely performed directly from the resting or feeding phases of behaviour; rather they show the more direct association with walking.

Investigations have been carried out on the minor time-consuming components of this behaviour category. Guhl (1958) and Dawson and Siegel (1967) studied the development of running, sparring, frolicking and fighting. These

actions do not occupy a large portion of the chicken's time. For example, running rarely lasts for longer than a quarter of a minute and a sparring encounter rarely lasts for longer than half a minute; whereas walking and pecking do occupy a large portion of its time and thus on the basis which the present study was conducted - that of how the animal portions out its available day-time, running, sparring, etc. are not of great importance.

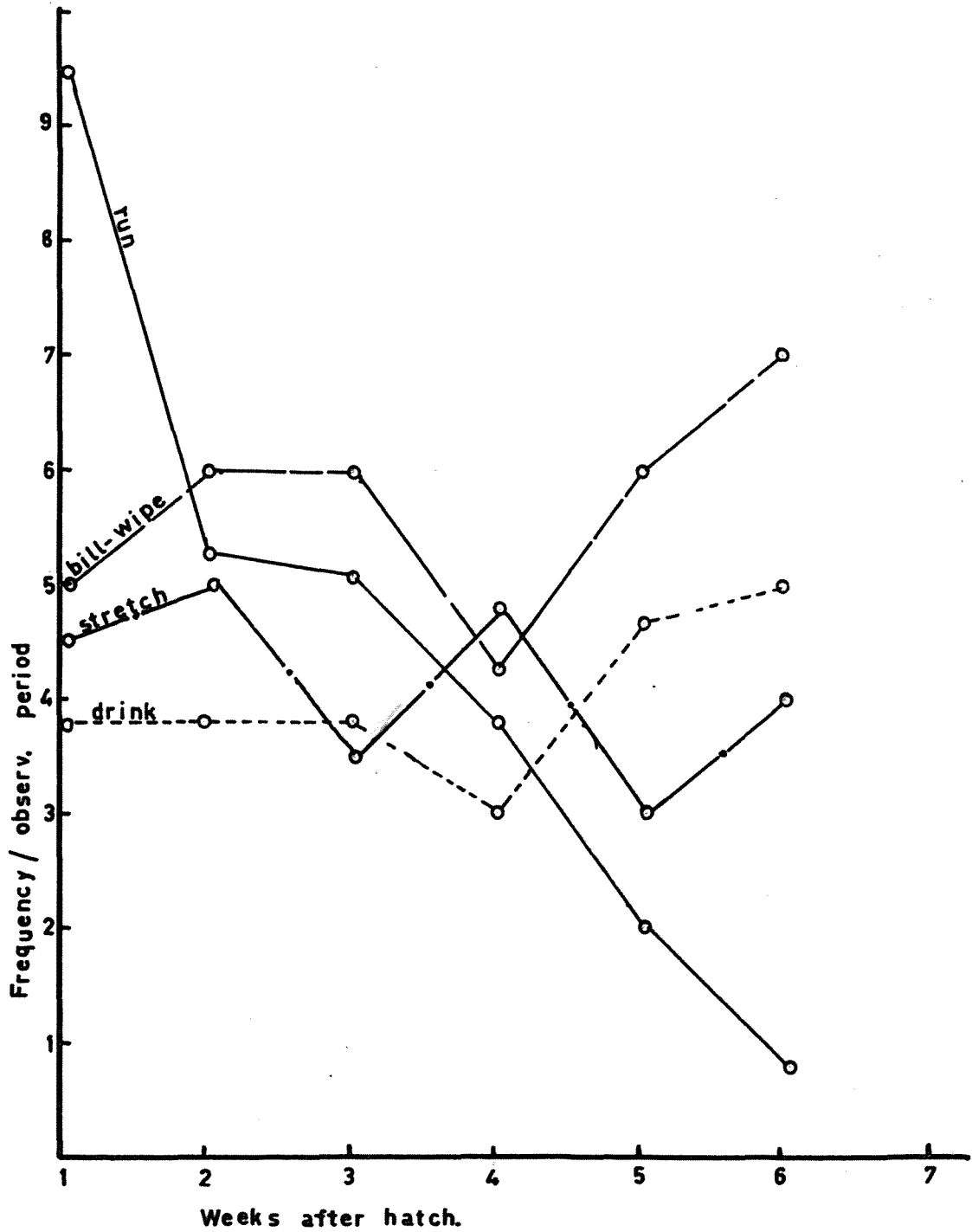
Walking and running were present on the first day as was the pecking action. Walking and pecking seemed to be automatically coupled from the very start; the chicks exhibiting the combination of this behaviour almost from when the first walking movement was performed. Prior to the onset of walking the chicks spent much time pecking while standing under the infra-red lamp. As they matured, pecking became more commonly associated with walking than with standing, until late in the first week when standing definitely could be categorized as a resting behaviour.

Running declined in the rate at which it occurred from the first few days onwards. By the sixth week there were very few running actions observed at all. Because running is not considered in any of the experiments reported in this study, a graphic presentation of its changes during maturation is given in figure 1, along with three other actions; stretching, bill-wiping, and drinking which are also not considered in the three experiments reported. The extra three actions were included to give a basis for comparison for placing the decline of the frequency of running in perspective.

Running appeared to be spontaneous; at least the chicks were not responding to any stimuli which was apparent to the observer. Dawson and Siegel (1967) described running as an "escape reaction" and that it was probably replaced by other escape responses with maturation. There is, however, no evidence for considering the spontaneous running as such a response.

Fig. 1.

Mean weekly scores for four actions of 16 White Leghorns, derived from 96 20-minute observation Periods / week.





Kruijt (1964) described the development of flying and was of the opinion that running, accompanied by wing-flapping was an ontogenetic precursor of flying. This seems a more likely explanation of the functional aspect of running in the life of the chicken.

### Walking

A little is known of the neurophysiological basis of this behaviour. Ten Cate (1965) described experiments on spinal pigeons in which the pigeon, if supported in a harness attached to a four-wheeled carriage, was capable of walking. Walking then is co-ordinated in the lumbo-sacral region of the cord. The higher brain centres initiate and regulate the walking movements. The spinal bird is also capable of flapping its wings which demonstrates considerable co-ordination in the cervical-thoracic region of the cord with a considerable degree of autonomy from the higher brain centres.

It is also well established that the intensity of illumination (in the domestic environment) has a great effect on the level of activity of chicks. Fox (1961) stated that broiler chickens under dull light are relatively quiet and docile compared to chickens kept under bright light conditions, and the general observations made in the present study confirm this.

The amount of walking performed in the first week was minute compared to that performed in succeeding weeks and this was almost certainly a reflection of the chicken's need to remain near an external source of warmth during that time. After the first week the chicks became increasingly independent of the external heat source and the amount of walking performed increased greatly.

The motivation or drive underlying walking is probably not that of any one need (food, exploration, exercise), but is more likely to be a general motivation to serve in several capacities. The necessity of walking for food-getting purposes in the natural environment is obvious, as is its necessity in exploratory

behaviour; a knowledge of the environment confers great survival value upon an individual and mobility is a necessity for this to be carried out adequately. The question of walking for the sake of "exercise" is not so easy to define, but it is probable that walking does act in a capacity of strengthening the body musculature which would also confer survival value upon the individual.

### Resting Behaviour

Within this category of behaviour, three sub-categories were set up :

- (i) Preening
- (ii) Standing
- (iii) Sitting

These three sub-categories do not have similar rates of metabolism or heat production. For instance, standing alone can increase the heat production of Light Sussex Cocks from 40 to 50 percent (Whittow, 1965). Preening would almost certainly involve extra heat production and a further increase in metabolic rate. However, such an increase in heat production is slight in comparison to the increase that occurs when the bird is running, walking or flying. It has been estimated that birds in flight increase their heat production by twenty-seven times above the resting level of heat production.

The three sub-categories then are different levels of resting with sitting being the most complete form of the three, followed by standing and then by preening.

The justification for grouping them together as resting behaviour comes from two sources :

- (a) that they occur together in time (temporal association).
- (b) biological function; all three are concerned with recovery from fatigue, and care and conservation of the body in general.



Plate 3. Resting. Two chicks are preening, three are sitting, and one is pecking in the litter (an activity).



Plate 4. Resting. Chickens are shown sitting, stretching, preening and standing.

Dawson and Siegel (1967) found that resting was most prevalent during the first few days of life, declined to  $3\frac{1}{2}$  weeks, and then increased again to 8 weeks of age. They postulated that one reason as to why chickens rest so much in the early days is the effect of mutual stimulation or allelomimetic behaviour to give rise to clustering together of the chicks. They also gave another possible explanation - that of the poikilothermous state of the chicken during the first week. To the writer the latter explanation is more than adequate to explain why chickens rest so much during the first few days of life; their primary requirement after hatching is warmth and it continues to be one of their major requirements right up to the end of the first week. This requirement necessitates the chicks remaining close to an external source of heat, thus precluding them from spending much time in active behaviour. Dawson and Siegel obtained a significant difference in their statistical analysis between males and females on scores for resting. However, the results obtained may be more apparent than real, for the scoring method of these investigators does not reveal if the females actually spent more time resting than the males, but only that the females were observed to rest more often. This method does not take into account the actual duration of the resting period; it is quite possible that the females could rest more often than the males without spending more time in resting than them.

(i) Preening

Preening behaviour is concerned with the care of the body surface and is accomplished by using the bill to comb the feathers, to peck particles from the body surface and to spread oil over them to prevent wetting of the skin itself. Kruijt (1964) defined four types of preening action in his Red Burmese Jungle-Fowl - pecking, nibbling, stroking and combing. The simplest form of preening - pecking, developed first, followed by nibbling. Both of these forms appeared on the first day after hatching. Stroking appeared on the second day

and combing on the fourth. Kruijt also noted that the amount of time devoted to preening different regions of the body changed with time : 75 percent of all preening during the sixth and seventh days was directed at the wings. This was presumed to be connected with the rapid growth of the wing feathers at that time. Dawson and Siegel (1967) produced "computer-fitted curves" for changes in behavioural responses over the ten weeks of their experiment. By this method they obtained a linear increase in preening from hatching to ten weeks. They explained this increase on the basis of there being several different forms of preening which act in an additive manner from hatching to ten weeks of age to produce the linear graph. The results of the present study differ considerably from those of Dawson and Siegel and the writer found difficulty in conceiving of a linear change in any behaviour pattern in the ontogeny of the chicken. The following figures represent the percentage of time that White Leghorns gave to preening three body regions :

TABLE 3.            PERCENTAGES OF PREENING TIME DIRECTED AT THREE BODY REGIONS  
(Data are mean figures for 24 White Leghorns)

(Age in weeks)

Age	1	2	3	4	5	6
Wings	54	49	45	40	30	40
Tail	9	10	11	16	20	20
Back or Front	37	41	44	44	50	40

The decrease in the amount of time spent preening the wings from one to five weeks is probably a reflection on the fact that the wing feathers develop earlier than the tail feathers or those feathers on the back and front. The increase in the amount of time given to preening the tail, and back and front up to the fifth week is a reflection of the fact that these areas feather at a slower rate than the wings.

(ii) Standing

This was very common during the first week when the chicks spent much time standing, warming themselves under the infra-red lamps. Time spent standing in later weeks was probably due to the chicks being in a confined environment and having little to interest them in that environment; they were forced to be idle. It is improbable that the amount of standing shown by the chicks in these experiments would be equalled by chicks under natural conditions.

(iii) Sitting

Along with standing, sitting was very common during the first week and probably for the same reasons - those of maintaining body temperatures and avoidance of chilling.

During the first week of the experiments the chicks often assumed the juvenile sleeping posture under the infra-red lamps, during the day-time. When this occurred it was classified in the same category as sitting, for both postures represent the extreme in energy conservation and heat conservation in the chicken. Also, the chick may sleep in either posture at this age and this further diminishes the apparent differences between the two postures.

After the first week the chickens begin to confine the performance of the sleeping posture to the night-time, more and more until, by the end of the second week it was rare to observe a chick in the sleeping posture during the day-time.

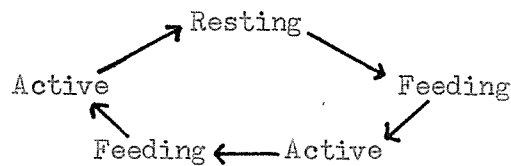
Interrelationships between the Behaviour Categories

Sequence of Categories

Figures selected at random in the sixth week from the 24 White Leghorns in Experiment 1 gave the following figures on the number of times each major phase of behaviour was performed :

Feeding : 30  
Active : 30  
Resting : 14

These scores gave an approximate ratio of 2:2:1 for the three phases. Interpreted as a behaviour cycle the ratio can be expressed as below :



The duration of such a cycle would be likely to vary from 15 minutes to 1 hour in six week old chickens.

Related to the proportions of time, the chickens spent on each of the phases of behaviour it is obvious that the duration of the resting phase was much longer than that of the active phase which, in turn, was longer in duration than the feeding phase.

TABLE 4.            PERCENTAGES OF TIME GIVEN TO THE THREE PHASES OF BEHAVIOUR  
(Data from 24 White Leghorns at 6 weeks' old)

Resting : 38  
Active : 36  
Feeding : 26  

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Total Time:100

## CHAPTER V

### METHODS AND MATERIALS

The chickens used for observation were housed in a room 16 feet by 11 feet in dimension. This was sub-divided into eight pens of 4 feet by 4 feet each.

The room had a door at one end, a louvre-type window at the other, and centrally situated was a thousand watt strip heater, slung six feet above ground level.

The material used in sub-dividing the room was "Pinex hardboard" of three-eighths of an inch thickness. The sides of the pens were six feet high while the fronts were two feet six inches high; this to permit the observer to clearly follow the movements of the chickens. The low frontage to the pens caused some problems after the chicks were two weeks' old and they began flying up onto the pen front. Wire-netting had to be used to raise the height of the pen frontage to six feet and still permit observations to be carried out. The central alleyway running the length of the room was three feet wide - only just enough to permit the observer to fit in on a small chair.

Each pen was provided with a one gallon "Eltex" waterer and a single feeding trough (see Plate 1). The floor was covered with wood shavings to a depth of approximately 4-5 inches and the litter renewed for each experiment.

Between experiments the walls and floors were thoroughly washed, scrubbed and disinfected to prevent any disease build-up over the course of the five trials performed. Only one serious outbreak of disease occurred; during the second trial Marrick's disease manifested itself in the sixth week. The results of this trial are not presented in this thesis for reasons other than the



disease outbreak; namely, that the length of the observation periods was not long enough to give representative samples of the animal's behaviour in time.

The brooders used were 250 watt infra-red heating lamps of the red fronted type. One lamp was installed in each pen and initially they were slung at a height of twelve inches above ground level to provide a temperature of approximately 110°F on the litter surface. The provision of more heat than the chickens required to maintain their body temperatures permitted them to rest at the periphery of the heat circle cast by the lamp. Consequently they did not have to travel far to the food and water containers and this decreased the risk of their suffering stress from exposure to lower temperatures (65°F usually) in the rest of the pen.

The infra-red lamps were progressively raised after the first week and were turned off at 3-4 weeks depending on the time of the year the particular trial was conducted in. In winter, the brooders were left on for longer than in the summer months.

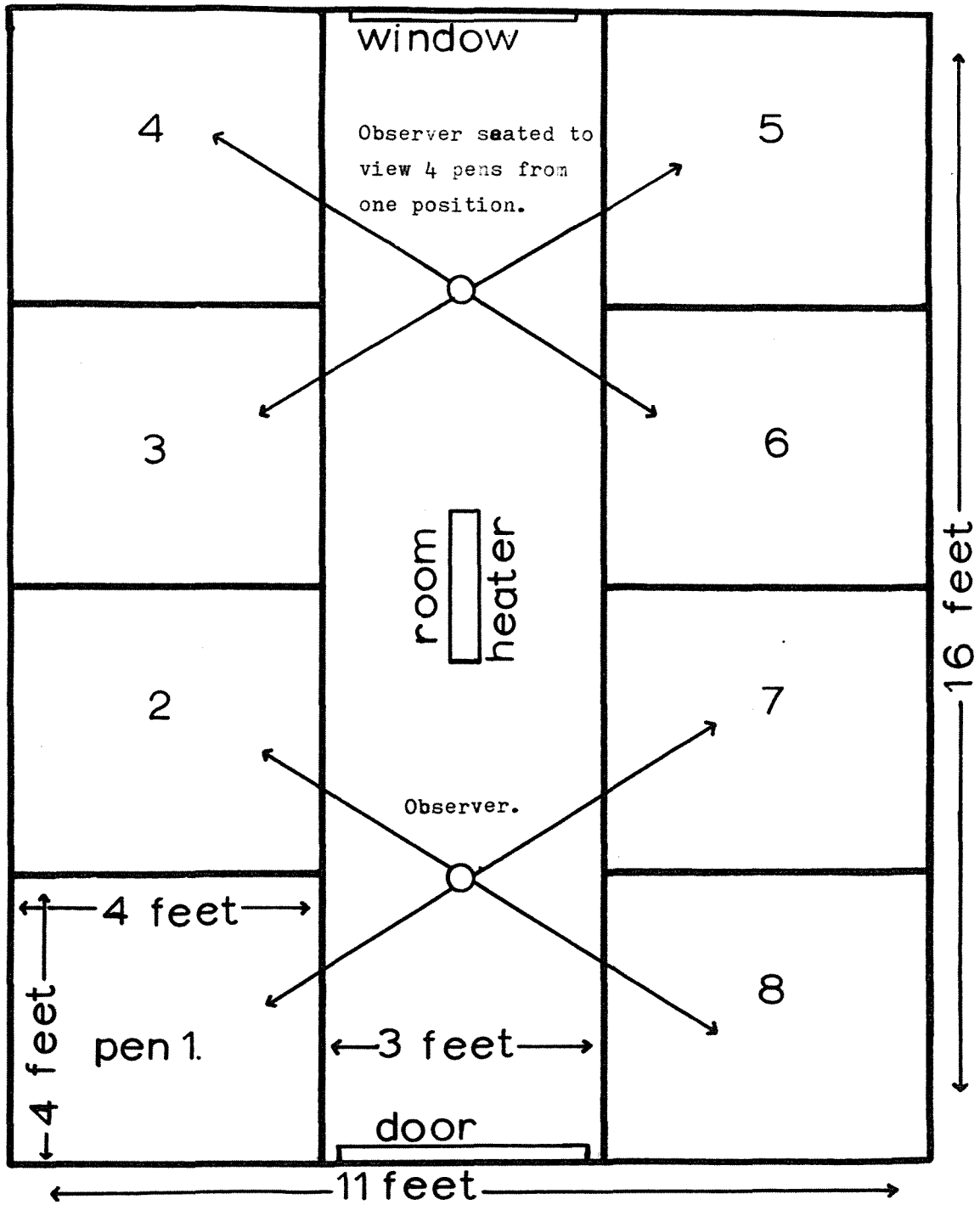
#### Lighting

Four 60 watt white light bulbs were linked to a time switch set to turn on the lights at 8.00 a.m. and off at 5.00 p.m. This regime was maintained for all of the trials except the last in which dull red lights were used for one half of the experimental animals.

