

Behavioural motivations and abilities in broilers

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Behavioural motivations and abilities in broilers

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Abstract

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Broilers are chickens kept commercially under intensive husbandry conditions for poultry meat production. They grow to a slaughterweight of approximately 2.2 kg in 6 weeks. Broilers show a pronounced decrease in behavioural activity during their short life. The aim of this thesis was to gain more insight into the influence of both motivation and ability on behavioural activity in broilers. The distinction between motivation and ability is relevant for the interpretation of behavioural activity in broilers in terms of welfare. Broilers were observed when kept in pens with good facilities and in several *ex situ* tests where they had to work for food. Broilers showed all normal juvenile chicken behaviours, but the time spent on each behaviour has changed. Many behavioural patterns were shown in a sitting posture instead of in a standing posture. Performance in short physical tasks depended on motivation and physical ability. Hunger and satiety mechanisms have changed compared to layer chickens, but the motivation to work for food still can be manipulated in broilers. Broilers are willing to peck a key many times or to walk long distances to obtain food rewards, but their performance seemed to be dependent on body weight. Apart from having an abnormal high motivation to eat, broilers are normal biologically functioning animals. Parallel to the effect of overweight on the quality of life in humans, the abnormal high body weight at a young age has a negative impact on the welfare of broilers. Broilers are restricted to display behaviours for which they are motivated imposed by their high motivation to eat, which is associated with their fast growth and high body weight at young age, or by environmental conditions in which they are usually kept.

Keywords: broiler; behaviour; motivation; physical ability; environmental conditions; animal welfare; operant conditioning; locomotion.

Voor de vleeskuikens

Ben je nog wie je was als je niet meer kunt wat je kon

Renate Dorrestein

Voor het onderzoek

Weej wat ut is leu.

D'r is gewoon veuls te veul ruimte in de log.

Ze wet gewoon nit woaj kieken mot,

want net aj denkt ik bun d'r,

maakt die ruimte plots nun bog

En in plaats van eindelijk thoes,

buj nog wieter vot

André Manuel

Voor de goede verstaander

Once it held laughter

Once it held dreams

Did they throw it away

Did they know what it means

Did someone's heart break

Or did someone do something wrong?

Tom Waits

Voorwoord

In 1997 vroeg de Raad voor Dierenaangelegenheden mij in korte tijd een rapport te schrijven over de welzijnsproblematiek in de vleeskuikenhouderij. Achteraf gezien was dat de opmaat voor een vierjarig promotieonderzoek waar ik eind 1999 mee begonnen ben en waarvan het resultaat nu voor u ligt. Ik wil hier graag de mensen bedanken die op een positieve manier deze periode tot een onvergetelijke tijd hebben gemaakt.

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Carline

Nu hebben we het beide volbracht. Dat is toch wel mooi.

Eddie

Wageningen, januari 2004

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General introduction



1.1 Introduction

Broilers become increasingly inactive during their short life. In the EU report on broiler welfare (EU 2000), an important recommendation for future research was: “Research should be conducted to closer elucidate the behavioural needs of broilers. In particular, it is not known to what extent the reduced activity in broilers is caused by a simple physical incapacity to carry out physical activity, or to what extent it is caused by reduced motivation for active behaviour.” In this thesis, the behavioural motivations and abilities were studied to find out what broilers want and what they can.

1.2 Animal welfare

The term welfare can be defined as: “the state of an individual as regards its attempts to cope with its environment” (Fraser & Broom 1997). But a coping animal does not necessarily feel well and therefore a more holistic definition can be used: “welfare consists of the animals’ positive and negative experiences” (Simonsen 1996). It is important to note that the assumption that animals have feelings provides the ethical motive for concern about animal welfare. Both positive and negative feelings play a role in motivation. Negative feelings create the need for immediate action (need situations), while positive feelings are beneficial for fitness at a variety of times (opportunity situations), not only when they are required to meet immediate needs (Fraser & Duncan 1998). In terms of keeping animals, basic facilities are required to fulfil need situations and extra facilities are required to fulfil opportunity situations. The latter could be interpreted as environmental enrichment (Koene & Duncan 2001). Needs can change with age, diurnal and annual cycles and can differ between breeds and individuals within breeds (Simonsen 1996). Animals can make a cost-benefit evaluation to make a decision which course of action should be taken. According to this, animals act to maximise positive feelings and minimise negative ones. This implies that animals themselves assess their different states of need and this constitutes their overall welfare (Bracke et al. 1999). Assessment of animal welfare, however, must be based on scientific knowledge of the mechanisms for trying to cope including behaviour, health, physiology, and immunology (Broom 1996; Simonsen 1996). Especially, behaviour might be a useful indicator of welfare, because it could provide indirect evidence of how an animal feels. Behavioural observations can be

used to assess whether a specific behaviour pattern is a behavioural need or not (Duncan 1998).

1.3 Motivation

Motivation has been a central concept in animal welfare research since the paper of Dawkins (1983) about measuring needs. Motivation is the internal force that produces actions on the basis of the momentary balance between needs and demands of the environment (Dorman & Gaudiano 1998). The combined physiological and perceptual state, as represented in the brain, is called the motivational state (McFarland 1999). Motivation is goal oriented, sensitive for sensory stimuli, dependent of emotional state, and can be learned (Dorman & Gaudiano 1998). The performance of behaviour itself does have motivationally significant consequences, but they are not necessarily related to functional requirements (Hughes & Duncan 1988). Although the absence of a behaviour does not necessarily imply that captive animals are suffering, they often suffer in situations in which they are prevented from doing something that they are highly motivated to do (Dawkins 1990). It is assumed that the welfare of an animal will be reduced in such situations (Hughes & Duncan 1988; Jensen & Toates 1993). An animal can express the feelings of reduced welfare in abnormal (differing in pattern, frequency or context of normal) or frustration-related (aversive motivational state) behaviour (Amsel 1992; Fraser & Broom 1997).

1.4 Broilers

There are separate breeding programmes for meat- and egg-type chickens (*Gallus gallus domesticus*). A broiler, which is a meat-type chicken, is defined as “a young chicken bred for broiling or roasting (cooking by direct radiant heat)” (Oxford Advanced Learner’s Dictionary, 5th edition, 1995). Broilers have been selected for fast and efficient poultry meat production. Slaughter age has decreased, while live weight at slaughter has increased during the last 40 years (Rauw et al. 1998). Savory (2002) showed an increase in body weight gain per day of 24% between 1972 and 1999. There has been a greater change of daily feed intake (15%) than in feed conversion ratio (-9%) until 1984, but thereafter there was a greater change in feed conversion ratio (-16%) than in daily feed intake (2%) (Savory 2002). Fed on a modern diet, feed conversion (average over both sexes) was 1.6 in a modern broiler strain and 2.1 in a random bred broiler strain, with a body

weight of 2.7 kg and 0.6 kg on 42 days of age (Havenstein et al. 2003a). Body weight of a modern broiler is about 9 times higher than that of the ancestor the jungle fowl at 6 weeks of age (Bokkers, unpublished). Besides the so-called fast growing strains, there are special slow-growing strains meant for free-range poultry meat production (Weeks 2002; Nielsen et al. 2003). Slow-growing broilers grow in 12 weeks to a similar slaughter weight as fast-growing broilers do in 6 weeks.

Under commercial conditions, fast-growing broilers are kept indoors in flocks of 10 000-30 000 birds, with stocking densities of 18-23 birds/m². In general, broiler houses are provided with artificial light of a low intensity and a lighting schedule of 23 h light: 1 h dark. The floor is covered with litter, usually wood shavings, and the climate in the house is controlled automatically. Feeding and watering are automated. Slow-growing broilers are generally kept under less intensive conditions than fast-growing broilers (Saveur 1997). In this thesis, the term broiler is used for fast-growing strains. When slow-growing broilers are meant this will be mentioned explicitly.

Many authors describe that broilers are increasingly inactive, especially after 3 weeks of age. It has been suggested that broilers have a lack of motivation or no need for energy consuming behaviours such as walking (Bizeray et al. 2000). This implies that the motivation to perform certain behaviours would have changed by selection on production traits. If that is true than fundamental biological changes have taken place in broilers in relation to other chicken breeds. The suggestion is, however, in agreement with a general believe that broilers are not willing (not motivated) to do anything else than resting, eating and drinking, and it seems to be true when having a quick view in commercial facilities. However, people forget to ask themselves, are the birds able to show more behavioural activities? Whether an individual can express the motivation to perform behaviour, depends on the physical ability of that individual and on the environmental conditions where it lives in.

1.5 Physical ability

Physical ability of broilers can be affected by two forms of asymmetry. First the fluctuating asymmetry, which results from the inability of individuals to undergo identical development of bilateral characters on both sides of the body where the optimum is perfect symmetry (Møller & Swaddle

1998). There exists a negative correlation between asymmetry and fitness (Swaddle et al. 1994). In broilers, a positive relationship was found between growth rate and asymmetry, indicating that a higher growth rate made the birds less fit (Møller et al. 1995).

Another kind of asymmetry that can be observed in broilers arises from the unbalanced growth of different body parts. In broilers but also in turkeys, the selection on rapid body weight gain and on birds with more breast muscle has resulted in a change in body conformation (Webster 1994). Total body weight and amount of breast muscle have increased, but the relative amounts of leg muscles and leg bones have declined (Nestor et al. 1985). In modern broilers, the breast muscle weighed 20.0% of the total body weight, while in old-fashioned random bred broilers this was 11.6% (Havenstein et al. 2003b). Increased body weight gain and disproportionate breast muscle development could create skeletal-biomechanical imbalances (Lilburn 1994). Corr et al. (2003a; 2003b) showed that the centre of gravity has changed due to the rapid growth of the breast muscle, which has implications for walking ability, gait and mechanical stress on the legs. This can cause bone deformities. Other causes for developing skeletal abnormalities in broilers that can have an influence on locomotory functioning are associated with bone growth disturbances and infectious disorders (Thorp 1994).

High body weight at young age has an important influence on locomotion (Reiter & Bessei 2001) and on the development of leg disorders (Kestin et al. 2001). Males are heavier than females, and have therefore a higher risk of developing leg disorders (Sanotra et al. 2001). Reiter and Bessei (2001) developed a special device to alleviate 25% weight load of the legs of broilers without hampering their mobility and found an increase of the mean daily distance walked and a decrease of the torsional deformity. Birds with locomotion problems seemed to suffer pain, since they consumed more feed containing an analgesic than birds without locomotion problems (Danbury et al. 2000). The same analgesic improved walking speed of birds with locomotion problems (Mc Geown et al. 1999).

Locomotory dysfunction, probably with associated pain, restricted and changed birds' behaviour (Vestergaard & Sanotra 1999; Weeks et al. 2000) and is considered a major economic and welfare problem (see for an exhaustive review Bradshaw et al. 2002). Several measures can be taken to prevent birds from developing leg disorders. Infectious disorders may be controlled by careful management and treatment. A reduction of growth rate

by means of genetics, meal feeding, feed restriction, stimulating activity and reduced stocking density can reduce the incidence of skeletal disorders in broilers (Hester 1994; Reiter & Bessei 1998; Kestin et al. 2001; Bradshaw et al. 2002). In addition, a careful management of the bedding is necessary to prevent contact dermatitis (Berg 1998), and attention must be paid to important factors in the diet (Lilburn 1994; Bradshaw et al. 2002).