#### Room Temperature

During the winter months this presented no problem, for it was merely a matter of maintaining a temperature around 60°F. This was achieved by closing the window and having the 1,000 watt strip heater thermostatically controlled to switch on when room temperature fell below 60°F.

Fig. 2. The Experimental Room.



In the later warmer months of the study, a hot spell was experienced and overheating of the room became a problem in the final experiment. Unless the door was opened through the day, room temperatures exceeded 80°F. This resulted in the data from one half of the last experiment having to be discarded because of daylight entering what was to have been a dull red light section of that experiment.

### Feeding

This was done in ad.lib.fashion; the food trays were kept full all day, thus the chickens fed to satisfy their appetite and/or energy requirements.

Measures of food consumption were achieved by placing a standard amount of food in the trays and weighing the food remaining in the tray at the end of the day. A day's food consumption was assessed as the amount consumed between 8.00 a.m. of one morning to 8.00 a.m. of the following morning. The procedure took into account any night feeding which took place. Night feeding did occur while the chicks were brooded under the infra-red lamps which provided sufficient light for the chicks to perform most of the behaviour characteristics of the diurnal repertoire, though the behaviour took place at lower intensity : less feeding, less activity and more resting.

### Body Weights

The chickens were weighed at hatching; at one week and then at fortnightly intervals (3 weeks, 5 weeks, 7 weeks).

### The Observations

These were performed from the alley-way between the pens with the observer seated relatively motionless on the chair, for the duration of the observation period. Before each period was begun, at least 5-10 minutes was allowed to elapse to permit the chickens to become accustomed to the presence of the

observer. It was noted that any sudden movement or noise made by the observer or noise coming from outside the room caused an abrupt cessation of activity. This lasted for only half a minute to one minute, after which time the chickens resumed the behaviour they had been performing prior to the interruptions.

#### Duration of Observations

In the first two trials a twenty-minute observation period was used as the basis for measuring the behaviour. This period proved inadequate because it did not always include a representation of each behaviour category. The chickens quite often rested for more than twenty minutes at a time and this aspect of their behaviour invalidated the sampling method.

In the experiments contained in the study, a fifty-minute observation period was used. This was sufficiently long to include representations of feeding, resting and activity in the one sample. Longer observation periods were found to be unsuitable due to the observer becoming fatigued and losing concentration.

One of the assumptions made in the study was that if enough of the fifty-minute observation periods were performed, they would be a representative measure of how the chicken distributes its day-time to the behaviour categories studied. Details on sampling and analysis of data are presented in the chapter on "Techniques of Measurement and Analysis".

CHAPTER VI

TECHNIQUES OF MEASUREMENT AND ANALYSIS

The observations were made from carefully selected positions in the central alley-way of the experimental room. From here the observer was able to view four pens and to assess the behaviour of each chick in those pens on a minute by minute basis. The process did entail the observer having to turn his head from side to side to widen the field of view sufficiently but this did not appear to disturb the chicks in any noticeable way. (See Figure 2).

From the diagram of the room, it is obvious that two observation periods were necessary to gain observations of the eight pens of chicks, and to ensure that diurnal variations in behaviour did not bias the sampling, a roster was drawn up to provide for each pen being observed in the early morning, late morning, early afternoon, and late afternoon during the course of one week. Early morning was from 8.00 a.m. to 10.30 a.m.; late morning from 10.30 a.m. to 1.00 p.m.; early afternoon from 1.00 p.m. to 3.00 p.m.; late afternoon from 3.00 p.m. to 5.00 p.m.

Four fifty-minute observation periods were made per day for four days per week, and the order in which the observations were made was varied from day to day.

First Day

Early morning	:	Pens 1,2,7,8
Late morning	:	Pens 3,4,5,6
Early afternoon	:	Pens 1,2,7,8
Late afternoon	:	Pens 3,4,5,6

Second Day

Early morning	:	Pens 3,4,5,6
Late morning	:	Pens 1,2,7,8
Early afternoon	:	Pens 3,4,5,6
Late afternoon	:	Pens 1,2,7,8

Over the four days used for observations in each week, each pen was observed in both early and late mornings and afternoons. The schedule resulted in each chick being observed twice daily, giving eight samples of behaviour per chick per week. The behaviour of each chick was followed at one minute intervals and any changes in behaviour were noted on this basis. In figure 3, a sample observation sheet is displayed, with the categories of behaviour represented by one or more letters. Feeding is abbreviated to F; standing to St; walking, pecking and running to W/Ps.

FIGURE 3.                    SAMPLE OBSERVATION SHEET OF SIX CHICKENS  
(Taken from Trial 1).

Chicks	1	2	3	4	5	6
Minutes						
1	F	St	W/Ps	F	St	S
2	F	St	W/Ps	F	S	S
3	F	F	W/Ps	W/Ps	S	S
4	F	F	W/Ps	W/Ps	S	S
5 to 50	F	F	W/Ps	W/Ps	S	S

From the observation sheets, the amount of time that each chick spent performing each category of behaviour was added up and expressed in the form of minutes per fifty-minute period, as in figure 4.

FIGURE 4.            DISTRIBUTION OF TIME FROM FIFTY-MINUTE OBSERVATION PERIOD OVER SIX CATEGORIES OF BEHAVIOUR.

(Data in minutes)

Category	F	W/Ps	Sc/Ps	St	S	Pr	Duration of Period
Chicken 1	10	9	6	10	5	10	50
Chicken 2	8	12	9	5	7	9	50
Chicken 3	9	10	5	6	10	10	50

and so on for the six chicks per pen.

In any one week there were eight samples of behaviour of each chick in the same form as the one shown in figure 4. These individual figures were used to calculate a mean figure for the chicks comprising an experimental group. For example, in the first experiment there were twenty-four chicks per group and so the mean figure for the time spent in any one category during a week was taken from 24 (individuals) by 8 (samples per individual) = 192 figures.

The weekly means were plotted on the graphs accompanying each experiment, where the vertical axis of "minutes/observation period" was derived from the sampling which has just been described.

While the graphs were formed from the means of experimental groups, the analyses of variance entailed the use of mean figures of individuals for calculations. Analyses were performed on the data for two, four and six weeks -

not on a week by week basis because any extra information obtained did not justify the time required to be spent on them. The results obtained in the analyses were not directly comparable to those trends displayed by the graphs because the mean figures used were different, as was the interpretation of results. The graphs show general trends from week to week and their interpretation tends to be subjective. Analysis of variance, on the other hand, is a respectable, objective and internationally accepted method of analysis with conventional levels (significant differences) for the acceptance or rejection of hypotheses.

In experiment 1, the means tested for significant difference were those for breeds, sexes and for weeks. In experiment 2, the food type means were tested instead of breed means as in experiment 1.

The analysis of variance model used in experiments 1 and 2 was a fixed factor; one which meant the use of the Error mean square in obtaining variance ratios. In experiment 1, there was a total of 143 degrees of freedom available for the analysis, resulting from the use of forty-eight chickens for three periods (weeks).

TABLE 5.                    ANALYSIS OF VARIANCE TABLE FOR FEEDING DATA, EXPERIMENT 1.  
(Data in minutes)

Source of Variation	d.f.	S.S.	M.S.	Variance Ratio
Breeds	1	22	22	-
Sex	1	5	5	-
Weeks	2	341	170	6.80**
B x S	1	124	124	4.96*
B x W	2	1	0.5	-
S x W	2	4	2	-
B x S x W	2	14	7	-
Error	132	3427	25	

\*\* Significant at the one percent level.

\* Significant at the five percent level.



In experiment 2, there were thirty-two chickens x three periods = total of ninety-three degrees of freedom. Again the error mean square was used for obtaining the variance ratios.

TABLE 6.            DEGREES OF FREEDOM FOR ANALYSIS OF VARIANCE, EXPERIMENT 2.

<u>Source of Variation</u>	<u>d.f.</u>
Food type	1
Sex	1
Weeks	2
F x S	1
F x W	2
S x W	2
F x S x W	2
Error	82
<hr/>	
Total	93

When more than two means were involved in a significant result, they were tested against one another with Tukey's D-test (Snedecor, 1956). This is the significant difference figure given below the standard error, where appropriate. The figure derived from the use of the D-test is preceded by the capital letter D for identification purposes. Similarly, the term "standard error" has been abbreviated to S.E. and precedes the figure given as the standard error of any particular table.

## CHAPTER VII

### EXPERIMENT 1 : QUANTITATIVE CHANGES IN THE MAINTENANCE BEHAVIOURS OF TWO BREEDS OF FOWL IN THE FIRST SEVEN WEEKS AFTER HATCHING.

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#### The Aims and the Design of the Experiment

To analyse in a quantitative form the changes in the maintenance behaviours displayed by chickens over the first seven weeks after hatching, two breeds of the domestic fowl were used to give the experiment a comparative basis, making the results obtained more valuable as generalizations on behavioural development.

The experiment was designed as a 2 by 2 factorial, using two breeds and two brooder types. In earlier trials it was found that under the infra-red lamp system of breeding, there was sufficient red light produced to enable the chicks to be active and feed at night. A dull brooder arrangement was made to test the effect of this nocturnal activity on diurnal activity; however the dull brooders were not successful because the blackened light bulbs used kept burning off the black paint and so this aspect of the experiment failed. The experiment was, therefore, changed to an all infra-red system and the factors tested for in the analysis were differences between breeds, sexes, weeks and the interactions between these factors.

#### Methods and Materials

The breeds used were a White Leghorn "M" strain and a Australorp strain. Both breeds were obtained from the Poultry Research Centre at Massey University. The White Leghorn strain was developed in Australia and has been bred at Massey for a number of years now. As a breed, the White Leghorn is thought to have originated in the Mediterranean region. In general characteristics it is an excitable, light-bodied, early feathering and generally precocious breed.

The Australorp originated in Australia from the local breeding of English Orpington stock. It is a black-feathered, heavy bodied breed with a relatively placid temperament. In general development (feathers and aggressiveness) it lags behind the White Leghorn in its rate of development. Both breeds were selected initially for high egg production qualities - that is they are both laying breeds. In New Zealand it is a common practice to mate a White Leghorn cock with an Australorp hen to obtain a dual purpose bird; one that has a high egg production and has a large enough body to be used in the poultry meat industry.

Twenty-four chickens of each breed were randomly selected from a hatch of approximately double the number of chickens required. The selection was made after sexing of the hatch so that equal numbers of males and females were included in the final total. Three chickens of each sex were assigned at random to each pen, the breeds being kept separate however. Thus the eight pens described in Chapter 5 each contained six chickens; four of the pens contained White Leghorns, the other four Australorps. The chicks were marked to enable individual identifications to be made. The Leghorns being white were easily marked using a variety of felt-tip pens. The Australorps were more difficult to mark because of their black plumage. Finally, a white latex-type paint was used to give six different identification marks. The food type used was a crumbled form "Snowball" brand manufactured by Farm Products (Manawatu) Limited and the feeding was done ad.lib. Measurements of food consumption were gained by totalling the amount of food a pen of chicks consumed between 8.00 a.m. of one day and 8.00 a.m. of the next. This took into account any night feeding that occurred. Individual measurements of food consumption could not be obtained because the six chicks in a pen fed from a communal food trough.

Results

TABLE 7.                    SUMMARY OF RESULTS OF ANALYSES OF VARIANCE FROM EXPERIMENT 1.  
(Mean squares only presented)

Source of variation	d.f.	Feeding	W/Ps	ScPs	Sitting	Standing	Preening	Growth
Breed	1	22	357**	0.4	222*	79	1	67,126
Sex	1	5	33	1.0	2	41	8	-
Periods	2	170**	2203**	10.5*	1277*	1009**	17.5*	-
B x S	1	124*	20	0.6	253*	1	0.4	-
B x P	2	0.5	356**	15.8**	427**	69	58**	-
S x P	2	2	3	3.5	19.5	26	7	-
B x S x P	2	7	13.5	1.2	5.3	45	2.3	-
Error	132	25	26.5	2.9	45	28	4.3	5,187

\*\* p : Significant at the 1 percent level (0.01)

\* p : Significant at the 5 percent level (0.05)

Growth Rates

The growth of each individual was obtained by subtracting the hatching weight from body weight at seven weeks after hatching. The differences between the breed means was highly significant.

TABLE 8.                    BREED MEANS FOR GROWTH

Australorps	549 gms
Leghorns	474 gms
S.E.±	10.43 gms

The graphs in figure 5 show the mean body weights of both breeds at hatching, and then at one week, three weeks, five weeks and seven weeks after hatching. At hatching the Australorps were heavier than the Leghorns; the mean figures being 35.5 gms.

and 33.25 gms. respectively. However, by the first week after hatching the Leghorns were heavier than the Australorps, a situation which persisted until the fifth week's weighing when a reversal took place. The trend displayed by the graphs was that the growth rate of the Australorps accelerated relative to that of the Leghorns and that this acceleration began at approximately four weeks after hatching.

#### Food Consumption Rates

The graphs in figure 6 were based on food consumption figures over four days per week. Daily averages were obtained from these for each week for each breed, and were subsequently plotted on the graphs.

The general trend displayed was that the Leghorns consumed more food per day until the fourth week when a reversal took place. By the fifth week the Australorps were consuming more food than the Leghorns and continued to do so for the duration of the experiment.

#### Time Spent Feeding

##### (i) Analysis of variance results

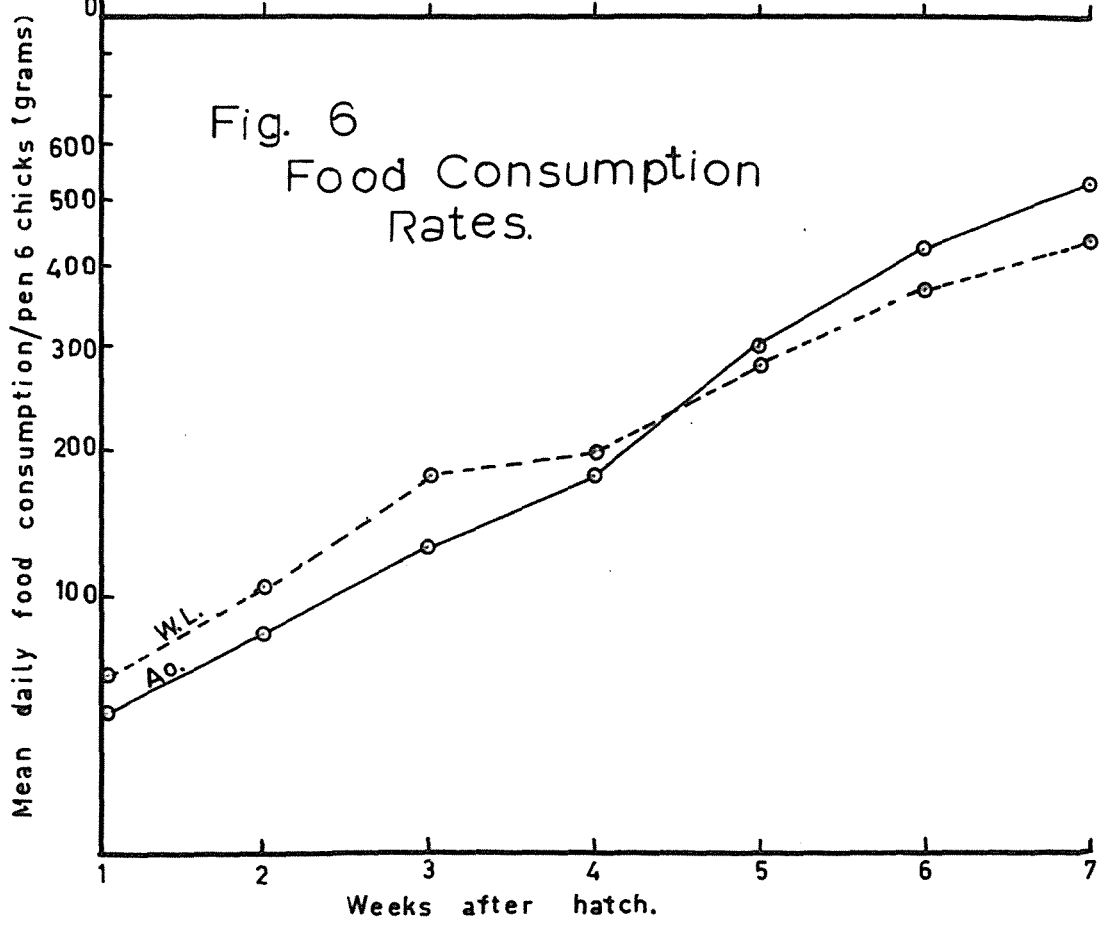
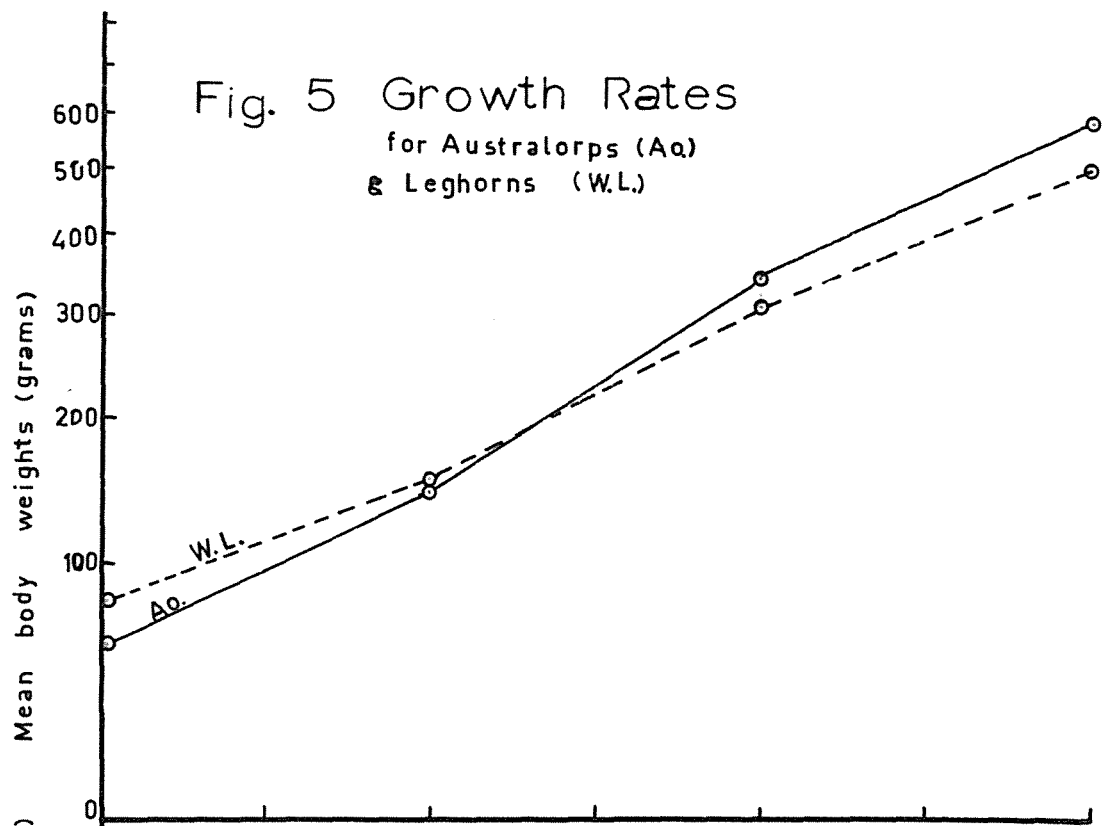
Significant differences were obtained between periods ( $P : 0.01$ ), and in a breed by sex interaction ( $P : 0.05$ ).

TABLE 9.

#### PERIOD MEANS FOR TIME SPENT FEEDING

(Data in minutes)

2nd Week	8.25
4th Week	10.95
6th Week	11.87
S.E. †	0.72
D.	2.41



The chicks spent significantly more time feeding in the 4th and 6th weeks than in the 2nd week. The difference between the 4th and 6th weeks was not significant.

TABLE 10.                    BREED BY SEX INTERACTION MEANS FOR TIME SPENT FEEDING

(Data in minutes)

	<u>Males</u>	<u>Females</u>
Leghorns	11.86	9.63
Australorps	9.22	10.72

S.E.  $\pm$  0.83

D. 2.3

The significant interaction occurred between the Leghorn males and Australorp males; the former spending significantly more time feeding than the latter.

Trends displayed by the graphs (Figure 7).

During the first week the Australorps spent more time feeding than the Leghorns; the position was reversed after the second week and from then on the Leghorns consistently spent slightly more time feeding than the Australorps.

The most notable feature of the graphs was the lack of any substantial change after the fourth week; a characteristic shared by both breeds.

Time Spent Scratching and Pecking in the Litter

(i) Analysis of variance results

Significant differences were obtained between periods (P:0.05); and in a breed by period interaction (P:0.01).

TABLE 11.                    PERIOD MEANS FOR SCRATCHING AND PECKING THE LITTER

(Data in minutes)

2nd week	1.58
4th week	2.48
6th week	1.70
S.E. <sup>±</sup>	0.24
D.	0.80

The significant difference was that between the 2nd and 4th weeks with more scratching being performed in the latter period.

TABLE 12.                    BREED BY PERIOD INTERACTION MEANS FOR SCRATCHING AND PECKING IN THE LITTER.

(Data in minutes)

	<u>2nd week</u>	<u>4th week</u>	<u>6th week</u>
Leghorns	1.95	2.0	1.87
Australorps	1.20	3.16	1.54
S.E. <sup>±</sup>	0.34		
D.	0.95		

The fourth week (Period 2) Australorp mean was significantly higher than all other means.

(ii) Trends displayed by the graphs (Figure 8)

The Leghorns displayed a steady increase in the time spent scratching up to the fifth week after which a steady decline in the rate of scratching was evident.

The Australorps displayed a sudden surge in time spent scratching during the fourth week and surpassed the peak reach by the Leghorns. After the fourth



week they displayed a rapid decrease in the rate of scratching to fall well below the Leghorn rate at the seventh week.

Time Spent Walking, Pecking and Running

(i) Analysis of variance results

Significant differences were obtained between breeds (P : 0.01); between periods (P : 0.01); and in a breed by period interaction (P : 0.01).

TABLE 13.            BREED MEANS FOR TIME SPENT WALKING, PECKING AND RUNNING

(Data in minutes)

Leghorns	14.9
Australorps	11.8
S.E. <sup>†</sup>	0.6

TABLE 14.            PERIOD MEANS FOR TIME SPENT WALKING, PECKING AND RUNNING

(Data in minutes)

2nd week	5.75
4th week	15.73
6th week	18.68
S.E. <sup>†</sup>	0.73
D.	2.44

The three periods were significantly different from one another.

TABLE 15.

## BREED BY PERIOD MEANS FOR TIME SPENT WALKING, PECKING AND RUNNING.

(Data in minutes)

	<u>2nd week</u>	<u>4th week</u>	<u>6th week</u>
Leghorns	7.45	14.50	22.91
Australorps	4.04	16.91	14.95
S.E. $\pm$	1.04		
D.	4.26		

- (a) The sixth week Leghorn mean was significantly higher than all other means.
- (b) The fourth week Australorp mean was significantly higher than the second week means for both breeds.
- (c) The fourth week Leghorn mean was significantly higher than the second week means of both breeds.
- (d) The sixth week Australorp mean was significantly higher than the second week means of both breeds.

(ii) Trends displayed by the graphs (Figure 9)

There were two obvious trends shown. Firstly, that the Leghorns spent a good deal more time than the Australorps in performing these activities; it was only during the fourth week that the Australorp level of activity exceeded that of the Leghorns during ontogeny. Secondly, that both breeds showed a marked increase in this activity from the third week onwards. The Australorps reached a peak at four weeks, and the Leghorns not until five to six weeks. Both breeds showed a decline to the seventh week.

Fig. 7 Time Spent Feeding.

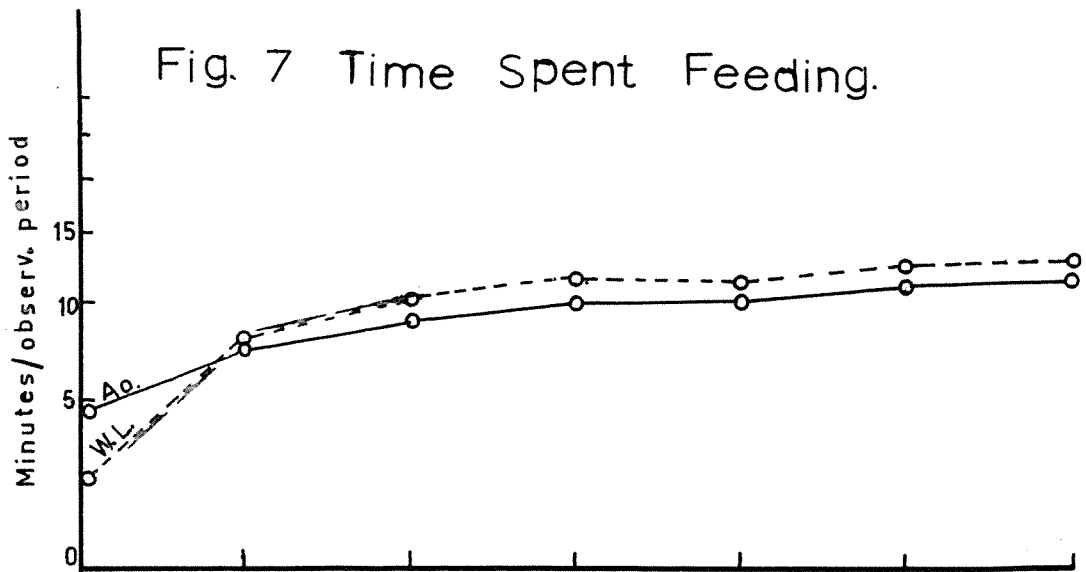


Fig. 8 Time Spent Scratching & pecking.

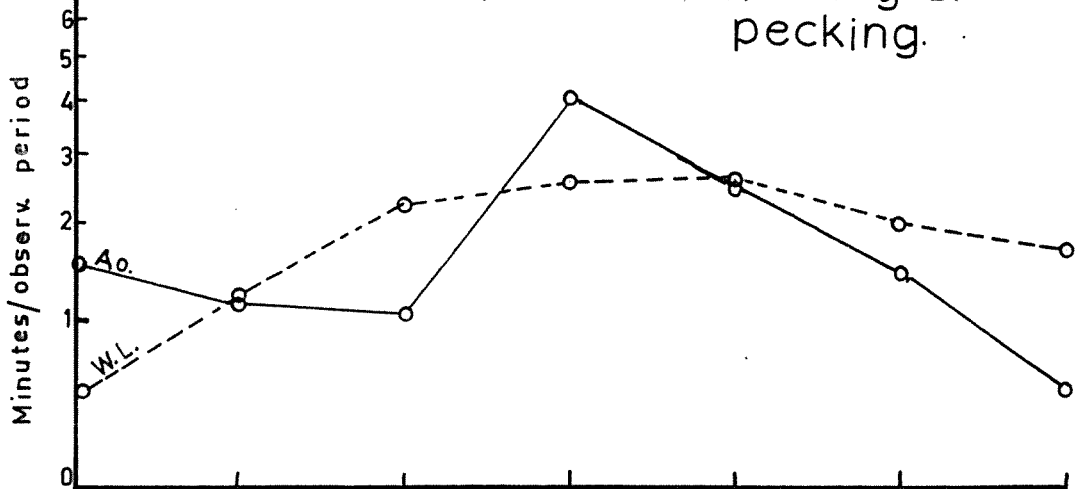
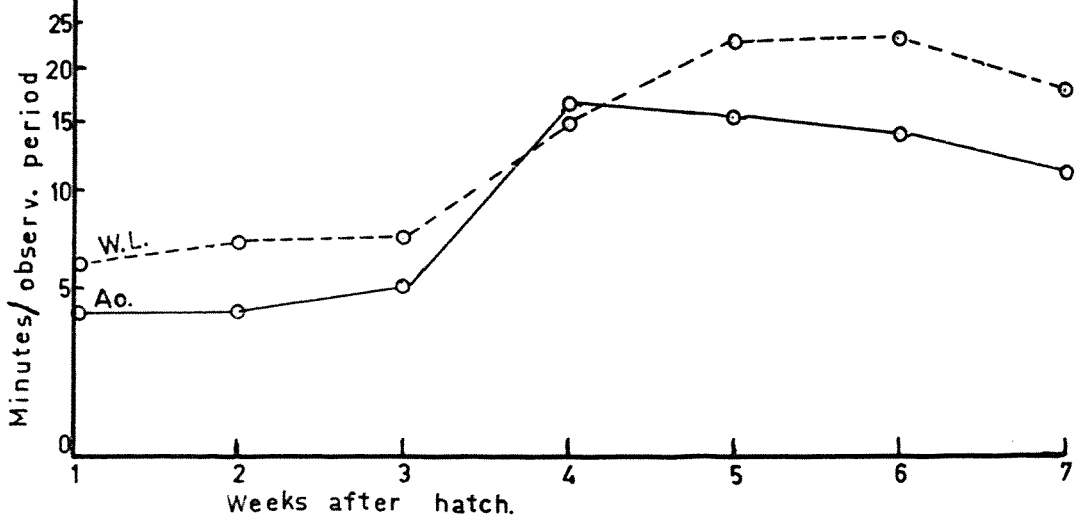


Fig. 9 Time Spent Walking, etc.



Time Spent Standing(i) Analysis of variance results

Significant differences were obtained between periods (P : 0.01).

TABLE 16.            PERIOD MEANS FOR TIME SPENT STANDING (Data in minutes)

2nd week	15.08
4th week	8.77
6th week	6.16
S.E. †	0.76
D.	2.54

The three periods were significantly different from one another.

(ii) Trends displayed by the graphs (Figure 10)

If the means for the first week were disregarded, then there was evident a steady decline in the time standing down to a low point at five weeks for the Australorps and six weeks for the Leghorns.

Time Spent Sitting(i) Analysis of variance results

Significant differences were obtained between breeds (P : 0.01); between periods (P : 0.01); in a breed by sex interaction (P : 0.05); and in a breed by period interaction ( P : 0.01).

TABLE 17. BREED AND PERIOD MEANS FOR TIME SPENT SITTING (Data in minutes)

	<u>2nd week</u>	<u>4th week</u>	<u>6th week</u>	<u>Breed</u>
Leghorns	16.4	8.8	3.8	9.7
Australorps	17.3	6.3	12.9	12.2
Periods	16.9	7.6	8.4	
S.E. for breeds	$\pm$ 0.79			
S.E. for periods	$\pm$ 0.97			
D. for periods	3.24			

The second week mean was significantly higher than the fourth and sixth week means, but the difference between the latter two was not significant.

S.E. for breed by period interaction	$\pm$ 1.37
D. for breed by period interaction	5.60

- (a) The second week Australorp mean was significantly higher than the fourth week Australorp mean and the fourth and sixth week Leghorn means.
- (b) The second week Leghorn mean was significantly higher than the following : the Leghorn fourth week mean; the Australorp fourth week mean; and the Leghorn sixth week mean.
- (c) The sixth week Australorp mean was significantly higher than the following : the means for the fourth week Australorps and the sixth week Leghorns.

TABLE 18.            BREED BY SEX INTERACTION MEANS FOR TIME SPENT SITTING

(Data in minutes)

	<u>Males</u>	<u>Females</u>
Leghorns	8.5	10.9
Australorps	13.6	10.7
S.E. $\pm$ 1.1		
D. 4.05		

The mean for the Australorp males was significantly higher than that of the Leghorn males.

(ii) Trends displayed by the graphs (Figure 11)

The general trend was for time spent sitting to decrease until the fourth week in the case of the Australorps, and the sixth week in the case of the Leghorns, after which time an increase in sitting time was shown. The Leghorns displayed a regular trend, the Australorps a rather irregular one, which resulted in the Leghorns spending more time sitting during the fourth week. The other major feature was that the Australorps spent a great deal more time sitting than the Leghorns - with the exception of the fourth week, of course.

Time Spent Preening

(i) Analysis of variance results

Significant differences were obtained between periods (P : 0.05); and in a breed by period interaction ( P : 0.01).

Fig.10 Time Spent Standing.

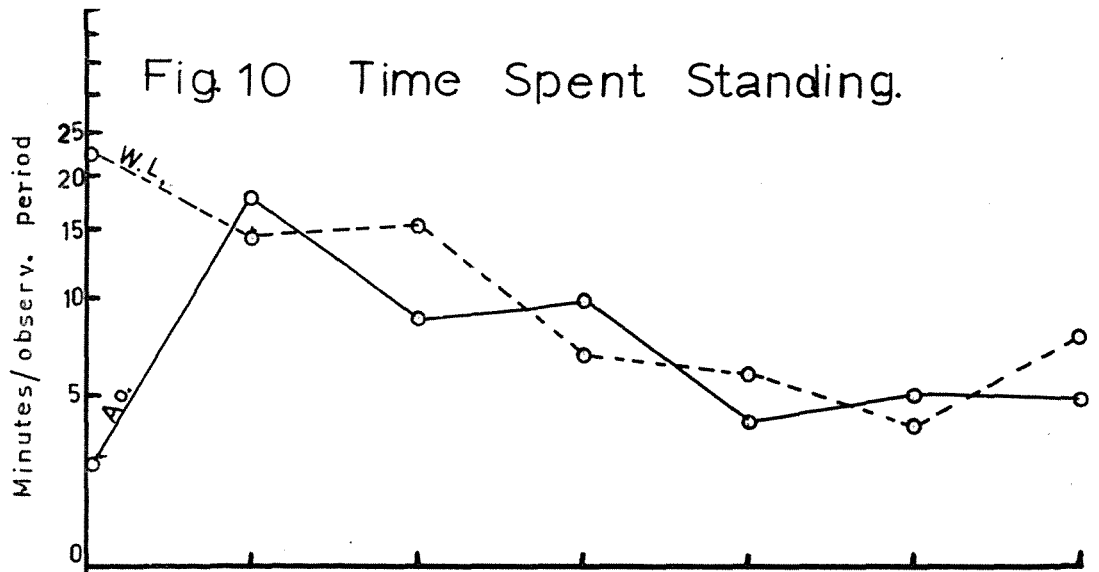


Fig.11 Time Spent Sitting.