An unbalanced growth has occurred also in relation to organs that are essential for metabolism. It was found that lung and heart weight as percentage of body weight were lower in a modern than in a random bred broiler strain (Havenstein et al. 2003b). Lung volumes as percentage of body weight dropped most rapidly between 3-4 weeks of age, (Julian 1989), the period inactivity becomes evident in broilers (Reiter & Bessei 1998). At that age was observed that panting started to occur and increased to 25% shallow and 44% deep panting at 6 weeks of age (McLean et al. 2002).

In broilers, different metabolic disorders have been detected that can be associated with the selection for fast, unbalanced growth and low feed conversion. The fast growth of broilers needs a high metabolic rate. A high metabolic rate means that much oxygen is required. Modern broiler strains have a slightly lower T_3 level - a hormone that stimulates oxidative metabolism - compared to a relaxed bred strain and would, therefore, reduce oxygen consumption (Gonzales et al. 1999). When not enough oxygen can be delivered to the organs, susceptibility for metabolic disorders such as sudden death syndrome and ascites will increase (Gonzales et al. 1999). Sudden death syndrome is known as the unexpected death of an apparently healthy bird (Olkowski & Classen 1995). Ascites is a disease that normally only occurs under hypoxic conditions at high altitudes, but nowadays it can be detected also at sea level, especially in unfavourable environmental conditions (Scheele 1996). In birds with ascites, the right side of the heart becomes enlarged, the bird breathes quickly, the lungs become congested, the liver function is affected and the abdomen becomes swollen with fluid increasing the risk of heart failure (Julian 1993).

Thus, there are strong indications that the genetic selection focused on growth and feed conversion has led to a mismatch between the oxygen-supplying organs and the oxygen-consuming organs, as already suggested by Reeves et al. in 1991. This can be considered as a production disease, because the oxygen demands (resource) for specific organs cannot be met anymore. Resources can be limited in the environment, but it can also be restricted within the organism (Beilharz & Nitter 1998; Schütz et al. 2001).

It is possible that with the aim to stay fit, the optimisation of the resource allocation resulted in a change towards less costly behaviour in modern broilers. Metabolic cost of locomotion (amount of energy expended in moving a unit mass a unit distance) varies as a regular function of body mass for bipeds (Taylor 1980). Larger animals have lower costs of transport than smaller ones (McNeil Alexander 1982). It can be questioned whether broilers also answer to this statement because of their unbalanced growth, altered gait and high body weight at young age.

1.6 Environmental conditions

Environmental conditions are important, because they determine the external opportunities for the performance of behaviour. Space per individual and number of individuals per space unit determine largely whether an animal can move around, perform behaviours and function in a social environment (Blokhus & Van der Haar 1990; Gordon 1992; Keeling 1995; Reiter & Bessei 1999; Hall 2001; McLean et al. 2002). Higher stocking densities resulted in higher values for asymmetry, which suggests that a high stocking density induced stress for the birds (Møller et al. 1995). A higher stocking density decreased the quality of litter (Blokhus & Van der Haar 1990) and increased the temperature at litter surface (Reiter & Bessei 2000), resulting in a higher risk for heat stress and skin damages. Heat stress may have been the reason for the higher percentage birds that were panting when kept in high stocking densities (McLean et al. 2002), and for the fact that individual birds appeared to be restless (Murphy & Preston 1988). Quality and type of the litter determine whether behaviours such as scratching and dustbathing can be performed normally (Shields et al. 2003). The light environment should permit the development of normal vision, allow the birds to see well enough to carry out critical visual tasks and establish a day-night rhythm (Gordon 1994; Prescott et al. 2003). Aspects of light such as intensity (Newberry et al. 1988; Prayitno et al. 1997; Davis et al. 1999), photoperiod (Gordon 1994; Sanotra et al. 2002), colour and source (Prescott & Wathes 1999; Kristensen et al. 2002) determine the quality of the light environment and have an influence on the opportunities to be active. Finally, the accessibility of well designed perches are important for chickens to perform normal resting behaviour (Blokhus 1984). Perches are not present in commercial farms, but when available broilers will use them. Usage, however, will depend upon perch height, available perch and

pen space and ontogeny (Hughes & Elson 1977). Perches increased the environmental complexity and the possibilities to exercise (Newberry 1995). The latter had a beneficial effect on leg strength and bone density (Haye & Simons 1978; Thorp & Duff 1988; Reiter & Bessei 1998), but perches did not reduce leg problems (Su et al. 2000).

1.7 Aim and outline of thesis

Despite the general observed inactivity, broilers were motivated to seek opportunities to explore novel stimuli (Newberry 1999). This indicates that a more challenging environment is needed when broilers want to display all behaviours for which they are motivated. Increased environmental complexity can enhance opportunities and physical abilities in broilers (Kells et al. 2001; Mench et al. 2001; Bizeray et al. 2002). Motivation and physical ability aspects in broilers can be measured when giving birds opportunities to display behaviour in the homepen. Modifications in the environment such as lower stocking densities, provision of perches, other litter, etcetera, should improve biological functioning and have a positive effect on welfare (Newberry 1995). Another way to gain insight in motivation and physical ability is to measure the animal's strive to obtain a commodity, possibly after a deprivation period of that commodity (Dawkins 1990). Individual birds can be tested in experiments where they can show what they can, and what they want.

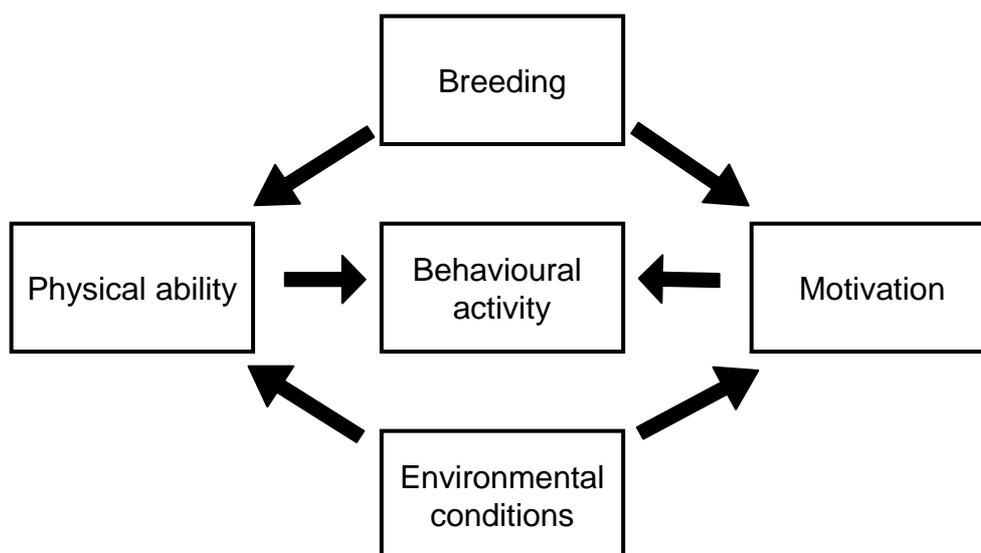


Figure 1.1: Schematic description of factors influencing behavioural activity.

In Figure 1.1, the main factors that have an influence on behavioural activity are summarised. Little is known about the motivation to show behavioural activity in broilers. The distinction between motivation and ability is relevant for the interpretation of behavioural (in-)activity in broilers in terms of welfare. The aim of the thesis was to gain insight into the influence of motivation and ability on behavioural activity in broilers. When birds have a low motivation or a low ability, they will be inactive (Figure 1.2). The hypothesis was that broilers are still motivated to behave, but that they are hampered by environmental conditions and physical abilities to be active. We studied this in homepen and test conditions at individual level.

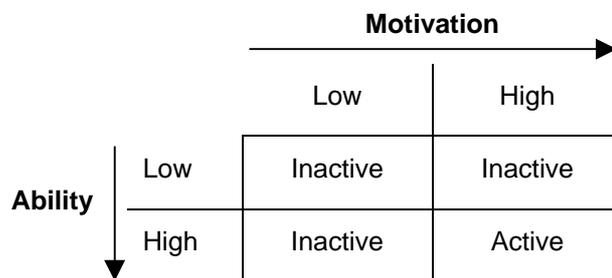


Figure 1.2: *Motivation and ability in broilers in relation to behavioural activity.*

In the next chapters, the following studies will be described. In Chapter 2, the aim was to study in detail the behaviour of fast growing (high body weight) and slow growing (low body weight) broilers to 12 weeks of age. A prolonged growing period would elucidate the disbalance between motivation and physical abilities with increasing weight. In order to minimise the effect of environmental conditions on behaviour, the birds were kept in pens that allow them to express their behaviour without restrictions. In literature, it was suggested that broilers might have a disturbed hunger and satiety mechanism, which may be of influence on motivation to obtain food. The purpose of Chapter 3 was to gain more insight in hunger and satiety mechanisms, by investigating individual eating behaviour of broiler and layer chickens. A runway experiment was conducted to investigate the influence of sex and type of feed (low versus high energy and protein content) on motivation and ability to walk for a food reward (mealworm) without depriving the birds from feed before testing (Chapter 4). In another runway experiment, we used two broiler strains with different physical abilities, determined by body weight, and tested them under different motivations until 12 weeks of age (Chapter 5). In Chapter 6, the aim was to

measure the maximum number of key pecks broilers with different physical abilities would perform for a food reward under different motivations. In Chapter 7, an experiment is described where motivation and physical ability to walk for a food reward were studied in an operant runway. Broilers with different physical ability were tested under similar motivation to walk an increasing distance within a session for a food reward. In Chapter 8, the main results of Chapter 2-7 are discussed.

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Behaviour of fast- and slow-growing broilers to 12 weeks of age and the physical consequences



2.1 Abstract

Behaviour of broilers up to 6 weeks of age has been studied extensively, but little is known what happens after six weeks. Insight in the behavioural abilities after 6 weeks may also yield insight in the period before 6 weeks as the disbalance between motivation and physical abilities is more clearly elucidated with increasing weight. The purpose of this experiment was to investigate behaviour in fast- and slow-growing broilers to 12 weeks of age and the physical consequences of the prolonged rearing period. Ninety-six 1-day-old female broiler chicks, 48 of a slow-growing and 48 of a fast-growing line were allocated to sixteen floor pens (1.5 m² per pen): eight pens of six birds per line. Each pen contained perches and the floor was covered with wood shavings. One day per week, each bird was observed five times, distributed regularly over the day. Behaviour, posture (sitting or standing) and position (floor or perch) of each individual were recorded. After 12 weeks, birds were killed and post-mortem examination was done to detect physical abnormalities. Fast- and slow-growing broilers performed the same behavioural elements, but time budgets of fast- and slow-growing broilers were different. Slow-growing broilers perched, walked and scratched more than fast growing broilers. Fast growing broilers performed more sitting on the floor, eating and drinking than slow-growing broilers. No differences were found for resting, preening, stretching, ground pecking or dustbathing. Time spent on several behaviours changed with increasing age or the posture during behaviour changed with age. Although several physical abnormalities were found in both lines, no correlations were found between physical abnormalities and behaviour. Physical abnormalities seemed not to be so severe to have hampered behavioural activity. The experimental conditions, such as only females, good quality of bedding, low stocking density, and perches seemed to be crucial to prevent serious physical abnormalities and to keep these birds to 12 weeks of age. This study showed that fast- and slow-growing broilers are motivated to perform all kinds of behaviour in an environment where that is possible also after 6 weeks of age, but that the ability of performing some behaviours are more and more hampered with increasing age most probably due to their weight.