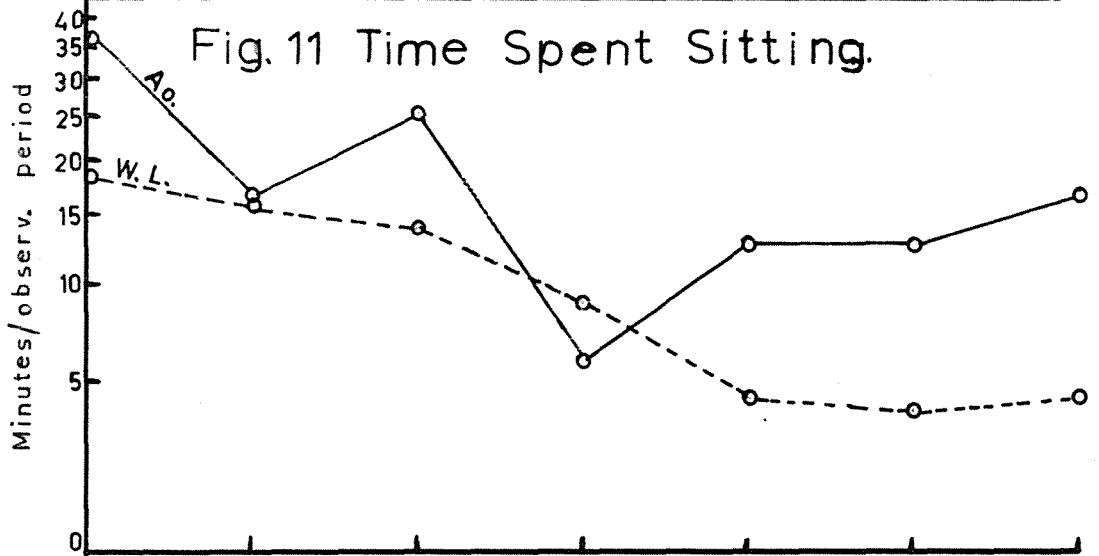


Fig.12 Time Spent Preening.

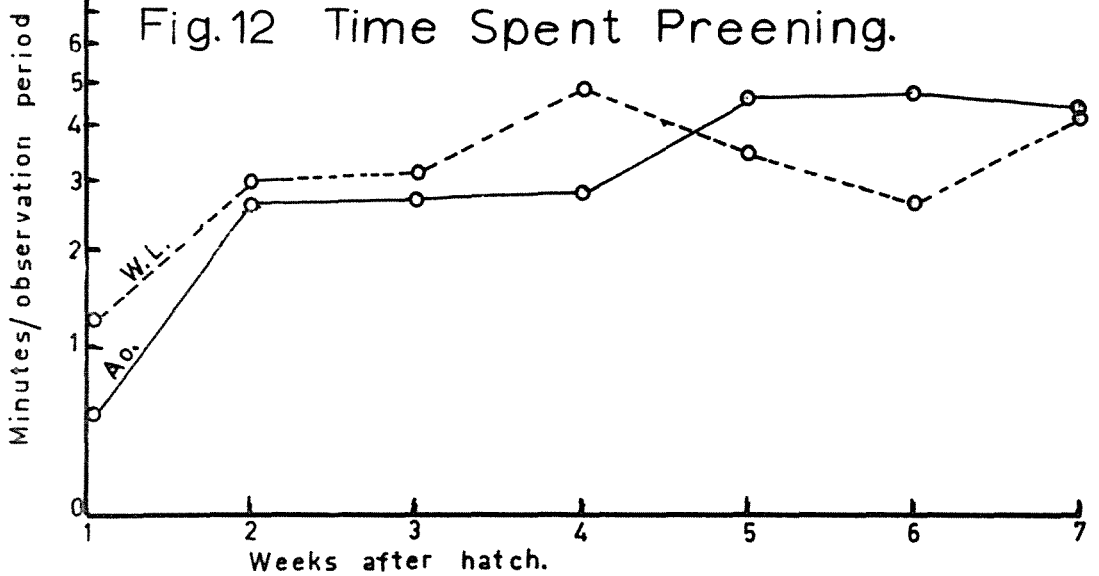


TABLE 19.

PERIOD AND BREED BY PERIOD INTERACTION MEANS FOR TIME  
SPENT PREENING.

(Data in minutes)

	<u>2nd week</u>	<u>4th week</u>	<u>6th week</u>
Leghorns	2.95	4.95	2.87
Australorps	2.66	2.62	4.95
Period Means	2.81	3.79	3.91
S.E. for Period Means	± 0.29		
D. for Period Means	0.97		

The fourth and sixth week means were both significantly higher than the second week mean.

S.E. for breed by period means ± 0.41

D. for breed by period means 1.14

- (a) The fourth week Leghorn mean was significantly higher than all other means with the exception of the sixth week Australorp mean.
- (b) The sixth week Australorp mean was significantly higher than all other means with the exception of the fourth week Leghorn mean.

(ii) Trends displayed by the graphs. (Figure 12)

There was a fairly regular change in time spent preening by both breeds. The Leghorns reached a peak during the fourth week, followed by a decrease to the sixth week and then an increase to a second peak at the seventh week. The Australorps reached a peak during the fifth and sixth weeks and then showed a decrease.



Concerning breed differences, the Leghorns spent more time preening up to the fourth week than the Australorps when the position was reversed by the substantial increase in the amount of preening done by the Australorps over their peak period.

## Discussion of Results

### General Features

The most notable feature of the development of the maintenance behaviours of the chick is the transition from a predominantly resting state during the first week to an intense, juvenile phase of activity. Equally notable is the decrease in activity which occurs after 4 to 6 weeks, depending on the breed of chicken.

The factors involved in the change of emphasis from resting to activity must include the following :

- (i) the change from a poikilothermic condition to a homeothermic condition.
- (ii) the development of plumage with a consequent decrease in cutaneous heat and water loss.
- (iii) the maturation of the endocrine system and its effects on metabolism, vigour and activity, etc.
- (iv) the maturation of the nervous system interacting with other changes in body physiology to give rise to a more varied range of behavioural responses as the chick develops and to facilitate the performance of responses already present.
- (v) general anatomical and physiological changes which are pre-requisites to behavioural change - for instance, the increase in erythrocytes in the blood to provide the extra oxygen carrying capacity to permit the chick to attain and sustain a highly active state.

## Specific Results

### Growth Rates

It was to be expected that the Australorps would show a significantly higher weight gain than the Leghorns over the 7 weeks of the experiment, for they are generally recognized as a "heavy" breed, and the Leghorns as a "light" breed.

What was not expected was that one week after hatching the Leghorns would surpass the Australorps in mean weight gain and maintain their weight advantage until the fifth week's weighing. The explanation of this may be that it is a manifestation of the general precociousness of the Leghorns (they feather earlier than the Australorps and their combs develop earlier too).

Of relevance to this point is that the Leghorns also consume more food over this period than the Australorps do. In fact there is a close correspondence between the food consumption rates and the body weight gains shown by the two breeds. For instance, the food consumption rate of the Australorps does not exceed that of the Leghorns until the fifth week and this is the approximate time (actually it is a little earlier) at which the Australorps surpass the Leghorns on mean body weights.

### Time Spent Feeding

One of the most unusual findings of the experiment was that while the mean body weight of both breeds doubles from four to seven weeks, there was no substantial increase in the amount of time spent feeding over this period. The question is then, what factors operate in the maturation of the chick to enable it to continue increasing its food intake and its body weight without also increasing the amount of time it spends feeding. A possible explanation is that it is the increase in the size of the bill which is the operating factor.

Whatever the explanation may be, there remains the major consideration that the chick does not have to devote excessively large amounts of time to feeding as it grows older. This is of value in that the chick is able to devote adequate time to activities such as exploration of the environment, reproductive activities, and care of the body surface.

Differences between breeds were slight. The Leghorns spent approximately 2 percent extra time feeding than the Australorps from the third week onwards. The interest lay in the fact that while spending less time feeding, the Australorps were consuming larger quantities of food than the Leghorns over this period.

An investigation into the amount of time that New Hampshire chickens of 3 to 4 weeks of age spent feeding was carried out by Jensen, Merrill, Reddy and McGinnis (1962). They obtained the following figures : mash diet 14.3 percent of day-time and pelleted diet 4.7 percent of day-time. These figures are considerably lower than those obtained in the present experiment. The crumbles used in this experiment would be far larger particles than the mash used by Jensen, et al. and it would be expected that chickens on a crumbled diet would spend less than 14.3 percent of their time feeding. This was not the case. At four weeks the Leghorns and Australorps were both spending at least 20 percent of their day feeding.

These differences are probably a reflection of aspects of management such as light intensity, day length, density of chicks and size of pen, and so on.

#### Time Spent Scratching and Pecking

The Australorps reached a peak in the time spent scratching at the fourth week; the Leghorns reached theirs over the fourth and fifth weeks. These results are compatible with the times at which the two breeds attained their highest

levels of general activity. Dawson and Siegel (1967) in their investigation found that their White Rock chickens reached a peak of scratching at the third week, declined rapidly to the seventh week, and then began increasing again at the ninth week.

The changes displayed in the rate of scratching emphasize the degree to which this activity has become detached from the feeding action, for feeding time changes little over the weeks when substantial changes take place in the rate of performance of scratching.

#### Time Spent Walking, Pecking and Running

The increase in this activity shown by both breeds can be related to the physiology of development - that the metabolic rate of the hatched chick is lower than that of the adult. The metabolism increases during the first four weeks after hatching to reach a level considerably higher than the adult level. It then decreases until the adult level is reached (Whittow, 1965).

The experiments of Freeman (1965) indicate that the time taken to attain the homeothermic condition probably restricts the activity of the chick for little more than one week. It is probable that the growth of feathers is an important factor in the changes in the rate of activity of the chick, for when the chick is active it is losing a considerable amount of body heat and it seems reasonable to assume that the development of an effective insulation (feathers) which reduced cutaneous heat loss would permit the chick to lead a more active existence.

The part played by the thyroid in the change of activity is uncertain, for the growth rate of the thyroid accelerates some time after the peak metabolic rate has been passed (Breneman, 1954).

Perhaps then there is a need to postulate the existence of some "metabolic accelerator" (Beattie and Freeman, 1962), which may act independently of the

thyroid in regulating the metabolism of the chick until 7 to 8 weeks after hatching.

The gonadal hormones may well be involved in the rapid increase in activity up to the fourth and fifth week. For instance, there is the evidence of Breneman and Mason (1951) that there is a marked increase in the secretion of androgens from 30 to 40 days after hatching.

The difference between the Leghorns and the Australorps which was obtained in the statistical analysis and which appears to be obvious on the graph was not unexpected. The Leghorns are a very active, highly excitable breed of fowl and it has been demonstrated that their metabolic rate is higher than that of "heavy" breeds such as the Rhode Island Red.

The placid temperament of the Australorps manifests itself in the relatively low levels of activity that this breed attained.

#### Time Spent Standing and Sitting

The large amounts of time the chicks spent resting during the first week was primarily due to their need to be near an external source of heat. In this case, the infra-red lamp. The Australorps did not spend a great deal of time standing compared to the Leghorns, but they did spend large amounts of time sitting under the brooder in the first week. The Leghorns, on the other hand, did not spend much time sitting but did do a lot of standing. The decrease in the amount of time spent standing and sitting was probably due to those factors operating to increase the metabolic rate of the chick, and secondly its growing independence of the external heat source.

The view being advanced is that resting and activity are mutually exclusive states, and that it is the increase in activity which has decreased the amount of time spent standing and sitting. A counter-argument could be that a decrease in standing and sitting time is primary and the increase in activity is

secondary, but there is little evidence for such a view.

### Time Spent Preening

Dawson and Siegel (1967) described a linear increase in the number of times their White Rock chicks preened; the linear trend continuing from hatching to ten weeks of age.

The results of the present experiment are at variance with those of Dawson and Siegel in that both breeds used displayed non-linear changes in the amount of time given to preening over the seven weeks of the experiment.

The Leghorns are an early-feathering breed and this is reflected in the high level of preening from the second week onwards.

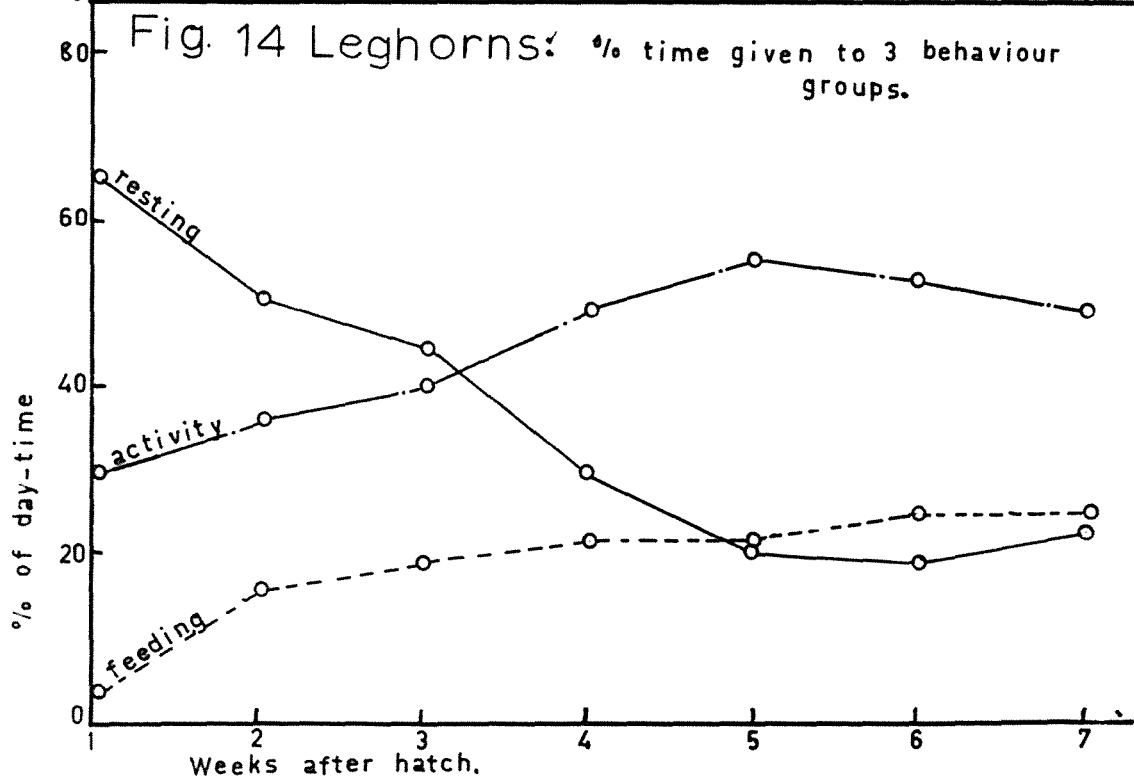
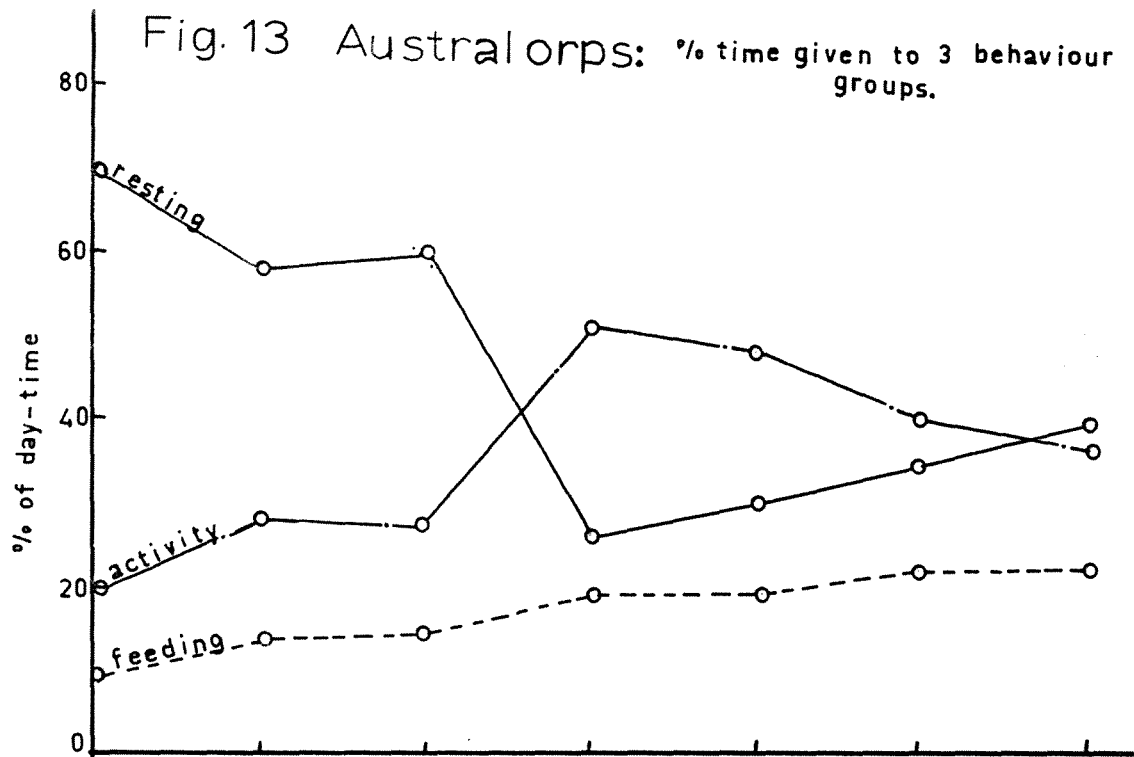
The Australorps are not an early-feathering breed and this too is reflected in that they reach a peak of preening activity much later than the Leghorns. Preening then is another example emphasizing the precociousness of the Leghorns when compared to a "heavy" breed of fowl.

### Interrelationships Between the Behaviour Categories

The results of Experiment 1 were converted from minutes per 50 minute observation period (means) to percentages. The three major categories of maintenance behaviour - feeding, resting and activity were graphed (Figures 13, 14) to demonstrate how their relationships with one another changed with the maturation of the chick.

In the first week the Leghorns spent 66 percent of their time resting; the Australorp figure for this time was 70 percent. At the seventh week the Leghorns spent 22 percent of their time resting; the Australorp figure was 38 percent.

It is tempting to assume that the greater body weight gain shown by the Australorps over the 7 weeks is partly a product of the extra time they spend





resting. However it is most likely that the primary factors involved in the high weight gain of the Australorps are also responsible for the low rate of activity with the consequence of making more "energy" available for growth in this breed.

The higher food consumption rate of the Australorps must be regarded as a major factor in their growth rate relative to the Leghorns, but at the same time it must be kept in mind that energy output (activity) will play a large part in determining the amount of energy left for growth purposes. In the sense of energy output, the temperament of the breed which is based on an interaction between the central nervous system and the endocrine system must be taken into account as a factor in the growth rate of that breed.

The evidence available is insufficient to objectively appraise the part played by temperament in the weight gain of the chick; however, this question could perhaps be answered by using several breeds or strains of differing temperament in an experiment measuring weight gain, activity level and food consumption. The breeds or strains used would, of course, have to be of similar body shape and size. For instance, they would all have to be "heavies" or "lights"; otherwise the experiment would not succeed.

#### Correlations Between Feeding, Activity and Resting

Correlation analyses were performed using the data from the 24 Leghorns. The data were in the original form of minutes per observation period. The fourth week mean figures were used.

TABLE 20.                    RESULTS OF CORRELATION ANALYSES PERFORMED ON THREE VARIABLES

<u>Total Correlations</u>	<u>Partial Correlations</u>
Feeding and activity    r - .08	r - .29
Feeding and resting    r - .80 p: .01	r - .53 p: .01
Activity and resting    r - .74 p: .01	r - .78 p: .01

The changes in the correlation coefficients after the performance of partial correlation analyses are not sufficiently large to warrant a separate discussion. The following discussion then relates to the total correlations only.

- (a) There is no correlation between the amount of time chickens spend feeding and the amount of time they devote to activity.
- (b) There is a significant negative correlation between time spent feeding and time spent resting.
- (c) There is a significant negative correlation between time spent resting and time spent active.

The interpretation of these results is that :

- (i) activity and resting tend to be incompatible factors in the chicken's behaviour; individual chicks either rest a lot and spend little time active, or they are active and spend little time resting. The two factors are rarely present at similar levels in any individual chick.
- (ii) feeding and resting are incompatible factors; it is rare to find similar levels of both factors in the one individual. Chicks that feed a lot spend little time resting and vice-versa.
- (iii) feeding and activity are not incompatible factors; it would not be rare to find an individual spending large or small amounts of time on both categories of behaviour.

The correlations apply only within the Leghorns; they cannot be generalized to the Australorps or be used to draw conclusions on differences between breeds.

### Body Weight and Behaviour

Regression analyses were performed to discover if there was any relationship between body weight and time spent on the different behaviour groups.

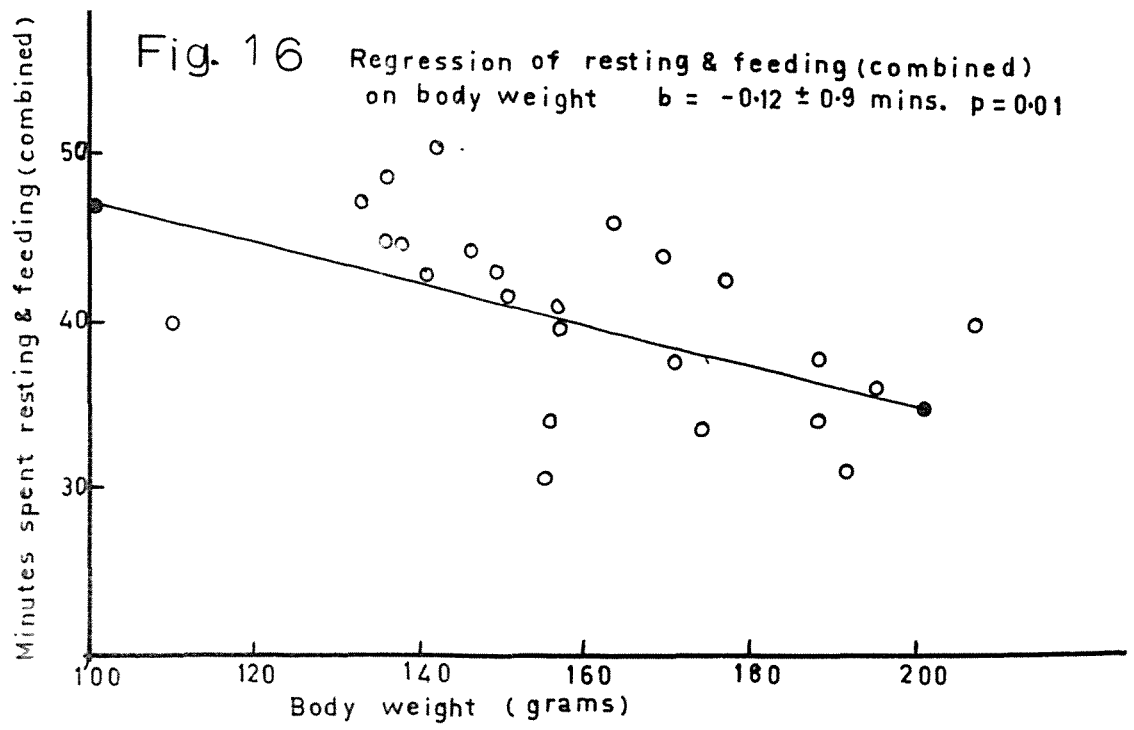
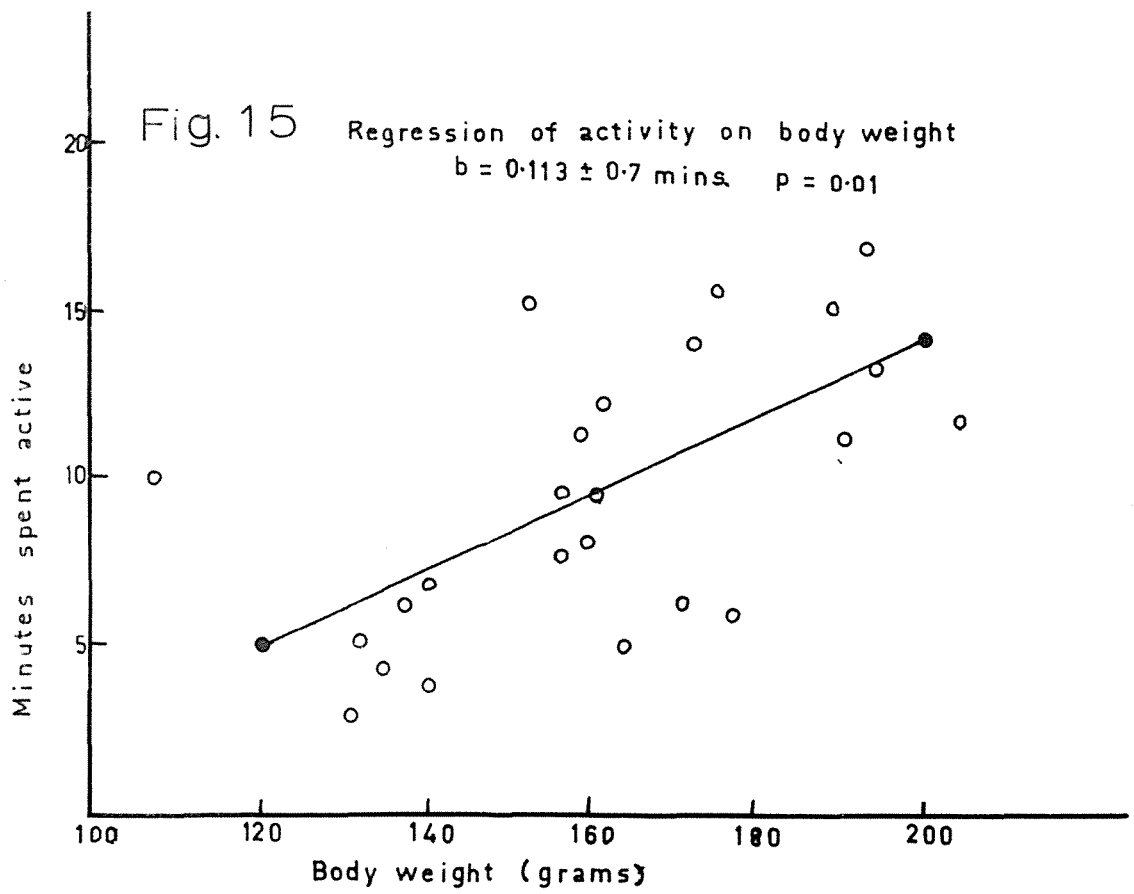
The data used were the body weights of the 24 Leghorns at three weeks of age, and the mean figures (minutes) for time spent feeding, active and resting during the fourth week.

Body weight was used as the independent variable and the behaviour groups as dependant variables in the analyses.

Figure 15 gives the results of the analysis using time spent active as the dependant variable. A significant ( $P:0.01$ ) positive regression was obtained; the regression being 0.113 minutes. That is, for every pound increase in body weight there was a corresponding increase of 0.113 minutes in time spent active. The result is of interest also in that there is a positive correlation between thyroid weight and body weight in New Hampshire chicks of four weeks of age. (Ringer, 1965).

Figure 16 gives the results of the analysis using the time spent feeding and resting combined as the dependant variable. A significant ( $P:0.01$ ) negative regression was obtained; the regression coefficient being 0.12 minutes. For every pound increase in body weight, there was a decrease of 0.12 minutes in the time spent feeding and resting.

Regression analyses using feeding and resting data in separate analyses as dependant variables had resulted in non-significant, slightly negative regressions. The combined effect of these two groupings as one dependant variable, resulting in a significant negative regression, complements the positive regression obtained using activity as a dependant variable.



The results of these analyses cannot be generalized to other breeds or even to the adult birds of this breed; they are specific results relating to juvenile White Leghorns of four weeks of age, and they demonstrate that there are relationships between body weight and time spent in activity, feeding and resting.

#### Summary

- (i) An experiment using 24 White Leghorn and 24 Australorp chickens was conducted to measure the changes occurring in the amount of time given from hatching to seven weeks after hatching, to six categories of maintenance behaviour.
- (ii) It was established by the use of statistical analysis and by studying trends displayed by graphs, that the two breeds differ considerably on the amount of time they spend on each category of behaviour.
- (iii) It was also established that both breeds displayed the same general trends; a departure from predominantly resting behaviour in the first week, to peak levels of activity several weeks after hatching. These peaks of activity were followed by declines in the time spent on this behaviour.
- (iv) Correlation analyses were used to demonstrate that a relationship existed between the amount of time individuals were likely to spend feeding, active and resting.
- (v) Regression analyses were used to show that at four weeks after hatching the heavier White Leghorn individuals tended to be the most active chicks.

CHAPTER VIIIEXPERIMENT 2. THE EFFECTS OF TWO DIFFERENT FORMS OF FOOD ON QUANTITATIVE CHANGES IN THE MAINTENANCE BEHAVIOURS OF WHITE LEGHORN CHICKENS.Background to the Experiment

The foods used in the poultry industry consist of two major forms :

- (i) the mashes, which are obtained by the grinding up of grains such as wheats, oats, etc. to which are added supplementary vitamins, minerals, and other factors involved in animal health: coccidiostats, etc.
- (ii) pellets (and crumbles) which are obtained by compressing the mashes under heat treatment to form a particle considerably larger than those particles comprising the original mash. The crumbles are obtained by breaking up the pellets into a size intermediate between that of the pellets and the mashes.

Scientific interest in the merits of these different forms of food, centres around the fact that chickens fed on pellets or crumbles have a higher growth rate than chickens fed on mashes. Lanson and Smyth (1955) using White Plymouth Rock chicks found that the group fed on pellets had a greater efficiency of conversion than the group fed on mash. These investigators noted that the pellet fed groups had more inactive time which may have accounted for the increased efficiency, but the density of the ration may be a factor too in their view.

Merritt and Gowe (1965) gave the following figures for pellet and mash fed groups : the extra increase in weight due to pelleting was 7.5 percent for males and 5.2 percent for females. The figures applied to 67 day body weights.

A great deal of research has been carried out by poultry scientists in an attempt to determine why pelleting of mashes results in a higher weight gain. The extensive review by Calet (1964) showed that, although a large number of investigations have been carried out on the chemical and physical aspects of the different particle sizes and their possible effects regarding the growth rate, only one study is recorded concerning the behavioural implications of the problem.

That study is the one of Jensen, Merrill, Reddy and McGinnis (1962). These authors, using New Hampshire chicks of 21 and 28 days of age, found that on a mash diet their chicks spent 14.3 percent of a 12 hour day in feeding. On the pellet diet the chicks spent only 4.7 percent of the day feeding. There were only very small differences in the weight of food consumed between the groups on the two food forms.

This evidence has been used to support the theory of Leroy; that the loss of heat which goes with eating is a function not only of the quantity of food ingested but also of the time required for this ingestion. Any reduction in this time results in an increase in the productive energy of the feed. Calet concluded that : "-- here lies the explanation of the beneficial effect of granulation".

In addition to giving a greater weight gain, the pelleting of mashes brings with it an increased risk of mortality due to cannibalism. Bearnse, Berg, McClary and Miller (1949) compared the amounts of feather-pulling and cannibalism in White Leghorn pullets fed on pellets and mash. The pellet fed group began feather-pulling at an earlier age and at the duration of the experiment the mortality from cannibalism was significantly higher compared to the mash fed group.

### General Considerations

The implications of food particle size and its effect on the life of the chick are greater than the nutritional concerns which have been outlined. For instance, Wood-Gush and Gower (1968) studied motivation in the feeding behaviour of the domestic cock. They used both mash and pellet foods and deprived the cocks of food for periods of 2, 24 and 48 hours. The most interesting result of their experiments was that there was no increase in the amount of mash consumed at 48 hours deprivation compared to the 24 hour deprivation experiment. Conversely, on the pellet diet, there was a substantial increase in the amount of food consumed at the 48 hour deprivation period compared to the 24 hour deprivation period. The interpretation placed upon these results was that pelleted foods probably represent more closely the food form (grain and insect foods) of the ancestor of the domestic fowl. Thus the results from the pelleting experiment are possibly a clearer picture of the interrelationships of the various measures of motivation. Mash has no counterpart in the wild and this presumably was the reason for the atypical results displayed by the group on mash deprivation. That is, this man-made food form does not interact with the endogenous factors involved in the motivation of feeding to produce a typical feeding pattern. A generalization on feeding is that the more hungry the animal, the more it will eat. This, the domestic chicken does not do when fed on a mash diet and tested by the food deprivation method.

### Conclusions

An investigation to amplify the evidence produced by the study of Jensen, Merrill, Reddy and McGinnis (1962) would be a profitable approach to the question of why chicks have a higher growth rate when fed on pellets without consuming a greater weight of food than when fed on mash.



### The Aims of the Experiment

- (i) To measure the differences in time spent feeding by two groups of chicks; one fed on mash, the other on crumbles.
- (ii) To note if the expected differences in time spent feeding by the experimental groups have an affect on the amounts of time given to the other categories of maintenance behaviour.
- (iii) To keep records of body weight gain (growth) and food consumption levels, for use in association with the behavioural data to assess the role played by the latter in the effect of crumbles on growth rates.
- (iv) That these three aims be put into effect over the first seven weeks after hatching so that the roles played by the factors involved are revealed in a developmental rather than in a static manner.

### Methods and Materials

Forty-eight White Leghorns (M-line strain) from the Massey population were wing-banded, sexed and weighed at hatching, and then three individuals of each sex were distributed at random to each of the eight pens. Marking, for purposes of individual identification, was done by an assortment of felt tip pens.

Each pen contained a feeder, a waterer, an infra-red brooder, and litter consisting of wood shavings 4 to 5 inches deep.

Room lighting consisted of four 60 watt white light bulbs connected to a time clock set to switch on at 8.00 a.m. and off at 5.00 p.m. for the duration of the experiment.

The food types were : (i) "Snowball" brand high energy chick crumbles;  
(ii) the same brand of high energy chick mash.

Four of the pens received the crumbles; the other four the mash. Room temperature was maintained above  $60^{\circ}\text{F}$  by the 1000 watt strip heater in the room. Occasionally temperatures rose up to  $70^{\circ}\text{F}$ , but the range did not exceed much more than  $10^{\circ}\text{F}$  in any one day.

### The Observations

Were performed according to the programme outlined in Chapter 6, using 50 minute periods, four times daily for four days a week. Records of the amounts of time which individuals spent performing the six categories of behaviour described in Chapter 4 were kept on a minute by minute basis, as in Experiment 1.

Each Pen contained 3 males and 3 females, but of these only two individuals of each sex were selected for observation for the duration of the experiment. Thus the weekly mean figure shown in the graphs for each experimental group is the mean of the sixteen individuals comprising that group. The individual means for each week were obtained from the eight samples of time taken of each individual in a week. Thus the experimental group mean for each week was composed of 128 samples ( 16 animals by 8 samples per animal).

### The Graphs

The only graphs to be plotted on a weekly basis were those for food consumption, and for time spent feeding. The others were plotted at two, four and six weeks after hatch, because the essential outline of the changes in each category of behaviour on a weekly basis had already been covered adequately in Experiment 1. An unnecessary duplication of results was, therefore, avoided without detracting from the differences displayed by the experimental groups on each behavioural category.

Results

TABLE 21. SUMMARY OF RESULTS OF ANALYSES OF VARIANCE  
(Mean squares only)

Source of Variation	df	Feed	Walking, Pecking	Scratching, Pecking	Sitting	Stand	Preen	Total Activity	Growth
Food type	1	1107**	86	43	55	213**	165**	931**	223,04
Sex	1	28	4	0.5	4	19	15	47	
Periods	2	88	14	336**	10 60**	203**	8	815**	
F x S	1	9	1	2	0.5	10	28*	7	
F x P	2	0.5	27	33	5.5	25	34**	89	
S x P	2	3	1	5	11	11	1	2	
F x S x P	2	2	28	0.5	19	4	3	24	
Error	82	52	25	23	32	28	5.8	53	3,149

\*\* Differences significant at the one percent level

\* Differences significant at the five percent level

Growth(i) Analysis of Variance Results

The difference between food types was significant at the 1 percent level.

TABLE 22.

GROUP MEANS FOR GROWTH

Crumbles 428 gms

Mash 291 gms

S.E.  $\pm$  8.1 gms

These means were obtained by subtracting hatching weights from body weights at 7 weeks of age.