2.2 Introduction

In poultry meat production fast- and slow-growing broiler breeds can be discriminated. Fast-growing broiler breeds are used in conventional,

commercial broiler production systems. These birds are normally kept in large flocks (10 000-30 000 birds) with high population densities (18-23 birds/m²) and grow to slaughter weight in about 42 days when they weigh approximately 2.2 kg. Slow-growing broiler breeds are used in free-range broiler production systems, for example, in Red Label (Label-Rouge) production systems in France. To come under the Red Label logo, production systems have to meet minimum husbandry standards: a) a slow-growing bird, b) foodstuffs low in fats and high in cereals, and free from growth promoters and animal protein, c) low stocking rates (maximum of 11 birds/m²) and a pasture of 2 m²/ bird from 6 weeks of age, d) minimum rearing period of 81 days (Saveur 1997). The reasons to keep slow-growing broilers under red label standards are better meat quality and a presumed improved animal welfare.

Behaviour of fast-growing broilers up to 6 weeks of age has been studied extensively in experimental (Murphy & Preston 1988; Hall 2001) as well as in commercial conditions (Murphy & Preston 1988; Newberry et al. 1988; Blokhuis & Van der Haar 1990; Bessei 1992; Weeks et al. 2000; Hall 2001). Behavioural differences have been found between fast- and slow-growing broilers. Fast-growing broilers showed, for example, a lower activity level than slow-growing broilers (Lewis et al. 1997; Siegel et al. 1997; Reiter & Bessei 1998; Reiter & Kutritz 2001).

It is obvious that fast-growing broilers will continue to grow when kept longer than the regular rearing period of 6 weeks, but what are the consequences for the birds? According to Havenstein et al. (1994), fast-growing female broilers will reach 4.2 kg and males 4.7 kg after 12 weeks of age. Kestin et al (2001) found a mean weight of 5.1 kg at 12 weeks of age. There are older studies where behaviour of broilers kept to 11-13 weeks of age was investigated (Masic et al. 1974; Savory 1975). They found differences in feeding and resting behaviour as compared to layer chicks. Nowadays broilers, however, grow much faster than at that time (Rauw et al. 1998). A risk of rearing fast-growing broilers longer than 6 weeks was not found in mortality rate, since this did not increase when birds got older (Havenstein et al. 1994). Actually, mortality was highest between 3 and 6 weeks of life. Mortality in fast-growing broilers was much higher than in birds not selected for fast growth (Havenstein et al. 1994), indicating that fast growth is a risk factor for the birds. Body weight and not growth rate of the birds was the major determinant factor for lameness at 7 and 12 weeks of age (Kestin et al. 2001). In a case study where broilers under commercial

circumstances had been reared through 12 weeks of age most birds in the flock had very serious leg problems (Butterworth et al. 2002). A study on the use of outdoor areas by fast and slow-growing broilers led to the conclusion that fast-growing broilers are unsuitable for 12 weeks growth in traditional free-range production systems (Nielsen et al. 2000). Outdoor areas seemed to have a positive effect on leg condition since in the study of Nielsen et al. (2000), gait scores were not as high as in the case of Butterworth et al. (2002) (2.2 vs. 3.8). Fast-growing broilers in free range conditions were initially more active than conventional housed broilers but from 6 through 12 weeks of age lying increased to comparable levels in these groups (Weeks et al. 1994).

Although there is some knowledge about body weight, mortality and leg problems of rearing broilers up to 12 weeks of age, detailed behavioural studies are missing. It is not known how strong the behavioural motivations and what the physical abilities of these birds are at a higher age. Insight in the abilities after 6 weeks may also yield insight in the period before 6 weeks as the disbalance between motivation and physical abilities is more clearly elucidated with increasing weight. The purpose of this experiment was to investigate behaviour in fast- and slow-growing broilers to 12 weeks of age and physical consequences of a twelve-week rearing period. Since males have a higher risk of leg disorders (Sanotra et al. 2001) only females were used in this study to prevent birds from serious welfare problems. Birds were kept in low stocking densities to allow them to live with little space restrictions. The pens were equipped with perches for an increase in environmental complexity and as a possibility to exercise to improve leg condition (Haye & Simons 1978; Hughes & Appleby 1990; Newberry 1995). Our hypothesis was that fast- and slow-growing broilers would perform the same behavioural elements but with different time budgets and that increasing age would increase this difference in time budgets. It was expected that fast-growing broilers would show less activity, make less use of perches and show more behaviour in sitting posture than slow-growing broilers. The other hypothesis was that fast-growing broilers would have more physical abnormalities than slow-growing broilers because of their higher growth rate and higher final body weight. Post-mortem examination was concentrated on growth and weight related physical abnormalities (Thorp & Maxwell 1993; Thorp 1994; Julian 1998).

2.3 Materials and methods

2.3.1 *Animals and housing*

Forty-eight 1-day-old female chicks of a slow-growing genetic line (JA 657, Hubbard ISA, Wezep, The Netherlands) and 48 1-day-old female chicks of a fast-growing genetic line (HI-Y, Hubbard ISA, Wezep, The Netherlands) were obtained from a commercial hatchery (Morren B.V., Lunteren, The Netherlands). Due to errors in gender determination, six males (five fast growers, one slow grower) were included in the experiment. Since this was discovered while the experiment was running the males were kept in the experiment and exposed to all measurements but excluded from analysis. Immediately after arrival, each bird got a small wingtag with an identification number and was coloured at its back with an animal-marking crayon for individual recognition. They were allocated to sixteen floor pens (1.0 × 1.5 m per pen): eight pens with six slow-growing birds and eight pens with six fast-growing birds (4 birds/m²). All walls of each pen were solid and 0.7 m high. The floor was covered with wood shavings. Once a week, at Fridays, part of the bedding was replaced with fresh wood shavings in order to keep the bedding in a consistent, good condition. Each pen contained one feeder of 80 cm wide, four drinking nipples with a cup underneath and two perches. The wooden slat of a perch measured 5 cm × 5 cm × 80 cm (wide × height × length) and had rounded angles. The slat was fixed on two 5 cm high structural foots. Each perch was 10 cm above the floor. Birds could eat and drink ad libitum. A two-phase conventional feed (meal) produced by TNO Nutrition (ILOB-department, Wageningen, The Netherlands) was provided. For the first 18 days, birds were fed a starter feed (23.0% crude protein and 12.7 MJ/kg ME), thereafter a grower feed (20.5% crude protein and 13.5 MJ/kg ME). Artificial light (25 lux) was provided initially at a schedule of 23-h light and 1-h dark. After 3 days, a schedule of 18-h light and 6-h dark was provided. No daylight entered the house. Temperature was maintained on 32 ± 1 °C at the beginning of the experimental period, and gradually decreased every 3 days by 1 °C eventually to a constant temperature of 20 ± 1 °C.

For a runway experiment, which will be described elsewhere, half of the birds of both lines (4 pens/line) were feed deprived for 3 h two times a week (Tuesday and Friday), the other half for 24 h two times a week (Monday-Tuesday and Thursday-Friday). This factor is called 'deprivation'

and is used in the statistical analysis. Birds had always 18 h ad libitum feed access before the first behavioural observation at Wednesday started.

The Wageningen University Committee on Animal Care and Use approved this experiment on condition that when for a particular bird a gait score of three or higher was determined and when this finding was confirmed the next day that individual had to be killed. The gait score has a six point scale: 0 = no detectable walking abnormalities, 5 = incapable of sustained walking on its feet (Kestin et al. 1992).

2.3.2 Behavioural observations

One day per week, on Wednesdays, each bird was observed once (instantaneous scan sampling) in its homepen at 09:00, 11:00, 13:00, 15:00 and 17:00 h. Observations were conducted from 1 to 12 weeks of age by an observer standing in front of an adjacent pen. Only one scan per observation was because previous experience showed that two or three scans increased the behavioural activity of the birds as reaction on the presence of the observer. Behaviour, posture (sitting or standing) and position (floor or perch) of each individual were recorded using The Observer® software package (Noldus 1993) installed on a Psion Organizer. The ethogram is given in Table 2.1.

2.3.3 Weight and feed consumption

Every week on Thursday, each bird was weighed. Feed consumption per pen per week was determined throughout the experiment.

2.3.4 Post-mortem examination

The experiment ended when the birds were 12 weeks old. Each bird was killed with an intravenous injection in the wing vein (*vena cutanea ulnaris*) of the euthanising agent T-61 (0.3 cm³/kg; Hoechst Roussel Vet GmbH). Immediately thereafter, post-mortem examination was carried out to determine physical abnormalities. A prepared checklist was followed during post-mortem examination. Special attention was given to abnormalities such as tibial dyschondroplasia, scoliosis, kinky back, tendon degeneration, epiphyseal separation, deviated breastbone, and rotated tibia (Thorp & Maxwell 1993; Thorp 1994; Julian 1998). Also presence of heart abnormalities (dilatation or heart fibrine), liver abnormalities (abnormal colour or shape), stomach erosions, and breast blisters (infection of the bursa on the breastbone) and condition of feet and hocks (swollen or

burned) were noted. For each attention point was noted if there was a physical abnormality or not. Post-mortem examination does not give information about developmental aspects of physical abnormalities, but it gives an overview of the physical consequences of a rearing period of 12 weeks.

Table 2.1: *Ethogram of recorded behaviours. Also is shown if posture was noted (Yes/No), which could be either standing or sitting. Besides behaviour and posture the position in the pen (floor or perch) of each individual was noted at the same time.*

Behaviour	Description	Posture
Eating	With head above or in the feeder	Y
Drinking	Pecking to a drinking nipple or drinking out of the cup beneath the drinking nipple	Y
Preening	Grooming of own feathers with the beak	Y
Scratching	Scraping of the litter with the claws	Y
Ground pecking	Pecking movements directed at ground	Y
Stretching	Stretching of wing and/or leg	Y
Aggression	Pecks directed to the head of a pen mate or sparring	Y
Standing idle	Standing without any other activity	N
Sitting idle*	Sitting with hocks resting on ground without any other activity	N
Walking	Locomotion with a normal speed or with quick steps	N
Wing flapping	Bilateral up-and-down wing flapping	N
Dust bathing	Performed with fluffed feathers while lying, head rubbed on floor, wings opened, scratching at ground	N
Lying*	With the head flat on the bedding or with the head under a wing either with eyes open or closed	N
Other	All other behaviours not mentioned above	Y

*Sitting idle and lying together are named resting.

2.3.5 Statistical analysis

Statistical analyses were performed using software from the SAS Institute Inc. (SAS® 1996). Data were analysed at pen level except for data of the post-mortem examination. Data, which met assumptions of normality, were analysed with an analysis of variance with the factors genetic line, deprivation, pen nested in genetic line and deprivation, and age included in the model. Data, which did not meet assumptions of normality, were analysed with the Kruskal-Wallis test and post hoc with the Wilcoxon two sample test. Data of the post-mortem examination were analysed with a Fisher's exact test. Spearman rank correlations (r_s) were calculated between behavioural and weight data. Post-mortem data were binary response

variables (physical abnormality was present or not present). Correlations between behavioural (explanatory variables) and post-mortem data were calculated with the binary response model in the Logistic procedure of SAS.

2.4 Results

Two fast-growing birds were killed due to a gait score of three: one at 6 and one at 9 weeks of age. Besides these birds, two to four birds in the 6-12 week of age had a gait score of two. All other birds had a gait score of zero or one.