Fig. 17 Growth Rates

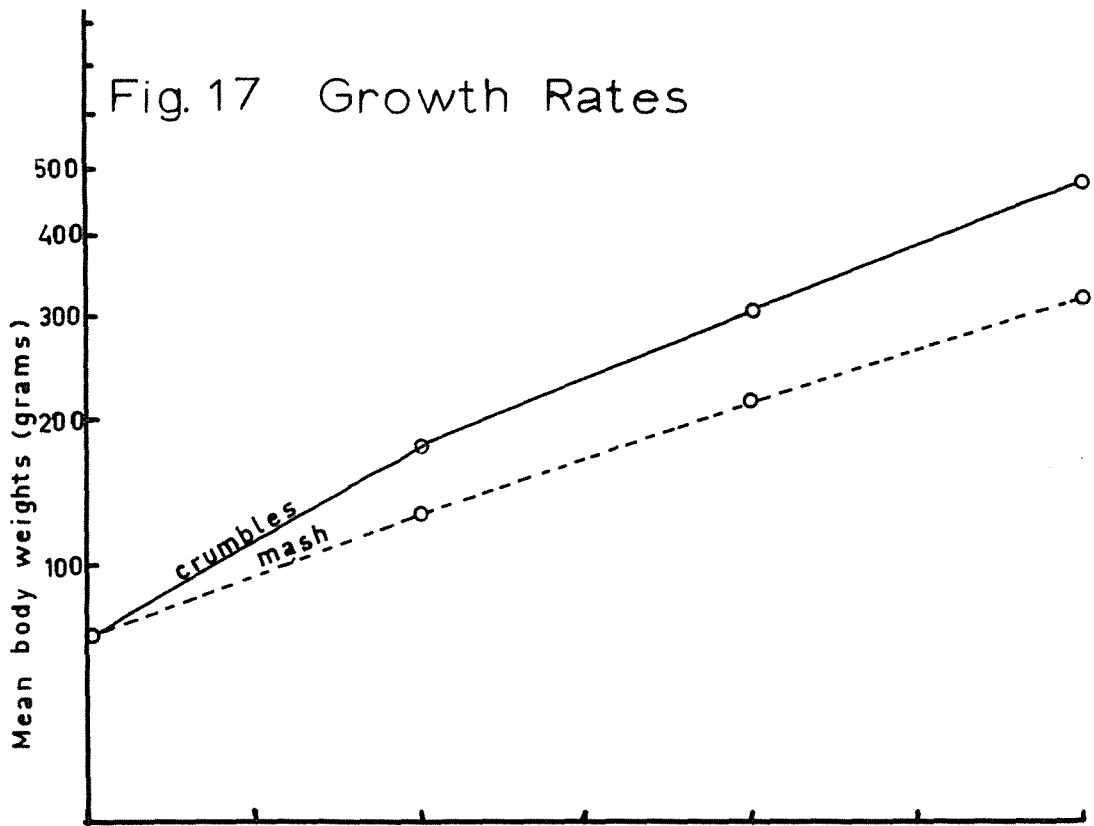
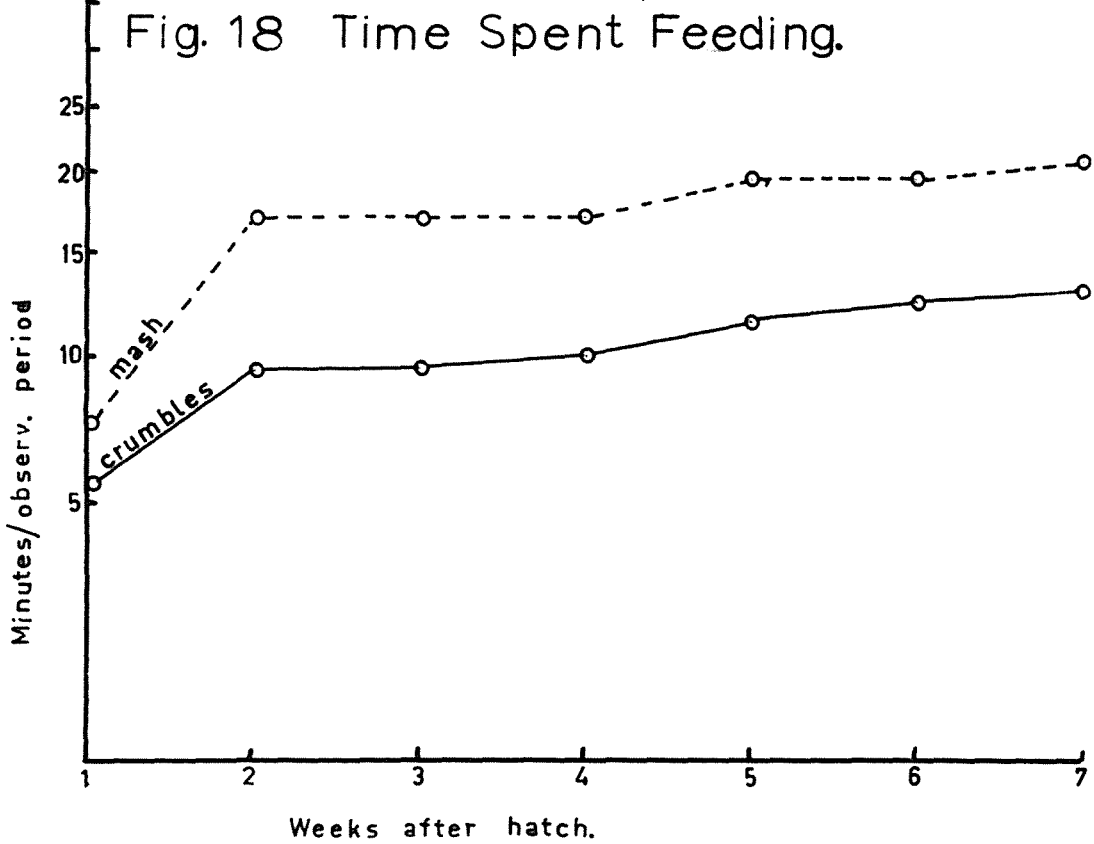


Fig. 18 Time Spent Feeding.



- (ii) The general trend (Figure 17) shown in the graphs was for the crumbles-fed group to progressively gain more weight than the mash-fed group from the second week's weighing until the termination of the experiment. At the seventh week's weighing, the difference between the group was 150 grams.

#### Food Consumption

Because of excessive spillage of food from the mash trays, the figures on food consumption were not considered accurate enough for presentation.

#### Time Spent Feeding

##### (i) Analysis of Variance Results

Significant differences between food types were obtained at the 1 percent level.

TABLE 23.

#### GROUP MEANS FOR TIME SPENT FEEDING

(Data in minutes)

Mash	17.8
Crumbles	11.0
S.E. $\pm$	1.04

The mash group spent significantly more time feeding than the crumbles group.

- (ii) The graphs (Figure 18) display quite clearly the difference in time spent feeding by the two groups. The difference between them remained consistent after the second week; both groups displayed a slight increase in feeding time from four to five weeks after hatching, followed by a smaller increase up to the seventh week.

Time Spent Scratching and Pecking

(i) Results of Analysis of Variance

Significant differences were obtained between periods (P : 0.01).

TABLE 24.                      PERIOD MEANS FOR TIME SPENT SCRATCHING AND PECKING  
(Data in minutes)

2nd Week	1.43
4th Week	6.75
6th Week	7.31
S.E. †	0.85
D.	2.89

Significantly more scratching and pecking occurred in the fourth and sixth weeks than in the second week. There was no significant difference between weeks four and six.

(ii) The graphs (Figure 19) showed that while the crumbles group scratched more during the second week, the mash group scratched more in the fourth and sixth week. The relative positions of the two groups did not change appreciably from four to six weeks.

Time Spent Walking, Pecking and Running

(i) Results of Analysis of Variance

No significant differences were obtained; however the mean square for food types did approach the 5 percent level of significance.

(ii) The trends displayed by the graphs (Figure 20) were for the crumbles group to be more active during the second week than the mash group. The fourth and sixth week group means show no appreciable differences. In addition, there was no appreciable overall change in the rate of this activity from four to six weeks.

Fig. 19 Time Spent Scratching

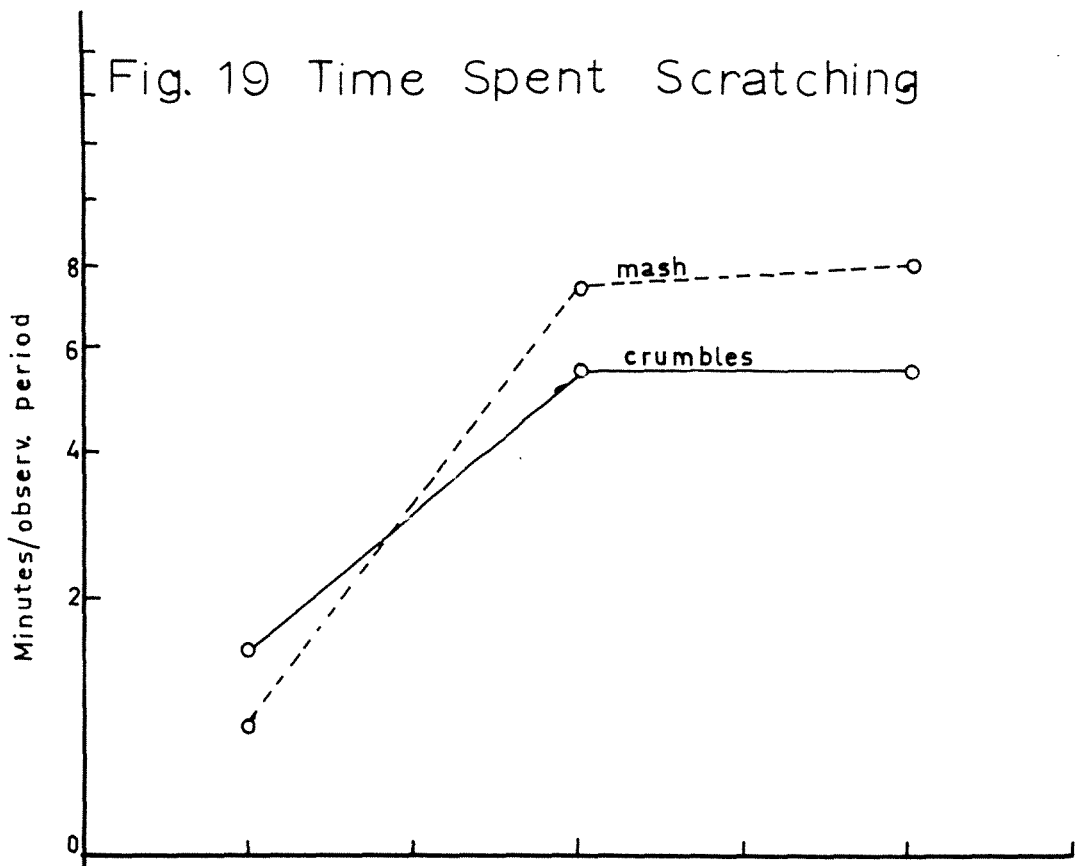
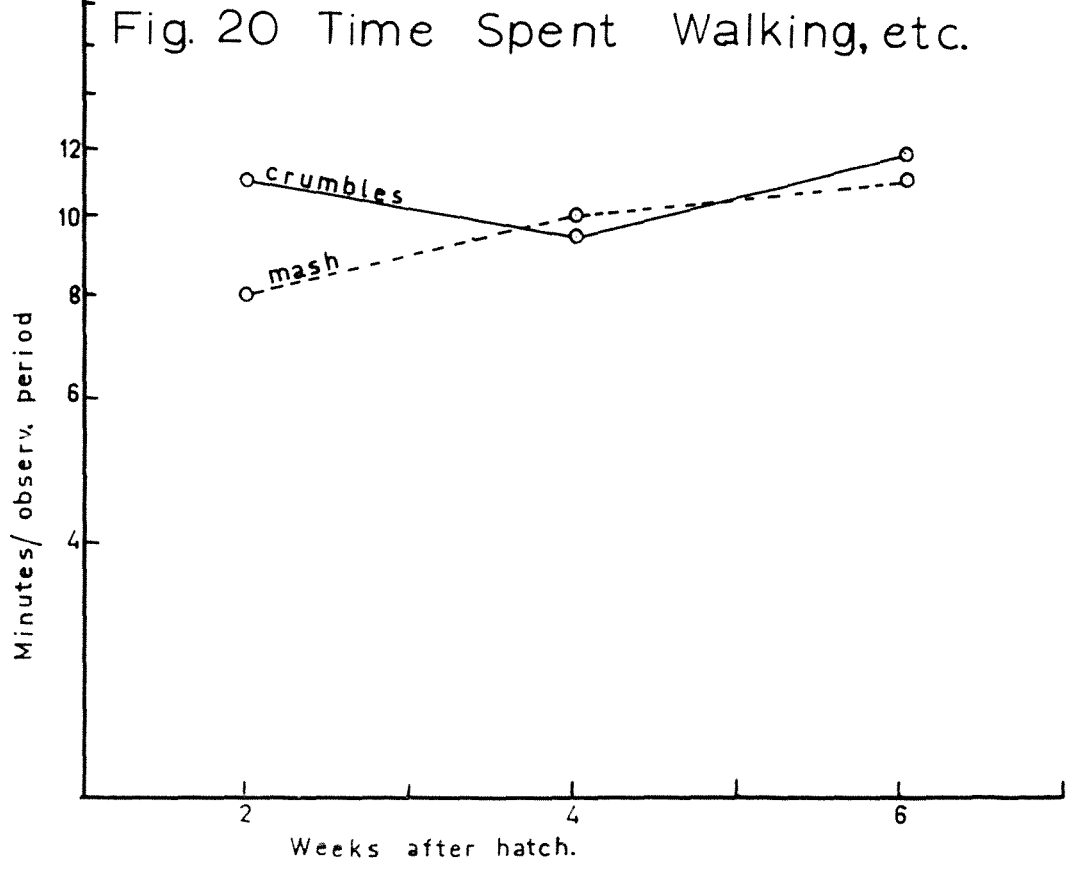


Fig. 20 Time Spent Walking, etc.



Time Spent Standing(i) Results of Analysis of Variance

Significant differences were obtained between food types (P : 0.01) and between periods (P : 0.01).

TABLE 25.GROUP MEANS FOR TIME SPENT STANDING

(Data in minutes)

Crumbles	10.04
Mash	7.06
S.E. $\pm$	0.77

The crumbles group spent significantly more time standing than the mash group.

TABLE 26.PERIOD MEANS FOR TIME SPENT STANDING

(Data in minutes)

2nd Week	10.78
4th Week	5.81
6th Week	9.06
S.E. $\pm$	0.94
D.	3.51

The difference between the means of the second and fourth week was significant. The other differences did not attain the level of significance.

(ii) The trends displayed by the graphs (Figure 21) were that both groups show a decrease in standing time from two to four weeks, followed by a rise to the sixth week. The differences between the groups remained consistent over the three periods.



Time Spent Sitting(i) Results of Analysis of Variance

A significant difference between periods was obtained ( $P : 0.01$ ).

TABLE 27.

PERIOD MEANS FOR TIME SPENT SITTING

(Data in minutes)

2nd Week	11.4
4th Week	11.5
6th Week	1.5

S.E.  $\pm$  1.0

D. 3.4

Significantly more time was spent sitting in the second and fourth week than in the sixth week.

(ii) Trends displayed by the graphs (Figure 22) were that there was a slight difference between the food groups, which remained consistent over the three periods. Secondly, there was the obvious decline in sitting time after the fourth week.

Time Spent Preening(i) Results of Analysis of Variance

Significant differences were obtained between food types ( $P : 0.01$ ) in a food by sex interaction and in a food by period interaction.

TABLE 28.

GROUP MEANS FOR TIME SPENT PREENING

(Data in minutes)

Crumbles	5.10
Mash	2.47

S.E.  $\pm$  0.34

The crumbles group spent significantly more time preening than the mash group.

TABLE 29.                      FOOD BY SEX INTERACTION MEANS FOR TIME SPENT PREENING  
(Data in minutes)

	<u>Males</u>	<u>Females</u>
Crumbles	4.16	6.04
Mash	2.62	2.33
S.E. †	0.49	
D.	1.83	

- (a) The crumbles female group spent more time preening than all other groups.  
 (b) The crumbles male group spent more time preening than the mash male group.  
 (c) There was no clear cut sex difference in the amount of time spent preening.

TABLE 30.                      FOOD BY PERIOD INTERACTION MEANS FOR TIME SPENT PREENING  
(Data in minutes)

	<u>2nd Week</u>	<u>4th Week</u>	<u>6th Week</u>
Crumbles	3.31	5.93	6.06
Mash	3.06	2.18	2.18
S.E. †	0.60		
D.	2.49		

Significantly more preening was done in the fourth and sixth week crumbles period than in all other periods.

The differences between all other means were not significant.

(ii) Trends Displayed by the Graphs.(Figure 23)

The crumbles group displayed the expected increase in time spent preening from two to four weeks, followed by a levelling out in the time given to this behaviour. The mash group showed a response in the other direction; that of a decrease in time spent preening from two to four weeks.

Fig. 21 Time Spent Standing.