2.4.1 Behaviour

No differences of feed deprivation two times a week on behaviour were found, except for drinking behaviour in slow-growing broilers. Twenty-four hours feed deprived birds showed more drinking behaviour than 3 h feed deprived birds ($Z=-2.17$, $p<0.05$). Behavioural results are shown, therefore, per week per line without distinction between deprivation schedule in Figures 2.1 and 2.2.

In Table 2.2 line differences over 12 weeks are shown. Over all weeks, slow-growing broilers perched more than fast-growing broilers. Fast-growing broilers perched significantly more at 3, 4 and 5 weeks of age compared with the other weeks ($p<0.05$). The main posture on the perches was sitting; few birds were standing on the perches. Slow-growing broilers walked, scratched, stood idle and lied more and showed more ground pecking in standing posture and aggression than fast-growing broilers. Fast-growing broilers showed more sitting on the floor ($F_{1,165}=37.27$, $p<0.001$), preening and stretching in sitting posture, eating and drinking in both postures and tended to perform more behaviours in sitting posture than slow-growing broilers. Over all weeks, however, both lines spent the same time on resting. In addition, no differences (slow- versus fast-growing broilers) were found for total preening, total stretching, total ground pecking, sitting idle or dustbathing.

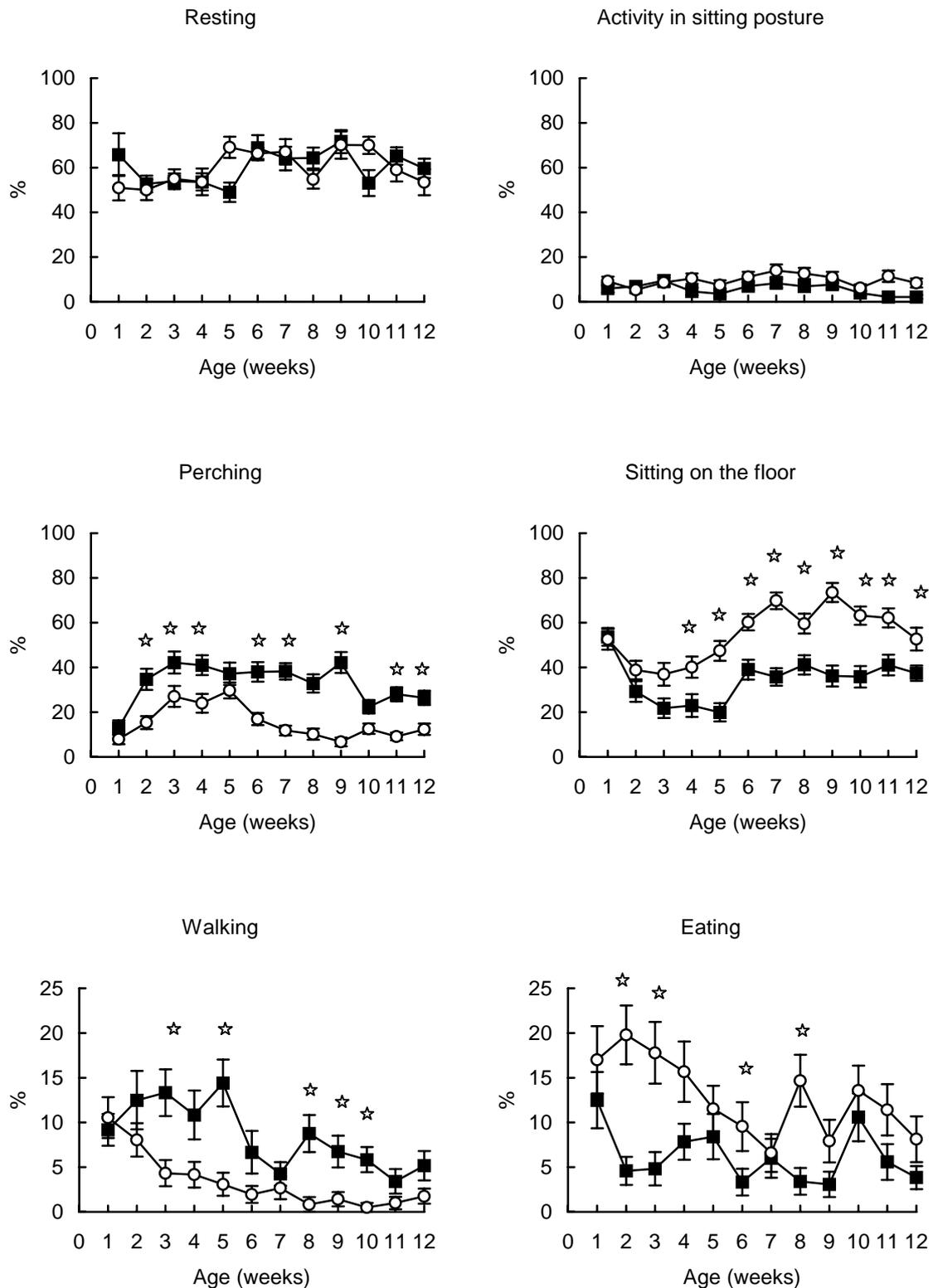


Figure 2.1: From top left to bottom right: resting, activity in sitting posture, perching, sitting on the floor, walking and eating as percentage of observed behaviour in fast-growing (O) and slow-growing (■) broilers. The symbol ☆ means a significant difference of at least $p < 0.05$ at a certain age.

Table 2.2: Behaviour as percentage (\pm SEM) of the observations over the first 6 weeks and over 7 to 12 weeks of age. Between parentheses the posture of the bird during a particular behaviour (sit or stand) or total percentage of a particular behaviour (tot). Line effects were analysed over 12 weeks.

Behaviour (%)	Slow-gr.	Slow-gr.	Fast-gr.	Fast-gr.	Line effect	P-value
	1-6 weeks	7-12 weeks	1-6 weeks	7-12 weeks		
	n=48	n=48	n=48	n=48	n=96	
Sitting idle	50.6 \pm 2.0	59.0 \pm 1.8	48.6 \pm 1.8	57.4 \pm 1.7	F = 0.33	0.567
Lying	6.7 \pm 1.5	4.0 \pm 0.6	8.9 \pm 1.2	5.0 \pm 0.7	Z = -2.66	0.008
Standing idle	10.4 \pm 1.1	9.2 \pm 0.8	4.7 \pm 0.8	5.6 \pm 0.8	Z = 5.14	0.001
Walking	11.2 \pm 1.2	5.7 \pm 0.8	5.3 \pm 0.8	1.4 \pm 0.4	Z = 5.25	0.001
Preening (tot)	6.1 \pm 0.8	6.3 \pm 0.8	5.8 \pm 0.9	9.0 \pm 1.0	F = 1.21	0.293
<i>Preening (sit)</i>	3.6 \pm 0.7	2.8 \pm 0.5	3.9 \pm 0.8	4.9 \pm 0.7	Z = -2.11	0.035
<i>Preening (stand)</i>	2.5 \pm 0.5	3.6 \pm 0.6	2.0 \pm 0.4	4.2 \pm 0.6	Z = -0.87	0.382
Eating (tot)	6.9 \pm 1.0	5.4 \pm 0.9	15.2 \pm 1.3	10.4 \pm 1.2	Z = -5.93	0.001
<i>Eating (sit)</i>	0.3 \pm 0.2	0.0 \pm 0.0	1.0 \pm 0.3	1.3 \pm 0.3	Z = -3.98	0.001
<i>Eating (stand)</i>	6.6 \pm 1.0	5.4 \pm 0.9	14.2 \pm 1.3	9.1 \pm 1.1	Z = -5.17	0.001
Ground pecking (tot)	4.0 \pm 0.5	3.4 \pm 0.5	3.8 \pm 0.6	2.7 \pm 0.5	Z = 0.81	0.420
<i>Ground pecking (sit)</i>	1.3 \pm 0.3	1.8 \pm 0.4	2.4 \pm 0.5	2.4 \pm 0.5	Z = -1.82	0.069
<i>Ground pecking (stand)</i>	2.7 \pm 0.4	1.6 \pm 0.3	1.5 \pm 0.4	0.4 \pm 0.2	Z = 3.68	0.001
Dustbathing	2.3 \pm 0.6	3.0 \pm 0.6	2.0 \pm 0.4	2.0 \pm 0.4	Z = 0.21	0.830
Drinking (tot)	1.7 \pm 0.3	3.0 \pm 0.6	5.0 \pm 0.7	4.8 \pm 0.7	Z = -4.42	0.001
<i>Drinking (sit)</i>	0.0 \pm 0.0	0.0 \pm 0.0	0.2 \pm 0.1	0.4 \pm 0.2	Z = -2.88	0.004
<i>Drinking (stand)</i>	1.7 \pm 0.3	3.0 \pm 0.6	4.8 \pm 0.7	4.4 \pm 0.7	Z = -3.90	0.001
Stretching (tot)	1.2 \pm 0.2	1.1 \pm 0.3	1.9 \pm 0.4	1.9 \pm 0.4	Z = -1.66	0.095
<i>Stretching (sit)</i>	0.6 \pm 0.2	0.4 \pm 0.2	1.2 \pm 0.4	1.6 \pm 0.4	Z = -2.44	0.015
<i>Stretching (stand)</i>	0.6 \pm 0.2	0.6 \pm 0.2	0.7 \pm 0.2	0.3 \pm 0.2	Z = 0.81	0.419
Scratching	0.5 \pm 0.2	0.5 \pm 0.2	0.1 \pm 0.1	0.1 \pm 0.1	Z = 2.92	0.003
Aggression	0.3 \pm 0.1	0.3 \pm 0.1	0.3 \pm 0.1	0.1 \pm 0.1	Z = 2.38	0.017
Wing flapping	0.4 \pm 0.2	0.1 \pm 0.1	0.0 \pm 0.0	0.1 \pm 0.1	Z = 1.29	0.196
Perching (tot)	34.3 \pm 2.4	31.7 \pm 2.2	20.1 \pm 1.8	10.5 \pm 1.3	F = 30.17	0.001
<i>Perching (sit)</i>	30.1 \pm 2.2	29.2 \pm 2.2	18.5 \pm 1.8	9.1 \pm 1.2	F = 23.82	0.001
<i>Perching (stand)</i>	4.2 \pm 0.7	2.5 \pm 0.4	1.7 \pm 0.4	1.4 \pm 0.4	Z = 3.41	0.001
Sitting while active	6.3 \pm 0.7	5.2 \pm 0.7	8.7 \pm 1.0	10.6 \pm 1.1	F = 4.88	0.052
Resting	57.3 \pm 2.5	63.0 \pm 2.1	57.5 \pm 2.0	62.4 \pm 2.2	F = 0.01	0.943

Since fast-growing broilers are normally kept to 6 weeks of age, an analysis was conducted by splitting behavioural data into two periods: the first 6 weeks and the last 6 weeks of the experiment (Table 2.2). Sitting idle increased in the last 6 weeks ($F_{1,94}=11.89$, $p<0.001$). A significant decrease

in walking ($Z=3.42$, $p<0.001$), eating in sitting posture ($Z=2.02$, $p<0.05$), and ground pecking in standing posture ($Z=2.11$, $p<0.05$) was found in slow-growing broilers between the first 6 weeks and the last 6 weeks. In fast-growing broilers a significant decrease in walking ($Z=4.50$, $p<0.001$), eating ($Z=2.80$, $p<0.01$), eating in standing posture ($Z=3.03$, $p<0.01$), ground pecking in standing posture ($Z=2.71$, $p<0.01$), perching ($F_{1,94}=20.14$, $p<0.001$), perching in sitting posture ($F_{1,94}=19.91$, $p<0.001$), and lying ($Z=2.38$, $p<0.05$) was found. Preening ($F_{1,94}=5.95$, $p<0.05$), sitting idle ($F_{1,94}=12.10$, $p<0.0001$) and preening in standing posture ($Z=-2.96$, $p<0.01$) increased in the last 6 weeks in fast-growing broilers.

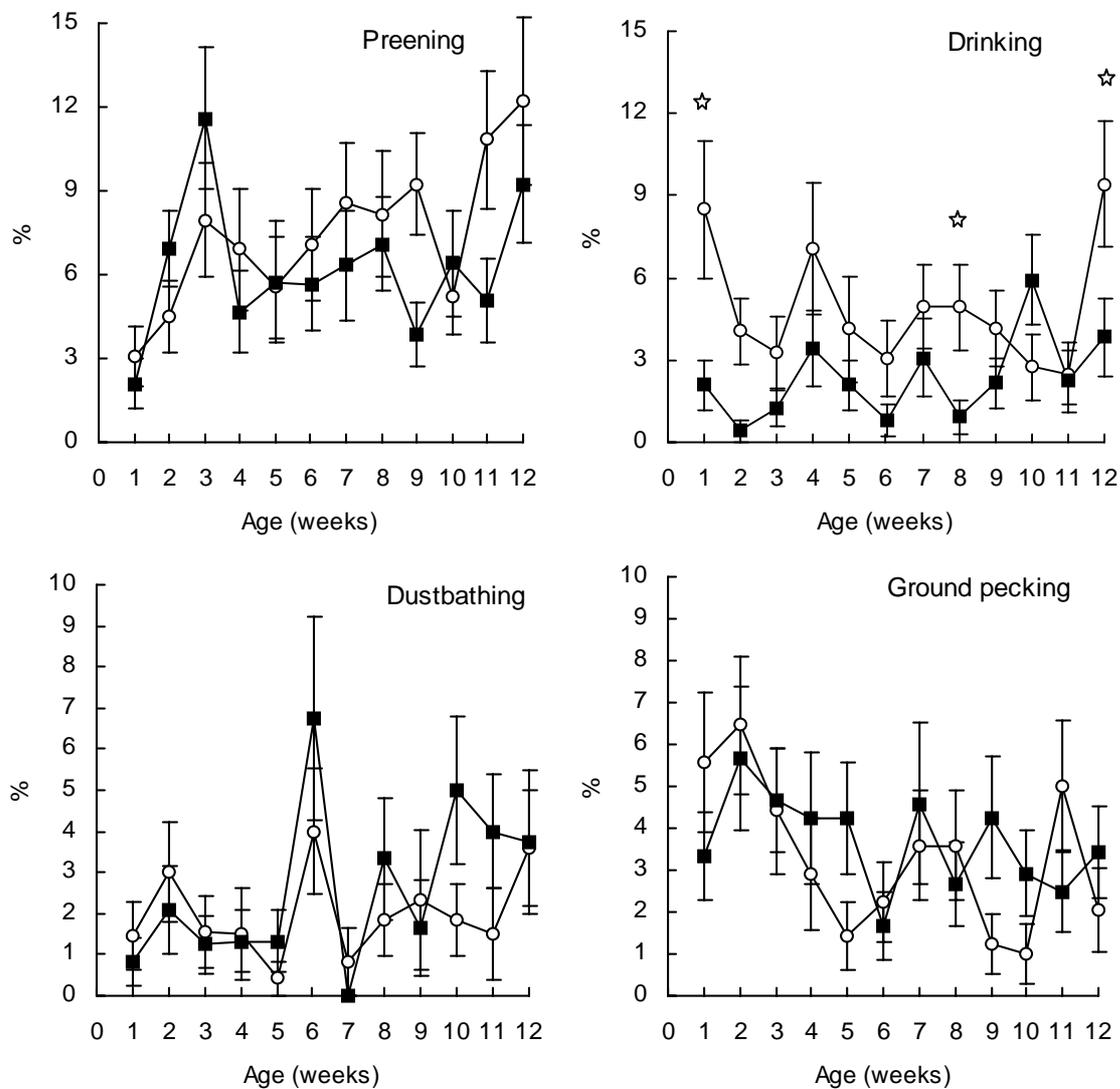


Figure 2.2: From top left to bottom right: preening, drinking, dustbathing and ground pecking as percentage of observed behaviour in fast-growing (○) and slow-growing (■) broilers. The symbol ☆ means a significant difference of at least $p<0.05$ at a certain age.

2.4.2 Body weight and feed consumption

On arrival, slow-growing chicks (45.4 g) were heavier than fast-growing chicks (37.6 g) ($F_{1,12}=129.88$, $p<0.001$), but the next week fast-growing birds were already heavier than the slow-growing birds and that difference increased until the end of the experiment (Fig. 2.3) (on day 84: $F_{1,12}=1807.21$, $p<0.001$). A deprivation effect on body weight was found for both lines from the second week of life onwards ($F_{1,12}=20.24$, $p<0.001$). An interaction effect between line and deprivation level was found at the age of 3 to 10 weeks of life. At these ages the groups differed significantly from each other ($p<0.001$).

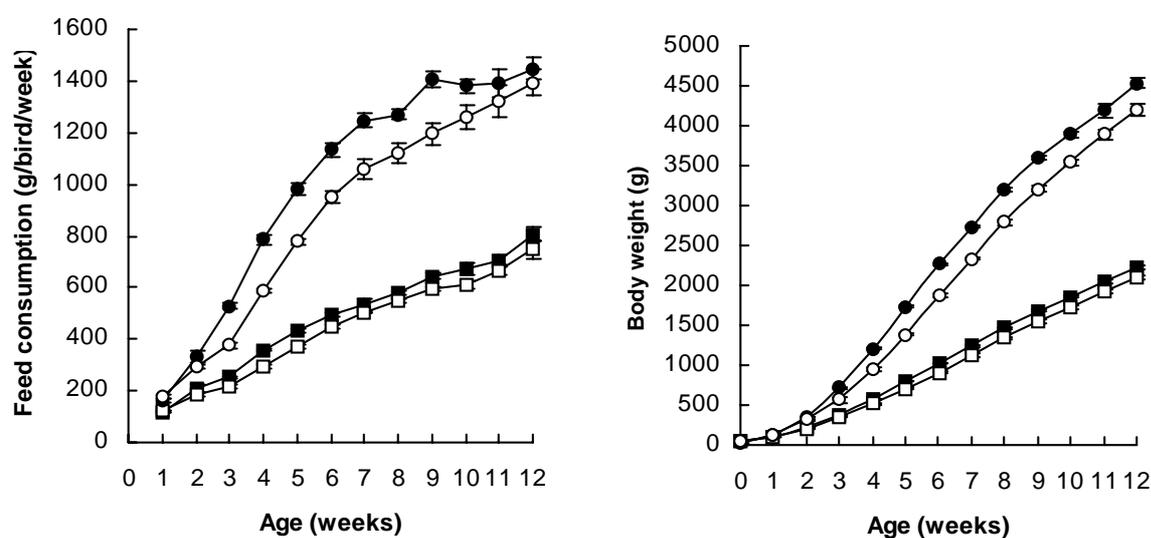


Figure 2.3: Feed consumption (g per bird per week; left) and body weight (g; right) over weeks in fast-growing broilers 3 h feed deprived (●) respectively 24 h feed deprived (○) two times a week and slow-growing broilers 3 h feed deprived (■) respectively 24 h feed deprived (□) two times a week.

From the first week of life fast growers consumed more feed than slow growers ($F_{1,12}=40.97$, $p<0.001$; Fig. 2.3). In both lines from 3 through 9 weeks of age birds that were 3 h feed deprived twice a week consumed more feed than birds that were 24 h feed deprived twice a week ($p<0.01$).

2.4.3 Post-mortem examination

Results of the post-mortem examination are summarised in Table 2.3. Heart abnormalities, tendon degeneration, scoliosis and rotated tibia were found more in fast-growing broilers than in slow-growing broilers. Slow-growing broilers had significantly more deviated breast bones. No tendon

rupture or slipped tendon were found since these are disorders that would have lead to gait scores higher than 2 and would therefore have been culled. Although the found breast blisters were not severe -no inflammations were observed- it was the physical disorder which was found most.

Table 2.3: Results of the post-mortem examination. Note that it is possible that one bird had more than one physical abnormality. Between brackets the percentage of birds with a particular abnormality is given.

Number of birds with:	Slow growers		Fast growers		Fisher's exact test
	(N=47)		(N=41)		P value
Tendon degeneration	0	(0.0%)	9	(22.0%)	0.001
Scoliosis	1	(2.1%)	8	(19.5%)	0.011
Deviated breastbone	9	(19.1%)	1	(2.4%)	0.017
Heart abnormality	2	(4.3%)	9	(22.0%)	0.021
Rotated tibia	0	(0.0%)	4	(9.8%)	0.043
Stomach erosions	6	(12.8%)	2	(4.9%)	0.276
Breast blister	21	(44.7%)	14	(34.1%)	0.384
Foot damage	0	(0.0%)	1	(2.4%)	0.466
Liver abnormality	0	(0.0%)	1	(2.4%)	0.466
Curved toes	1	(2.1%)	2	(4.9%)	0.596
Liquid in tendon	1	(2.1%)	2	(4.9%)	0.596
Epiphyseal seperation	2	(4.3%)	3	(7.3%)	0.661
Tibial dyschondroplasia	1	(2.1%)	1	(2.4%)	NE
Hock damage	0	(0.0%)	0	(0.0%)	NE
Kinky back	0	(0.0%)	0	(0.0%)	NE

NE=not estimable

No correlations were found between behaviour and physical abnormalities. A negative correlation was found between perching and body weight in slow-growing broilers at 12 weeks of age ($r_s=-0.31$, $p<0.05$) and in fast-growing broilers at 9, 10 and 12 weeks of age ($r_s=-0.35$, $r_s=-0.39$, $r_s=-0.35$, $p<0.05$).

2.5 Discussion

The purpose of this experiment was to investigate behaviour in fast- and slow-growing broiler females to 12 weeks of age and physical consequences of rearing broilers up to 12 weeks of age. The results of this investigation showed that time budgets of fast- and slow-growing broilers were different and that time budgets changed in the prolonged rearing period. Contrary to our expectations, no difference was found in resting

behaviour between fast- and slow-growing broilers. Both lines, in the first place, are selected for a specific growth rate. Behavioural differences seemed, therefore, to be a result of growth or weight differences. Both lines rested 57% during the first 6 weeks and 63% during the last 6 weeks of the observed time, which is little lower as compared to other observations of fast-growing broilers under commercial conditions (64-65%, Murphy & Preston 1988; Hall 2001), and experimental conditions (64-67%, Bizeray et al. 2000; Cornetto & Estevez 2001) and observations in slow-growing broilers (60%, Siegel et al. 1997; Reiter & Kutritz 2001). It is remarkable that in most papers no distinction is made between sitting idle and sitting while performing another behaviour. This distinction is relevant since a characteristic of fast-growing broilers is that behaviour such as preening, stretching and ground pecking are mostly performed in sitting posture. Time spent on behaviour such as preening, ground pecking is, therefore, often underestimated and resting overestimated, as illustrated by our results. No differences between fast and slow-growing broilers were found when total preening and ground pecking were measured.