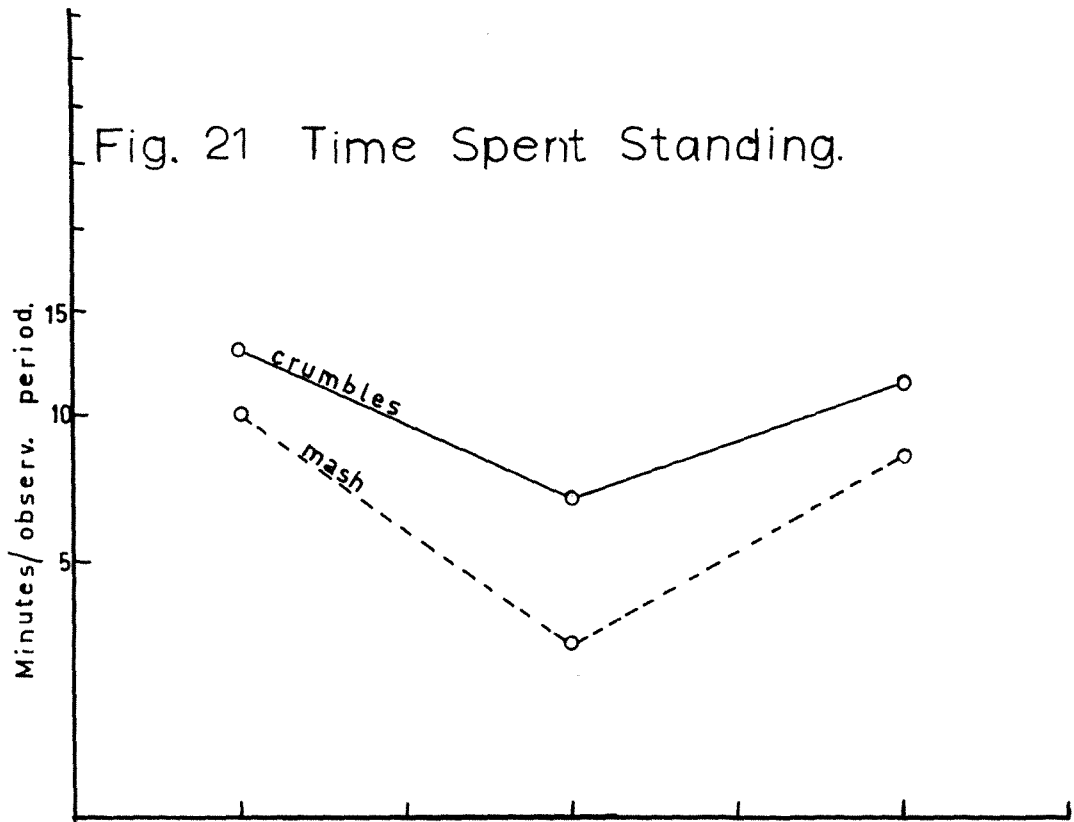
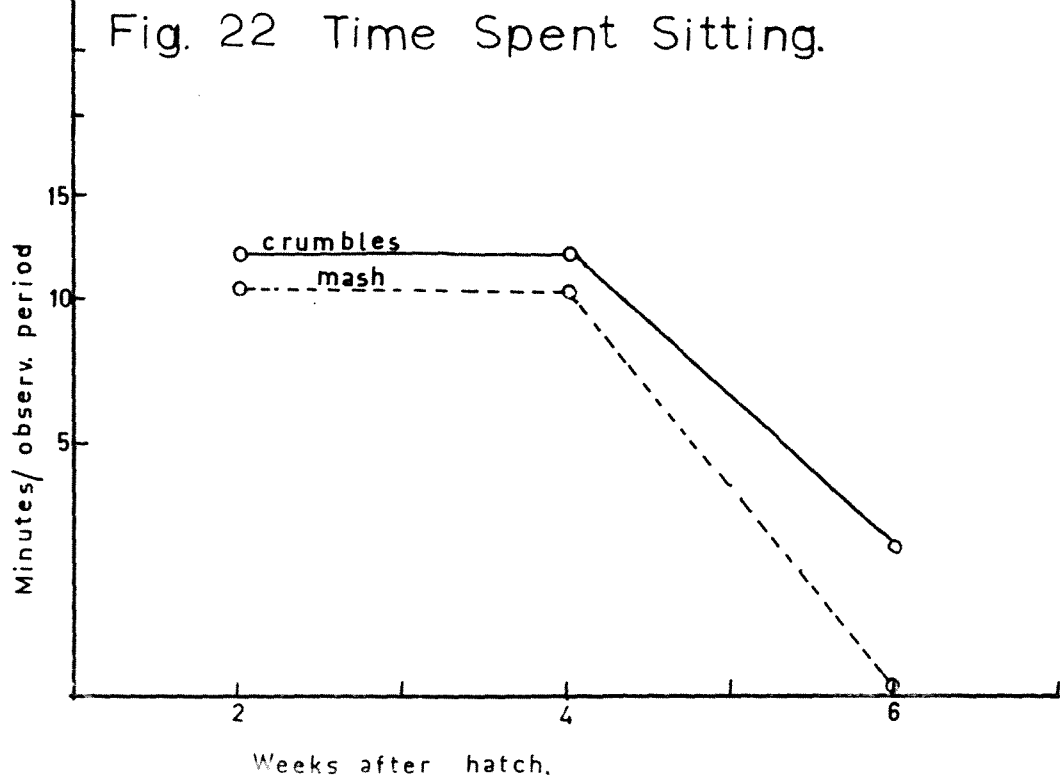


Fig. 22 Time Spent Sitting.



Time Spent in Total Activity

The mean figures for feeding, scratching and pecking, and the walking-pecking, etc. categories were added together to give a figure representing the total time the chicks spent active.

(i) Results of Analysis of Variance

Significant differences were obtained between food types and between periods.

TABLE 31.                    GROUP MEANS FOR TIME SPENT IN TOTAL ACTIVITY  
(Data in minutes)

Mash	33.0
Crumbles	26.7
S.E. †	1.05

The mash group spent significantly more time in total activity than the crumbles group.

TABLE 32.                    PERIOD MEANS FOR TIME SPENT IN TOTAL ACTIVITY  
(Data in minutes)

2nd Week	24.6
4th Week	30.3
6th Week	34.6
S.E. †	1.29
D.	4.38

The means for the fourth and sixth week are significantly higher than the mean for the second week.

The difference between the fourth and sixth week was not significant.

Fig. 23 Time Spent Preening.

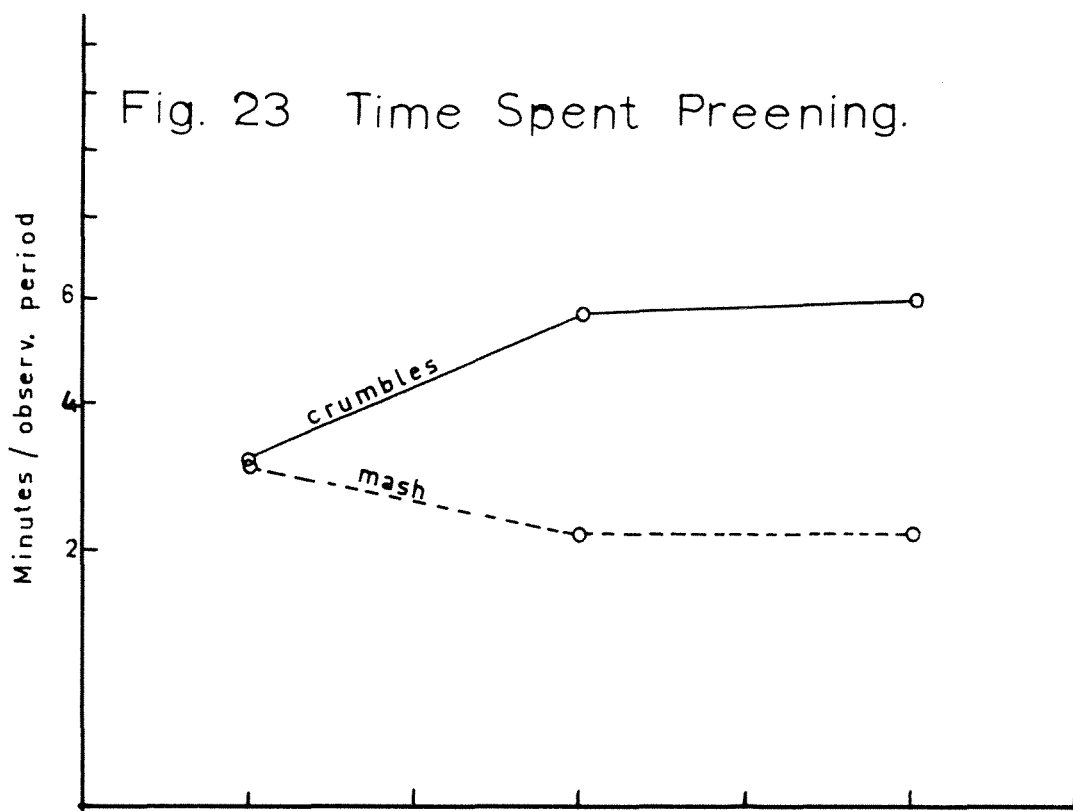
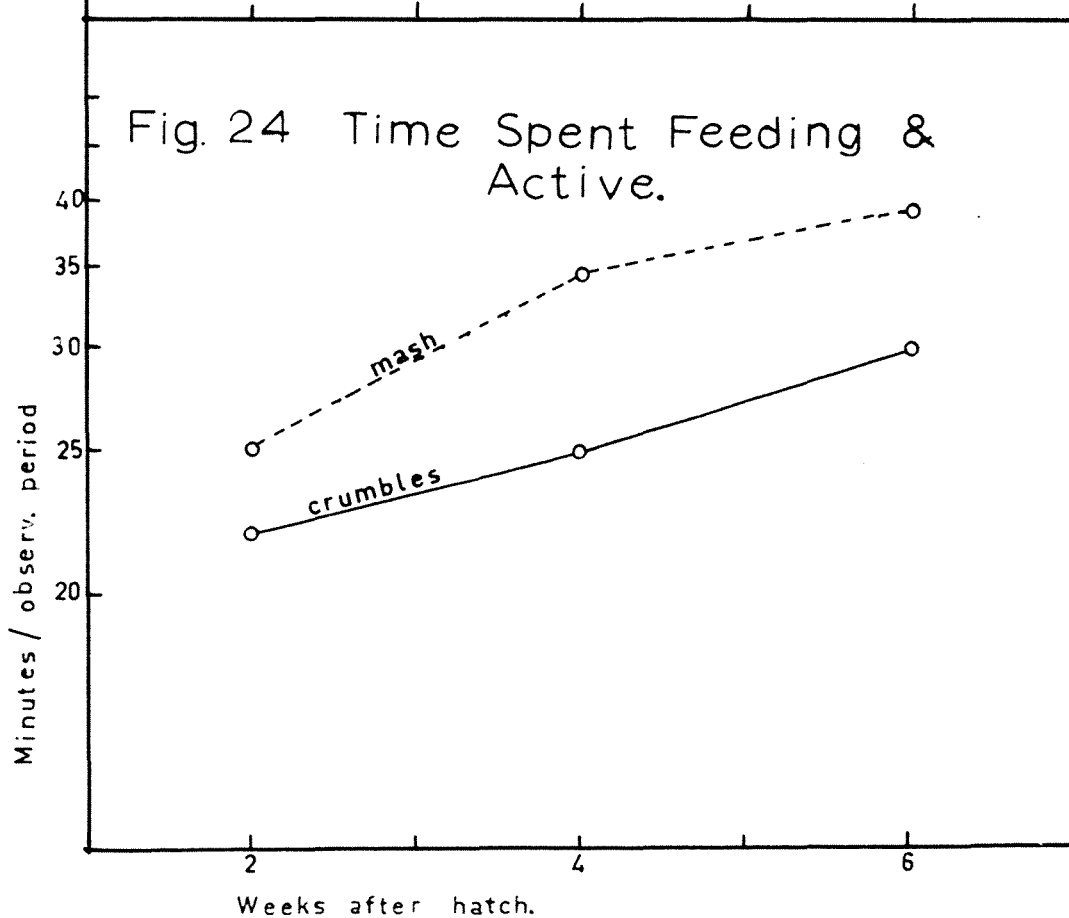


Fig. 24 Time Spent Feeding & Active.



(ii) Trends Displayed by the Graphs (Figure 24)

Both experimental groups showed an increase in time spent in total activity from two to six weeks. The graphs for time spent inactive were the reverse of those for time spent active. This result could not be otherwise, for the two groups of behaviour are mutually exclusive. That is, an increase in one automatically leads to a decrease in the other. The differences between the experimental groups remained consistent over the three periods.

The Behaviour Categories as Percentages of Time

The graphs and statistics presented so far in this experiment have been in the form of minutes per observation period or as mean figures derived from a number of observation periods.

The duration of the observation period - 50 minutes made conversion to percentages easy. This merely involved the doubling of the minutes per observation period figures and working on the assumption that the observation periods were representative of the chicks' behaviour over the total day length. That is, that the samples taken were a realistic representation of the chicks' activities and inactivities over the seven weeks of the experiment.

TABLE 33.PERCENTAGES OF TIME SPENT ACTIVE AND INACTIVE

	<u>Active</u>	<u>Inactive</u>	
2nd Week	44.2	55.8	Crumbles
	51.6	48.4	Mash
4th Week	50.5	49.5	Crumbles
	69.0	31.0	Mash
6th Week	60.0	40.0	Crumbles
	78.7	21.3	Mash

TABLE 34.

DISTRIBUTION OF TIME OVER SIX CATEGORIES OF BEHAVIOUR

(Data in Percentages)

		Feeding	Walking, Pecking	Scratching, Pecking	Sitting	Standing	Preenin
2nd Week	Crumbles	19	22	3.2	23.5	25.6	6.7
	Mash	34	16	1.6	21.5	20.9	6.0
4th Week	Crumbles	20	19.5	11	24	14	11.5
	Mash	34	20	15	20.5	6	4.5
6th Week	Crumbles	25	24	11	5	23.5	11.5
	Mash	38	23.7	17	0.3	17	4.0

Over the three periods the mash-fed group displayed a much higher level of total activity than the crumbles-fed group. Most of this extra activity came from the large amount of time spent feeding by the chicks on the mash diet. However, in addition to the extra time spent feeding, the mash group also spent much more time scratching and pecking than the crumbles group.

In devoting so much of their time to activity, the mash group sacrificed preening time and standing time mainly, with a minor sacrifice of sitting time also evident.

The amount of time spent walking, pecking and running, varied little between the two groups. The crumbles group, although obtaining their food requirements in less time than the mash group, did not spend any extra time in non-feeding activity compared to the mash group. The extra time available to the crumbles group was spent in preening and standing idle. They did not spend much extra time sitting when compared to the mash group.

The behavioural analyses provide good evidence to account for the increased body weight gain obtained when chicks are fed on a diet of crumbles (or pellets).

The reasons are twofold :

- (a) there is the theory quoted by Calet (1964) that the loss of heat which goes with eating is a function not only of the quantity of food ingested but also of the time required for this ingestion. Any reduction in this time results in an increase in the productive energy of the feed.
- (b) that the extra time the crumble-fed group spent resting was energy conserving behaviour and also resulted in a reduction of heat expenditure and loss. This must certainly be taken into account as a factor in making available more energy for growth and development of the chick.

Finally there is the suspicion that the mash-fed group actually engaged in more non-feeding activity than did the crumble-fed group. This would tend to accentuate even more the differences in energy available for growth between the two groups.

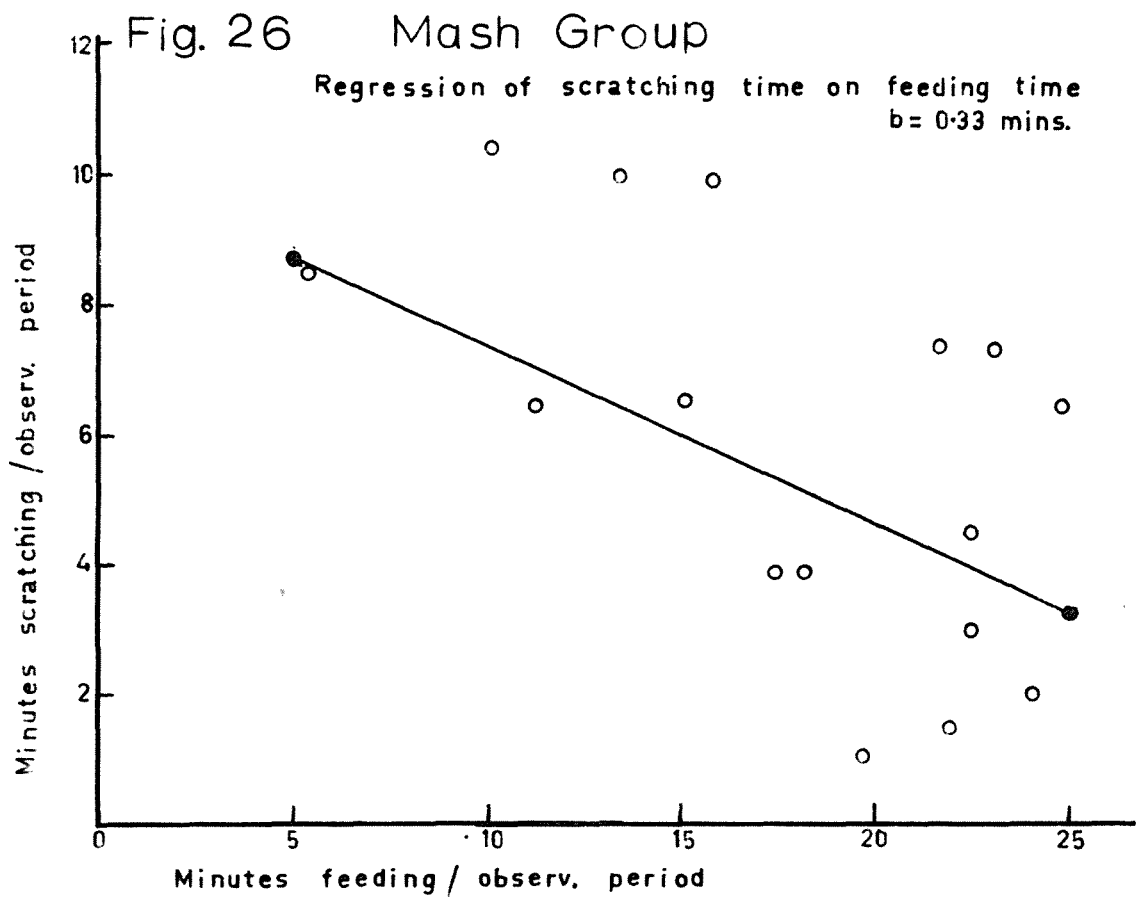
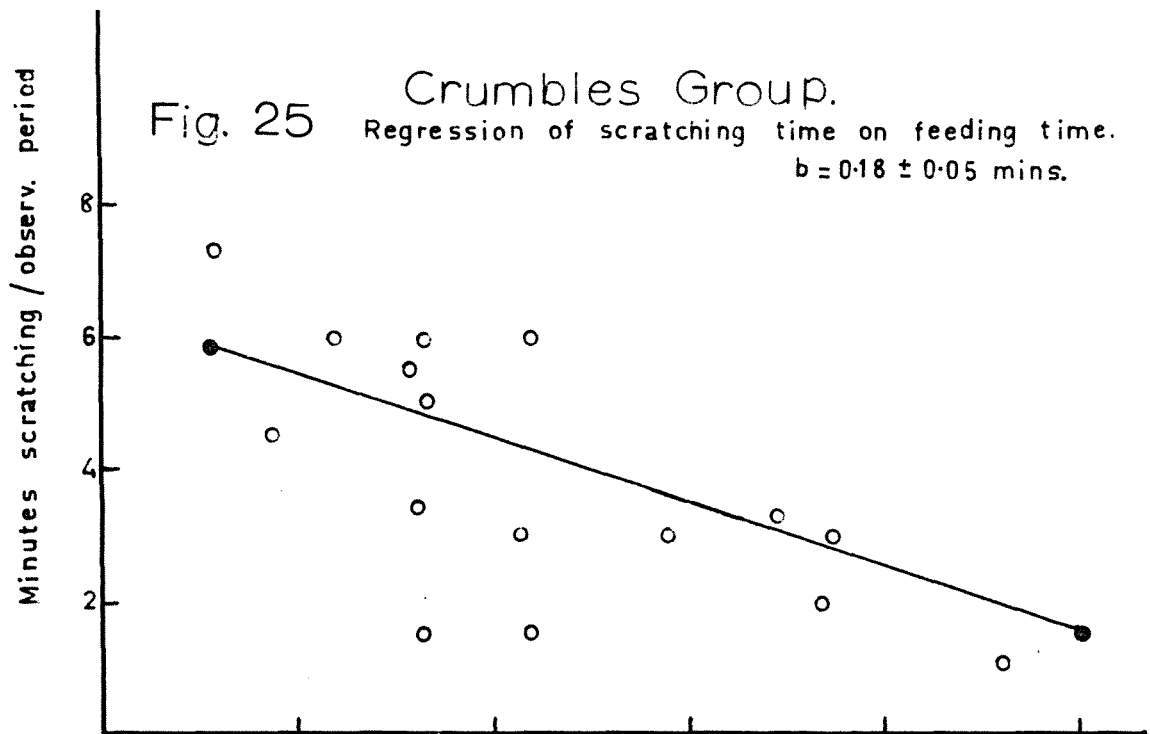
That the crumbles-fed group spent extra time inactive is the probable reason as to why more aggressive activities were displayed by that group. The following figures were derived from observations on fighting encounters during the sixth week :