Slow-growing broilers made more use of the perches than fast-growing broilers. In slow-growing broilers, no significant differences in perching behaviour were found between the first 6 weeks and the last 6 weeks. Until 9 weeks of age the proportion slow-growing birds that perched (around 40%) was comparable to perching behaviour of laying hens during daytime (43%, Hughes & Appleby 1990) and even higher than that of layer chicks (around 30% during daytime, Newberry et al. 2001). During the last 3 weeks of the experiment, perching decreased also in slow-growing broilers to around 25%. Perching behaviour of fast-growing broilers was observed most at 3, 4 and 5 weeks of age. Perching behaviour decreased thereafter with increasing age to a consistent level of 11% during the last 6 weeks. This was lower than perching behaviour of slow-growing broilers, but much higher than 2-3% perching behaviour found by LeVan et al. (2000) and Pettit-Riley and Estevez (2001) during the first 6 weeks of life. Design of the perch may be a crucial factor to explain these differences. Perch height, perch length per bird and design of a perch are of major importance for birds' propensity to use a perch. LeVan et al. (2000) and Pettit-Riley and Estevez (2001) used circular perches with a rather small diameter (2.6 cm) which is not a very proper design for heavy birds to perch on. Since even laying hens, which are lighter, slipped and had difficulties in maintaining their position on circular perches (Hughes & Appleby 1990). In our experiment, space and perch

length were no limiting factors. Birds were free to rest wherever and whenever they wanted since there was always perch and floor space enough. Perches may have had physical consequences for the birds, as indicated by Tauson and Abrahamsson (1994). It was thought that perching caused the deviated breastbones and the breast blisters, but no correlation has been found between perching behaviour and these abnormalities.

The time spent on walking behaviour in our experiment (11% in slow- and 5% in fast-growing broilers during the first 6 weeks) was in accordance with that of Weeks et al. (2000) and Cornetto and Estevez (2001). Bizeray et al. (2000), however, found 5% walking in slow-growing broilers during the first 3 weeks of life and Reiter and Kutritz (2001) just 3.8% walking during the first 5 weeks of life. Our experiment showed that walking behaviour in fast growers decreased quickly and from 8 weeks of age just around 1% of the time was spent on walking, which seemed to be just enough to walk to the feeder and the drinker. In slow-growing broilers, a decrease in walking behaviour was observed with increasing age. Since birds grew, less space was left per bird when they got older. This may have caused this decrease in walking behaviour. Differences in walking activity, as also in perching and scratching may be partly explained by physical abnormalities as tendon degeneration, rotated tibia and scoliosis, since these may cause pain or physical limitations, although no serious walking disorders were seen with the external examination (gait score). Also heart abnormalities may have influenced these behaviours, since reduced heart function may result to quick tiredness. The fast-growing broilers were probably frustrated in their walking behaviour. Displacement preening is associated with frustration (Duncan & Wood-Gush 1972). The increase of preening behaviour in fast-growing broilers when growing older could therefore be a reaction to frustration that they could not walk as much as they were motivated to do. Slow-growing broilers did not show such an increase in preening behaviour, although their walking behaviour also decreased with increasing age, but not to such a low level as in fast-growing broilers.

The percentage dustbathing we found (2-3%) is higher than found in other studies (0.1-0.9%, Weeks et al. 2000; Cornetto & Estevez 2001; Hall 2001). Birds in our study were housed in low stocking density and the quality of the litter was maintained at the same quality throughout the experiment. Since quality of the litter may be of importance for litter directed behaviours such as dustbathing this can explain the difference. Another aspect of dustbathing is that it is performed for rather short periods with a

peak 6-7 h after onset of light (Vestergaard 1982). This corresponded with a peak in dustbathing activity (3.6%) in our observations at 13:00 h. The chance that we observed dustbathing was rather high, while this behaviour may be underestimated in other studies because of the method or the time of observation.

Eating behaviour differs among genetic lines selected for body weight (Barbato et al. 1980). This was confirmed in our experiment. Slow-growing broilers spent less time on eating behaviour, consumed less feed and, not surprisingly, grew slower. Time spent on eating behaviour decreased in fast-growing broilers from 15% in the first 6 weeks to 10% in the last 6 weeks, while feed consumption increased. Time spent on eating during the first 6 weeks of life was rather high compared to other studies where birds spent 5-11% of the time on eating (Murphy & Preston 1988; Weeks et al. 2000; Hall 2001).

Although an effect of feed deprivation on body weight was found, no deprivation effects were found on behaviour. If feed deprivation would have affected behaviour than it could be expected that behavioural changes were measurable in the group which was feed deprived for 24 h in relation to the group which was feed deprived for 3 h. Since we did not find such an effect, we assumed that there was no influence of deprivation on behaviour in the homepen. Body weights at 12 weeks of age of the 3 h feed deprived fast-growing birds were similar to those of Havenstein et al. (1994) and Kestin et al. (2001). Body weights of the 3 h feed deprived slow-growing birds were in accordance with the predicted values of Hubbard ISA. Thus, there was no need for an extra non-deprived control group.

Fast- and slow-growing broilers performed the same behavioural elements, but time budgets of fast- and slow-growing broilers were different. Time spent on several behaviours changed with age or the posture during behaviour changed with age. Since slow-growing broilers were half the weight of fast-growing broilers, it seemed that the similar percentage resting for both lines has a genetic background rather than a physical background. Although several physical abnormalities were found in both lines, no correlations were found between physical abnormalities and behaviour. Physical abnormalities seemed not to be so severe to have hampered behavioural activity. The experimental conditions, such as only females, good quality of bedding, low stocking density, and perches seemed to be crucial to prevent serious physical abnormalities and to keep these birds to 12 weeks of age. This study showed that fast- and slow-growing broilers are

motivated to perform all kinds of behaviour in an environment where that is possible also after 6 weeks of age, but that the ability of performing some behaviours are more and more hampered with increasing age most probably due to their weight.

2.6 Acknowledgements

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Eating behaviour, and preprandial and postprandial correlations in male broiler and layer chickens



3.1 Abstract

It has been suggested that broiler chickens have a disturbed satiety and hunger mechanism. The satiety mechanism for eating can be expressed as the positive correlation between meal length and the length of the preceding (preprandial) interval; the hunger mechanism for eating as the positive correlation between meal length and the length of the succeeding (postprandial) interval. An experiment was conducted to investigate eating behaviour of male broiler and layer chickens by measuring meal and interval lengths. Eight male broilers and 8 male layer chickens were housed individually and visually isolated in floor pens (1m² per pen) on wood shavings. From 4-7 weeks of age, eating behaviour of each bird was recorded for 3 h in two conditions each week. In the first condition, the birds were not deprived from feed. In the second condition, they were 24 h feed deprived and feed was provided just before the observation started. Preprandial and postprandial correlations were calculated based on data of the non-deprived condition. Before and after each observation bird and feeder were weighed to measure weight gain and feed consumption during observation. Under the non-deprived condition, the broilers spent initially more, but at a later age less time on eating. The broilers had fewer meals per hour, consumed more feed per hour, and had longer meal and interval lengths than the layer chickens. After 24 h feed deprivation, the broilers had a longer first meal, consumed more feed per hour and spent more time on eating than the layer chickens. Significant preprandial correlations but no postprandial correlations were found in the broilers. In the layer chickens, both significant preprandial and postprandial correlations were found. This indicates that for regulating eating behaviour, the satiety mechanism is dominating the hunger mechanism in broilers, and satiety and hunger mechanisms are equally involved in layer chickens. The typical eating behaviour of broilers and the calculated preprandial and postprandial correlations have given new indications that hunger and satiety mechanisms in broilers have changed compared with layer chickens. In broilers, there is no lower set point, but only an upper set point for controlling eating behaviour, which suggests that broilers eat to their maximal physical capacity.

3.2 Introduction

Broilers have been selected extensively for increased growth rate. This selection resulted primarily in increased appetite with a minimal increase in feed efficiency (Dunnington & Siegel 1996). Barbato (1994) stated on the basis of studies of Nir *et al.* (1978) and Barbato *et al.* (1984) that chickens from body weight selected lines voluntarily consume a volume of feed approaching the full capacity of their gastro-intestinal tract, whereas low weight selected consume a small percentage of total capacity. Providing two types of feed with different energy and protein content had no effect on feed intake in broilers (Bokkers & Koene 2002), which was in agreement with the proposition of Barbato *et al.* (1994). Burkhart *et al.* (1983) compared fast- and slow-growing chickens with or without ventromedial hypothalamic lesions, and found no changes in the fast-growing strain, and increased fat deposition in the slow-growing strain. They suggested that selection for increased body weight resulted in a diminution of hypothalamic satiety mechanisms. This interpretation of the results has been criticised by Nielsen (2002) recently. She suggested that a reduction in behavioural activity of the slow growing line resulting from the ventromedial hypothalamic lesions would offer an alternative explanation of the results.

Feed intake regulation is a complex physiological system having many levels of control (Denbow 1994a; 1994b; Kuenzel 1994). Components of the internal control mechanisms such as plasma glucose concentration, body temperature, plasma amino acids, leptin, and cholecystokinin can all modulate meal patterns (Kuenzel 1994; Friedman & Halaas 1998; Denbow *et al.* 2000). Meal patterns, such as meal length, size and frequency, are typical behavioural manifestations of the internal control mechanisms (Reddingius 1980). Measuring meal length and intervals between meals can be used, therefore, to study hunger and satiety mechanisms, as shown in older work of, for example, Clifton (1979) and Savory (1981). Savory (1981) described the mechanisms as follows: The correlation coefficient of length of meals and the successive intervals is called the postprandial correlation. Periods of non-feeding tend to depend on amounts eaten. This suggests that interval length may be controlled by a lower set point at which feeding starts, or in other words, a hunger mechanism. The correlation coefficient of length of intervals and successive meal length is called the preprandial correlation. Amounts eaten tend to compensate for periods of non-feeding. This suggests that meal size may be controlled by an upper set point at

which feeding stops, or in other words a satiety mechanism (Savory 1981); (Figure 3.1).

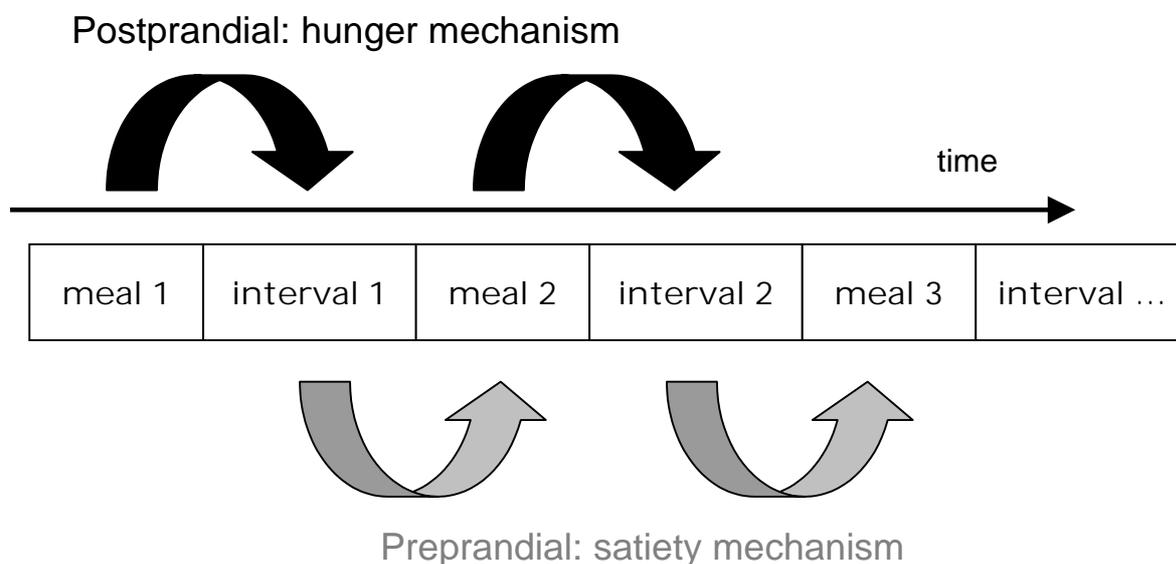


Figure 3.1: Schematic representation of preprandial and postprandial correlations between meals and intervals between meals.