Crumbles group	- 35 encounters;
Mash group	- 7 encounters.

Unfortunately no records of feather-pulling were taken during the course of the experiment, but it is probable that the extra time spent idle by chickens on a pelleted or crumbled diet is a factor in the increased feather-pulling and cannibalism noticed when these food forms are used.

A proposition and assumption which has been used in this study is that scratching and pecking in the litter was, in the ancestor of the domestic fowl, part of the behaviour used to obtain food. Accordingly it was considered





of interest to perform a regression analysis on these two variables. Time spent feeding was used as the independent variable, while time spent scratching was used as the dependant variable. The figures used for the analysis were the individual figures at two, four and six weeks, combined to give a mean figure for each individual on each variable.

The sixteen chicks from each experimental group were used and the results of the analysis are shown in figures 25 and 26.

In both the crumble and mash-fed groups, significant negative regressions were obtained.

The regression coefficients (minutes) :

Crumbles group : b :  $-0.18 \pm 0.05$

Mash group : b :  $-0.33$

Both significant at the 2 percent level.

That is, in the crumbles group, for every extra minute of time spent feeding, there was a decrease of 0.18 of a minute of time given to scratching and pecking.

Correlation coefficients were obtained to broaden the picture of the relationship between the two variables. In both food types there were significant negative correlations :

Crumbles group : r :  $-.72$

Mash group : r :  $-.58$

Both significant at the 2 percent level.

It would appear that there is a definite relationship between feeding and scratching in the litter. The interpretation placed upon the results is that the extra amount of pecking involved in more time spent feeding, decreases the

motivation to scratch and peck in the litter. This interpretation requires the assumption that in a neurological sense, the two variables are connected and that the expression of feeding activity tends to inhibit the motor centres involved in the motivation of scratching and pecking. The observations of Breland and Breland (1966) that scratching is elicited when there is a delay in the chick obtaining food, is relevant evidence for the views being put forward in the present study.

### Summary

- (i) The effects of different forms of food on the growth rate of chicks were given in a background, introductory section to the experiment.
- (ii) An experiment was set up using White Leghorn chicks and two food forms : mash and crumbles. The object of the experiment was to quantify the effects of food particle size on the behaviour of the chicks.
- (iii) The results presented show that food particle size affects most aspects of the chicks' behaviour; that is, in a quantitative sense.
- (iv) It was demonstrated beyond doubt that the effect of the food type upon the chicks' behaviour plays a major role in energy expenditure and in energy conservation.
- (v) It was shown that more aggressive encounters occurred in the crumbles group.
- (vi) Attention was drawn to the relationship between time spent feeding and time spent scratching and pecking in the litter. It was postulated that there must be a close neurological relationship between the two variables, and that scratching and pecking was responsive to the factors motivating feeding behaviour.

CHAPTER IXEXPERIMENT 3. AN INVESTIGATION OF FEATHER-PULLING IN CHICKENS

In the first few days after hatching, chicks have a tendency to peck at a wide variety of objects including the particles of the litter, spots on the wall, of the pen, the food, the water, and also at each other. Pecks at other chicks are directed at the eyes, toes, bill and the down feathers.

Towards the end of the first week after hatching, chicks may begin pecking and pulling at the feathers developing on each others bodies. When this pecking and pulling becomes persistent it is designated as feather-pulling, to distinguish it from the earlier chance or random pecking at feathers. The result of continued feather-pulling is that some chicks begin to bleed where feathers have been pulled from their wings, tail, or other feather tracts. The bleeding may then lead on to cannibalism for it is well known that chicks have a "pecking mania" - they will rush to peck at any wound in a fellow brood member. (Wood-Gush,1955). There have been many attempts to prove that feather-pulling is caused by some nutritional deficiency, but as Wood-Gush (1967) in his review of these experiments showed, there was no positive evidence to support such a view.

Food type does play a role in some cases of feather-pulling. For instance, Bearnse, Berg, McClary and Miller (1949) investigated the effect of pelleting chicken rations on the incidence of cannibalism and gave clear evidence that higher mortality occurred in the pellet fed group than in a control group fed on mash. This effect is probably due to the shorter time taken to consume the pellets, with the consequently greater amount of time spent standing idle, giving the chicks more opportunity to indulge in feather-pulling.

Morris (1967) in a review of the effects of light intensity on pullets,



Plate 5. Feather-pulling. The two chicks in the left foreground can be seen pulling at the feathers of the chicks in the background.



Plate 6. Feather-pulling. This Black Leghorn hen portrays vividly the results of sustained feather-pulling.

gave the following summary of the causes of cannibalism : "Because cannibalism results from the complex interaction of many factors, including strain, density of stocking, type of feed, light intensity and other features of management, it is not possible to define any constant relationship between the intensity of lighting in a poultry house and the associated risk and incidence of cannibalism. In general, the brighter the light, the greater the risks of losses due to cannibalism, but such losses are usually avoided in houses which exclude daylight and in which the artificial light is evenly distributed, and is no more than the minimum necessary to stimulate good egg production".

Payne (1961) noted that in broiler chicken houses in Britain, the light intensity was maintained at 0.05 to 0.20 ft.c. as a control measure for the prevention of cannibalism. It is normal practice in such establishments to use dull red lighting in preference to white light or any other colour. Payne found that dull white light of 0.20 to 0.50 ft.c. gave a better food conversion factor than a dull red light group without causing any cannibalism to occur.

The reason for the continued popularity of red light in poultry houses seems to be that even under dull light some breeds (White Leghorns) still develop feather-pulling habits, and that if any bleeding occurs it will not be noticeable under the red light; whereas the blood would show a contrast against the skin under dull white light and perhaps cause cannibalism to occur.

The approaches to prevent and control cannibalism have been through the manipulation of the environmental variables - and mainly through the control of light intensities. There appears to have been no attempts to understand the nature of the feather-pulling response or as to why it occurs at all.

Information gathered by animal behaviourists may provide a basis for understanding the problem of feather-pulling in chicks. Hediger (1955) described the behaviour of animals in zoos and the effects of "unnatural inactivity" on

individuals. He noted that the boredom resulting from confinement often led to behavioural abnormalities and even to extremes such as self-mutilation. Usually these behavioural abnormalities could be prevented by providing the animals with objects or surroundings to permit play activities to take place. Examples given by Hediger were that Macaws played with stones; sea-lions with pieces of wood floating in their pond, and lonely elephants which gained much pleasure out of a plank or a stump of root that was placed in their quarters.

The principle underlying these observations is that there is a need for stimulation which is inherent in the more highly developed vertebrates. With reference to this need for stimulation, Nissen (1954) asserted the need to postulate an actual drive to perceive and explore. Woodworth (1947) and Thorpe (1963) expressed similar convictions; these investigators thus emphasized the endogenous aspects of exploratory behaviour (i.e. the active seeking out of stimuli).

There is evidence that much exploratory behaviour is elicited by external stimuli. The key stimulus properties seem to be "novelty" and "complexity" (Berlyne, 1960). Marler and Hamilton (1966) summarized the evidence thus : --- "there is suggestion of spontaneous exploratory behaviour, implying that the natural behaviour is a result of interaction between internal and external factors".

### General Hypothesis

The evidence from animal behaviour studies suggests that the confinement of chickens in houses or sheds and the consequent environmental monotony may be a primary causal factor in the appearance of feather-pulling and cannibalism.

### Experimental Design

An experiment was set up to test :

- (i) the effect of environmental monotony as a factor in feather-pulling.
- (ii) the relative amounts of feather-pulling done under (a) red light, and (b) white light.

The experimental design was a 2 by 2 factorial to test for any interaction occurring between the variables being investigated. Unfortunately the comparisons between lighting types were invalidated due to the red light section of the experiment having to be abandoned. This was brought about by the high temperatures experienced at this time of the year, leading to an excessive heat build-up inside the experimental room. To provide ventilation, the door to the room had to be left open, thus admitting daylight into the red light section and making it irrelevant as an experimental variable.

Consequently the experiment was reduced to two groups; one group having in their pens the experimental object designed to reduce the monotony of the environment by attracting the exploratory pecking of the chicks. The other group lacked the experimental object and thus acted as the control group in the experiment.

#### Methods and Materials

There were four pens of eight chicks each in the experiment. Each pen was provided with a feeder, a waterer, an infra-red brooder, a 60 watt white bulb, and litter consisting of wood shavings, four to five inches deep.

The chicks were White Leghorn "white control" strain (Massey population); they were sexed and wing-banded after hatching, and then four chicks of each sex were distributed to each pen. Marking, for purposes of individual identification, was done with a selection of felt-tip pens.

In two of the pens, the experimental object - a piece of sacking with well frayed edges was nailed to the wall. Thus there were sixteen chicks in



both the experimental and control groups.

Food type was crumbles, to ensure the chicks had sufficient "leisure" time for feather-pulling to appear and the feeding routine was ad.lib.

### The Observations

Fifty-minute observation periods were used and the whole four pens in the experiment could be checked at one-minute intervals to ascertain if any feather-pulling was occurring. Four observation periods were performed per day for three days a week over the duration of the experiment, which was from the end of the first week after hatching to the eight week after hatching.

The scoring for feather-pulling was done on a minute by minute basis. Any individual chick seen feather-pulling in the duration of one minute scored a point irrespective of the amount of feather-pulling done by that chick in that minute. Scores for individuals were obtained by adding together the points accumulated over the fifty one-minute intervals comprising the observation periods. Thus the maximum number of points any one chick could score in one observation period was fifty.

The total number of points accumulated by the individuals over the duration of the experiment were the scores used in the statistical test used to assess the significance of the difference in the amounts of feather-pulling done by the control group compared to the experimental group. Because the data could not be assumed to be normally distributed, a non-parametric test, the Mann-Whitney U test was used to test for differences between the experimental groups.

### Results

Feather-pulling was well established by the end of the first week and continued at a uniform rate until the end of the fifth week when it ceased abruptly for no apparent reason.

TABLE 35.

ACCUMULATED FEATHER-PULLING SCORES FOR DURATION  
OF EXPERIMENT

---

<u>No Sacking</u>		<u>Sacking Present</u>	
162		46	
<u>Males</u>	<u>Females</u>	<u>Males</u>	<u>Females</u>
40	122	4	42

Mann-Whitney U values : Group differences U = 21 p : .001

Sex differences U = 15 p : .001

In those pens containing the pieces of sacking the chicks spent large amounts of time pulling and pecking at the loose threads. Sometimes the threads were swallowed, but usually the chicks were content to have pulled the loose threads from the sacking and to leave them scattered around the litter. The sacking had to be replaced with fresh material at every third day. The chicks did not appear to suffer any ill health from the swallowing of the sacking threads; thus, overall, the presence of sacking presented no extra problems regarding the management aspect of the experiment.

#### Discussion and Interpretation of Results

That significantly less feather-pulling occurred in those pens supplied with sacking supports the hypothesis outlined on page - that monotony of the environment and the lack of objects for the chicks to direct their exploratory pecking at is a major factor in the appearance of feather-pulling.

Feather-pulling is, under the definitions used and the behavioural evidence advanced, a behavioural perversion in that it is the abnormal expression of a strong endogenous tendency, to explore the environment and to maintain a stimulus input via the motor structures normally involved in exploratory behaviour (i.e. the bill).

The tendency or need to maintain a certain level of exploratory pecking varies from breed to breed. The "light" breeds such as the White Leghorns are bad offenders in this respect, while the "heavy" breeds such as the Australorps very rarely indulge in feather-pulling. Perhaps there is an association between temperament and the need to maintain exploratory pecking. It would appear that the more excitable breeds suffer more from confinement than the placid breeds.

The relationship of the behavioural evidence to practical aspects of poultry management are that, in the dull-lighting conditions in poultry houses, the developing feather tracts of the chicks do not present a strong enough stimulus to elicit very much feather-pulling. However, the fact that some feather-pulling is still found under such conditions emphasizes that the endogenous factors involved are very strong. The role played by the properties of the external stimuli : "novelty" and "complexity" do not appear to be so important as the actual intensity of the stimuli involved. The apparent fascination the chicks show for elongated, thread-like objects such as feathers and pieces of sacking is difficult to explain or interpret, but it may be that the preferential response to such stimuli has survival value in the environment in which the ancestors of the domestic fowl evolved.

In relation to the physiological basis of feather-pulling, there does not seem to be any connection between physiological maturation and the onset of feather-pulling. It is certainly not connected with the appearance of aggressive behaviour, for aggressive pecking does not become obvious until after four weeks from hatching, and the increase in androgen production does not occur until this time either. There is no connection between the quantitative changes shown in the maintenance behaviours and the onset of feather-pulling. The fact that feather-pulling hardly varied at all from week to week is clear evidence against any such association.

Summary

- (i) The nature of feather-pulling and its impact on practical aspects of poultry farming was discussed.
- (ii) Feather-pulling was then discussed in the context of research into animal behaviour and the possible light the latter might shed on the reasons as to why feather-pulling occurs at all.
- (iii) An experiment was set up to test the effect of reducing the environmental monotony in the experimental pens.
- (iv) From the results it was concluded that the monotony resulting from confinement could be a major factor in the causation of feather-pulling behaviour.
- (v) There does not appear to be any connection between physiological changes in ontogeny and the onset of feather-pulling.

## CONCLUSIONS

The individual experiments each carried a section dealing with discussion and interpretation of results and these also contained conclusions which were specific to the topics dealt with in those experiments. This section then must deal with general conclusions over and above the principals and generalizations discussed in the earlier chapters.

The first general conclusion relates to the nature of the measurement used in Experiments 1 and 2; it would appear that the method of sampling was reasonably successful, in that the trends shown by the graphs did, in general, conform to the patterns of physiological changes taking place in the ontogeny of the chick. In Experiment 2, the fact that it was possible to offer a behavioural explanation to a problem which had been the subject of intensive physiological and chemical investigations, is a fair indication of the consistency of the measurement achieved on these behavioural variables over a period of seven weeks.

The validity of the methods by which the information was obtained has been stressed here because of the general unreliability of behavioural variables as units of measurement when compared to the units of measurement used in the physical sciences, or even to those used in biological disciplines, i.e. Anatomy or Physiology.

The second general conclusion is that the amount of information obtained from such a study is relatively small; for it was possible to measure a small number of variables only during the course of each experiment. Coupled with this is the fact that large numbers of individual figures were compressed into

the mean figures used in the graphs and that even larger numbers are represented by the mean figures presented as the results of the statistical analyses.

The third conclusion is that an indirect function of this thesis has been to emphasize certain areas which are open to further research, particularly as regards the physiological aspects of developmental changes. Quite apart from investigating the part played by the endocrine system in development, there are two other rather intriguing areas open to further research. Firstly, there is the question of : What are the mechanical factors involved in feeding? (See Experiment 1). Secondly, there is the matter of the relationship between scratching and pecking; this presents an opportunity for the study of a central problem in ethology - that of the part played by endogenous factors in the expression of species - typical motor patterns. In this context, it would be interesting to see this motor pattern used to test the Lorenzian hypothesis : that the fixed action pattern provides the chief source of the drive and not vice versa.(Thorpe,1963).

Finally, it may be reiterated here that this whole study has its closest affinities to physiology than to any other branch of Biology; a statement of belief and intent which formed a central theme in the Introduction to the thesis, and which it is hoped has been adequately proved during the course of the study.

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