In most birds and mammals the postprandial correlation coefficient is higher than the preprandial correlation coefficient (Savory 1981). The significance of correlation coefficients in rats have been criticised, since feeding patterns are sensitive to a large number of variables, which has some risks with regard to statistical analysis (Panksepp 1978). Controlled experimental conditions and a comparison within one study can overcome this criticism.

If feed intake control mechanisms in broilers have changed due to genetic selection for growth (Denbow 1994b), it can be expected that some characteristics of eating behaviour have changed compared to poultry lines that have not been selected for growth. A change in behavioural characteristics for eating means that it can be expected also that broilers have a different balance in postprandial and preprandial correlations than, for example, layer chickens of the same age. To investigate this, an experiment was conducted with broiler and layer chickens to study their eating behaviour and to calculate postprandial and preprandial correlation coefficients. In addition to a non-deprived condition, a feed deprived condition was used to study the influence of hunger on temporal patterns of eating behaviour in the two lines. The research questions were: What are the

behavioural characteristics of eating in modern broiler and layer chickens in non-deprived condition and after feed deprivation? How high are the postprandial and preprandial correlation coefficients in broiler and layer chickens with ad libitum access to feed?

3.3 Material and methods

3.3.1 Animals and housing

Eight male broilers (Ross) and 8 male layer chicks (White Leghorn) were obtained from a commercial hatchery (Morren B.V., Lunteren, The Netherlands) at 1-day-of-age. Birds were individually housed in sixteen floor pens (1.0 × 1.0 m/pen) covered with wood shavings. Pens were separated by solid partitions. All birds could eat and drink ad libitum. A conventional commercial broiler feed was provided to all birds. Each pen contained one feeder and two drinking nipples with a cup underneath. The feeder was designed in a way that feed was easily accessible and spillage was minimised. Artificial light (20 lux) was provided at a schedule of 18-h light and 6-h dark. No daylight entered the house. Temperature was maintained on 32 ± 1 °C at the beginning of the rearing period, and gradually decreased every 2 to 3 days by 1 °C, to reach eventually a constant temperature of 21 ± 1 °C. The experiment ended when the birds had reached an age of 8 weeks. The Wageningen University Committee on Animal Care and Use approved the experiment.

3.3.2 Behavioural observations

Birds were observed in two conditions each week, from 4 to 7 weeks of age. In the first condition birds were not feed deprived (control) and in the second condition birds were 24 h feed deprived (deprivation) before the observations. In the latter condition, observation started at the moment the feeder was placed back in the pen. Within a week, birds were observed in non-deprived condition first, to exclude influence of feed deprivation on these observations. Observations were conducted at individual level for about 3 h in both conditions. Four birds, two broilers and two layer chickens, were observed at the same time. Start and end of a meal was recorded. The start of a meal was defined as the moment a bird pecked at the feed. Meal definition was based upon pilot-observations in the third week of life. The end of a meal was defined as the moment when a bird had

not pecked at the feed for 10 s or more. It appeared from the pilot-observations that birds performed another behaviour when having stopped eating for 10 s or more. The inter-meal interval is called simply 'interval' in the rest of the paper.

3.3.3 Feed intake and weight gain

Immediately before and after each observation, each bird and feeder were weighed to measure feed intake and weight gain during observation.

3.3.4 Statistical analysis

All statistical analyses were performed using software from the SAS Institute Inc. (SAS® 1996). Data were analysed with the GLM procedure with the factors line, condition, and their interactions, and age in weeks as repeated measurement. Age effects were analysed using orthogonal polynomial contrasts. Preprandial and postprandial correlations were calculated with the Spearman partial rank-order correlation test at individual level over the 4 observed weeks, with age in weeks as partial factor. Fisher's method for combining probabilities was used to test combined significance (Sokal & Rohlf 1969). Correlation coefficients were transformed to the function Z (Sokal & Rohlf 1969). Z -values were normally distributed and were analysed with an analysis of variance.

3.4 Results

3.4.1 Eating behaviour

Time spent on eating by the broilers and the layer chickens in both conditions is shown in Figure 3.2. In the control (non-deprived) condition, only an interaction effect between line and age was found ($F_{3,42}=6.35$, $p<0.01$). At 4 weeks of age, broilers spent more time on eating than layer chickens ($p<0.05$) but this was reversed at 7 weeks of age ($p<0.05$). The broilers spent much more time on eating during observation than the layer chickens after 24 h feed deprivation ($F_{1,14}=21.09$, $p<0.001$), with a mean linear increase for age ($F_{1,14}=26.69$, $p<0.001$). In both conditions, the broilers consumed more feed per hour (control: 10.6 ± 0.6 versus 3.4 ± 0.3 ; $F_{1,14}=78.95$, $p<0.001$; deprivation: 24.9 ± 1.6 versus 6.5 ± 0.4 ; $F_{1,14}=112.62$, $p<0.001$) and gained more weight per hour (control: 7.3 ± 1.1 versus 1.1 ± 0.2 ; $F_{1,14}=26.05$, $p<0.001$; deprivation: 37.1 ± 1.9 versus 7.6 ± 0.9 ;

$F_{1,14}=114.47$, $p<0.001$) than the layer chickens. No age effect was found in the control condition and a first, second and third degree polynomial contrast for age was found for lines after 24 h of feed deprivation. After 24 h feed deprivation, birds of both lines consumed more feed per hour (broilers: $F_{1,14}=74.65$, $p<0.001$; layer chickens: $F_{1,14}=19.38$, $p<0.001$) and gained more weight per hour (broilers: $F_{1,14}=122.09$, $p<0.001$; layer chickens: $F_{1,14}=23.34$, $p<0.001$) than without feed deprivation. The layer chickens had more meals per hour (7.0 ± 0.4 respectively 7.7 ± 0.5) than the broilers (5.0 ± 0.6 respectively 5.7 ± 0.5) under control condition ($F_{1,14}=7.19$, $p<0.05$) and after 24 h feed deprivation ($F_{1,14}=4.79$, $p<0.05$) with no age or interaction effects.

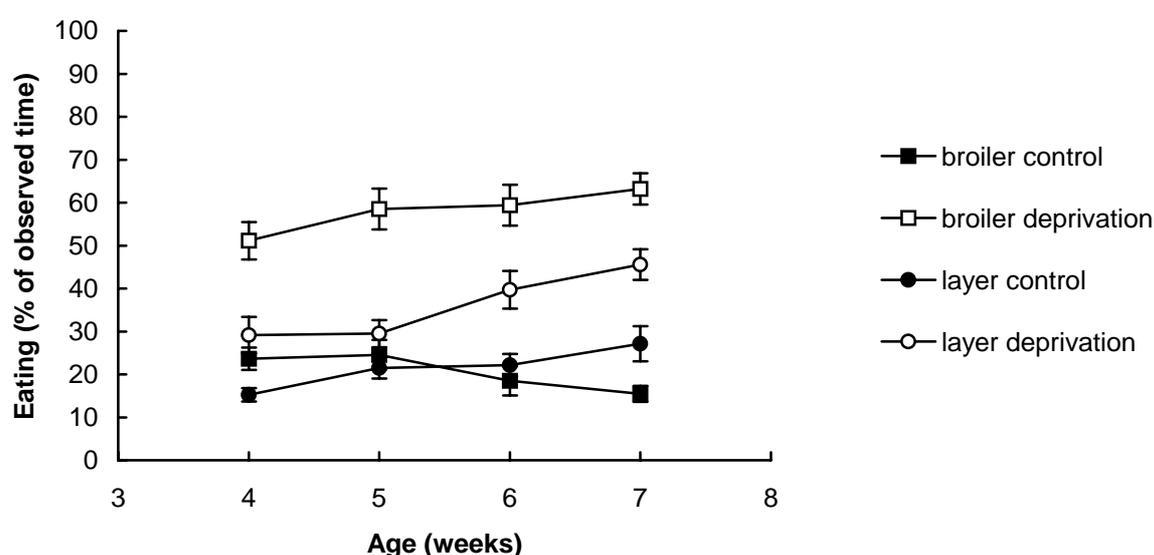


Figure 3.2: Percentage of time during observation spent on eating in broilers and layer chickens without feed deprivation (control) and after 24 h feed deprivation.

In the control condition, the broilers had longer meals ($F_{1,14}=4.88$, $p<0.05$) and intervals ($F_{1,14}=6.13$, $p<0.05$) than the layer chickens (Fig. 3.3). In both lines, no age or interaction effects were found for meal length or interval length. After 24 h feed deprivation took the first meal much more time than the successive meals (Fig. 3.4). The first meal of the broilers took on average 1684 ± 125 s and of the layers 862 ± 55 s ($F_{1,14}=20.16$, $p<0.001$) with no age effect within line. After the first meal, average meal length was 331 ± 32 s for the broilers and 143 ± 12 s for the layers. No line difference was found for interval lengths after 24 h feed deprivation (Fig. 3.4).

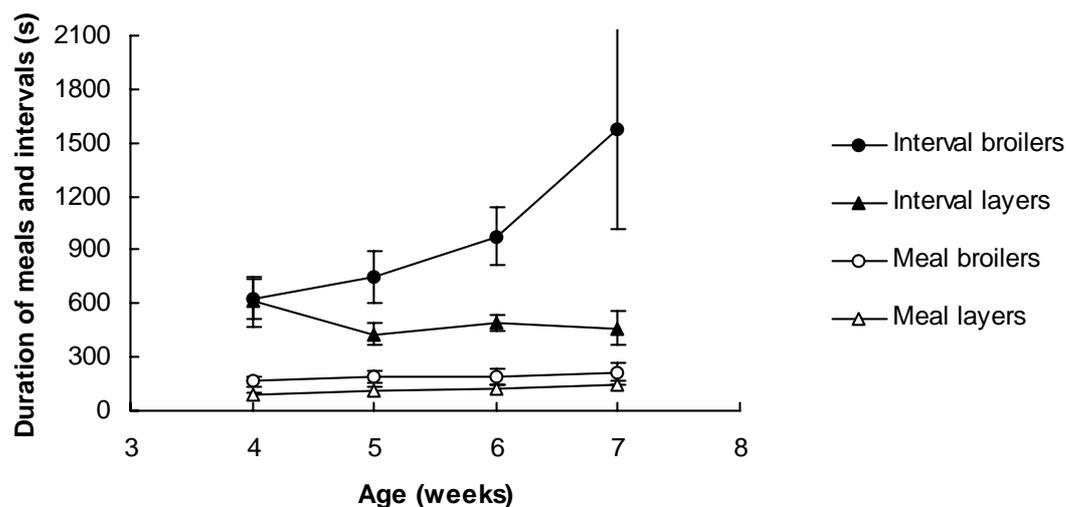


Figure 3.3: Duration (s) of meals and intervals between meals in broilers and layer chickens in the control condition.

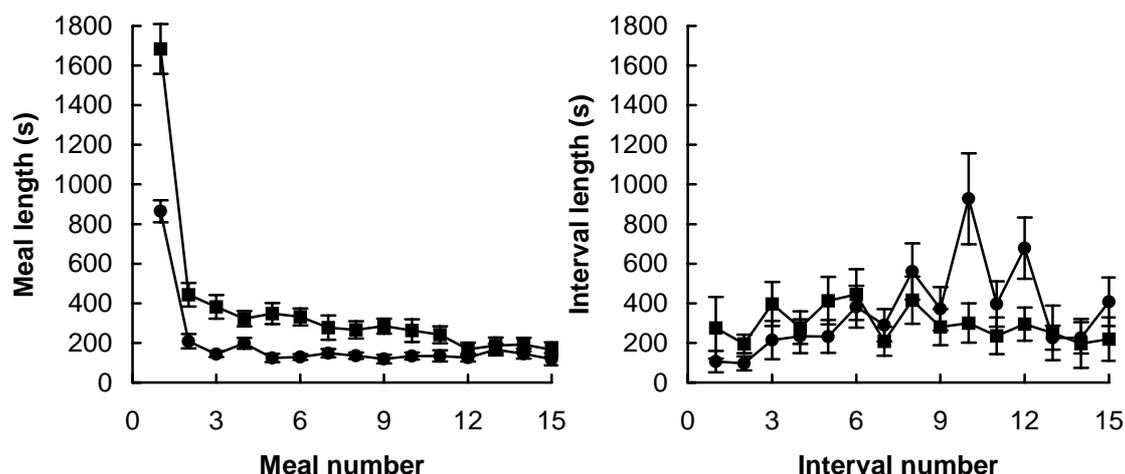


Figure 3.4: Duration (s) of the first 15 meals (left) and first 15 intervals (right) in broilers (■) and layer chickens (●) after 24-h feed deprivation over 4 weeks of observation.

3.4.2 Postprandial and preprandial correlations

Postprandial correlation coefficients of the eight broilers and the eight layer chickens are shown in Table 3.1. For the broilers, no significant postprandial correlations were found and also with the Fisher's test for combining probabilities no significant effect was found. Three layer chickens had a significant postprandial correlation coefficient and for one layer chicken, there tended to be a significant postprandial correlation. For the layer chickens, a significant postprandial correlation was found by combining the probabilities.

Table 3.1: Postprandial correlations coefficients (r_s) controlled for age of the individual broilers and layer chickens, with n as the number of meal interval combinations per bird. Within each line, combined significance was tested.

Broiler (No.)	r	n	P-value	Layer (No.)	r	n	P-value
1	-0.07	57	0.60	1	0.31	79	0.01
2	-0.11	19	0.68	2	0.46	54	0.01
3	0.14	29	0.47	3	0.19	45	0.22
4	-0.17	34	0.35	4	0.13	88	0.22
5	0.03	77	0.78	5	-0.01	51	0.92
6	-0.10	43	0.64	6	0.23	67	0.06
7	0.07	33	0.70	7	0.02	69	0.88
8	0.01	46	0.92	8	0.38	58	0.01
Chi-square			7.67	Chi-square			39.74
Comb. Probability			NS	Comb. Probability			0.001

Table 3.2: Preprandial correlations coefficients (r_s) controlled for age of the individual broilers and layer chickens, with n as the number of interval meal combinations per bird. Within each line, combined significance was tested.

Broiler (No.)	r	n	P-value	Layer (No.)	r	n	P-value
1	0.36	57	0.01	1	0.14	79	0.23
2	0.24	19	0.35	2	0.29	54	0.03
3	0.11	29	0.57	3	0.35	45	0.02
4	0.26	34	0.14	4	0.03	88	0.81
5	0.28	77	0.01	5	0.07	51	0.62
6	0.21	43	0.18	6	0.16	67	0.20
7	0.39	33	0.03	7	0.29	69	0.02
8	0.24	46	0.11	8	0.20	58	0.14
Chi-square			40.43	Chi-square			34.13
Comb. Probability			0.001	Comb. probability			0.01

Table 3.3: Differences between preprandial and postprandial correlation coefficients (r) transformed to Z-values between lines and within lines.

	Postprandial Z \pm SEM	Preprandial Z \pm SEM	P-value
Broilers (n=8)	-0.03 \pm 0.04	0.27 \pm 0.03	0.001
Layer chicks (n=8)	0.22 \pm 0.06	0.20 \pm 0.04	0.724
P-value	0.004	0.189	

In Table 3.2, the preprandial correlation coefficients of the 8 broilers and the 8 layer chickens are shown. Three significant preprandial

correlations and a significant correlation for the combined probabilities were found for both the broilers and the layer chickens.

When analysing the transformed individual correlations coefficients (Z-values) with an analysis of variance, it was found that the broilers had significant higher preprandial than postprandial correlations ($F_{1,14}=34.93$, $p<0.001$). No difference was found between the postprandial and preprandial correlations for the layer chickens. The layer chickens had higher postprandial correlations than the broilers ($F_{1,14}=11.57$, $p<0.005$), but no line difference was found for the preprandial correlations (Table 3.3).

3.5 Discussion

The aim of this research was to study behavioural characteristics of eating in broiler and layer chickens by measuring meal and interval lengths. Correlation coefficients between meals and intervals were calculated to gain more insight in hunger and satiety mechanisms of these birds.

Significant preprandial correlations but no significant postprandial correlations were found in broilers. This indicates that in broilers eating behaviour is more controlled by satiety mechanisms than by hunger mechanisms, which is an interesting result, because Savory (1981) suggested that satiety mechanisms were either absent or of little effect in fowl. In broilers there seemed to be no lower set point, but only an upper set point for controlling eating behaviour, which suggests that broilers eat to their maximal physical capacity, confirming the proposition of Barbato *et al.* (1984; 1994). Preprandial and postprandial correlations were about equal in the layer chickens. Therefore, eating behaviour in layer chickens is controlled equally by satiety and hunger mechanisms. The postprandial correlations of the broilers were remarkable low compared with those of the layer chickens and to other studies with birds (Clifton 1979), laying hens (Duncan *et al.* 1970; Savory & Hodgkiss 1984), and Japanese quail (Savory 1981).

The definition of meal and interval has received much of attention in literature. The problems around defining a meal and an interval between meals have been elucidated by Panksepp (1978). Most studies utilised automatic recording, instead of applying direct behavioural recordings and an arbitrary time criterion is used to define a meal. The method most used is to plot log survivorships of gaps between meals (Clifton 1979). It provides a way of separating short intervals with a high probability of ending from

longer intervals with a much lower probability of ending (Clifton 1979). Different meal criteria caused, however, no or minor changes in the preprandial and postprandial correlations (Becker & Grinker 1977; Savory 1981). We plotted log survivor curves of all birds but just a few showed the typical shape as shown by Clifton (1979). This confirms that meals and intervals cannot be defined solely in terms of mathematical criteria, but that the decision must also be based on reasonable behavioural and physiological grounds (Panksepp 1978). We conducted direct observations and observed that birds always performed another behaviour after 10 s of non-feed pecking. With this knowledge, we chose to take a 10-s criterion of not having pecked at the feed as interval between meals, which was actually the same criterion as Savory (1981) used.

Under non-deprived condition, broilers spent initially more, but at a later age less time on eating. They had fewer meals per hour, consumed more feed per hour, and had longer meal and interval lengths. Similar results were already found by Masic *et al.* (1974), although broilers by that time were not selected for growth as extensively as nowadays. Dunnington and Siegel (1996) mentioned, however, that a selected line for high body weight had an increased number of meals compared to a selected line for low body weight.

Broilers had a longer first meal than layers after 24 h feed deprivation. Broilers are bigger than layer chickens and have probably a larger crop. It is known that after feed deprivation domestic fowls eat large amounts to fill the crop (Savory & Hodgkiss 1984). Crop filling in turkeys did not influence the size of the first meal post-fast. Instead, satiation was related to inhibition of oesophageal peristalsis, which was caused by filling the stomach, duodenum and the proximal one-third of the ileum (Chaplin *et al.* 1992). Crop filling was associated with meal termination in only 30 to 40% of chickens whereas meal termination was associated with stomach filling in the remaining birds (Savory 1985). The crop may play an important role in feed intake of wild birds, but it probably has a limited role in domestic chickens allowed free access to feed (Denbow 1989). In our study, the broilers consumed more feed per hour and spent more time on eating than the layer chickens after 24 h feed deprivation. No differences were found for intervals between meals. It seemed that similar speed of feed transport from crop to gizzard takes place in broilers and layers.

Both broilers and layer chickens were provided with conventional broiler feed. We chose one diet to reduce the number of factors in the

experiment. The broilers were the main subjects of study, so, they were fed with their normal feed. It might be that layer chickens spent less time on eating because satiety was reached sooner, since broiler feed has higher energy and protein content than feed normally given to layer chickens.

In general we concluded from this study that the typical eating behaviour of broilers and the calculated postprandial and preprandial correlations have given new indications that hunger and satiety mechanisms in broilers have changed compared with layer chickens. In contrast to the layer chickens, which had both a lower and an upper set point, the broilers had no lower set point, but only an upper set point for controlling eating behaviour, which suggests that broilers eat to their maximal physical capacity.

3.6 Acknowledgements

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Sex and type of feed effects on motivation and ability to walk for a food reward in fast-growing broilers



4.1 Abstract

Housing conditions, body weight, leg problems and pain influence behaviour of broilers. Apart from the physical ability, little is known about the motivation to perform behaviour. The distinction between motivation and ability is relevant as a lack of motivation has consequences for the interpretation of the observed immobility in terms of welfare. A runway experiment with fast-growing broilers was conducted to investigate the influence of sex and type of feed on motivation and ability to walk for a food reward (mealworm) without depriving the birds from feed before testing. Twenty-four males and 24 females fed with two types of feed, conventional or free-range (less energy and protein) feed, were individually tested in a 2 m long runway from 4 to 7 weeks of age. Five bowls were placed in the runway, one at every 40 cm. Three sessions were applied within one week 1) control session: each bowl contained one mealworm, 2) frustration session: the first four bowls were empty, the last bowl contained five mealworms, and 3) obstacle session: each bowl contained one mealworm and 10 cm high obstacles were placed between the bowls. Weekly, body weight and feed consumption were measured and gait score was assessed of each individual. Over all weeks, birds walked faster in frustration sessions than in control or obstacle sessions and faster in control than in obstacle sessions. Birds sat more in obstacle than in control sessions, indicating that ability to walk was affected by the difficulty of the task. Males walked faster in control and obstacle sessions than females, despite the higher body weight. The number of vocalisations in the runway decreased over time and males vocalised more than females. In both sexes, free-range fed birds vocalised more than conventionally fed birds. Differences between sessions were calculated at individual level, called the motivation and the ability effect. Concluded is that sex and type of feed have effects on different measures in the runway. Male broilers walked faster to a food reward and vocalised more than females. The role of type of feed was ambiguous. It did not influence body weight, walking speed or gait score, but conventionally fed birds sat more and had a higher latency to leave the start box and to reach the last bowl, and free-range fed birds vocalised more. No sex or feed differences were found for the motivation and the ability effect. That means that frustration and obstacles had similar impact on both sexes and both types of feed and that sex differences in walking speed probably were a result of physical differences (males are stronger and bigger).

4.2 Introduction

Broilers have been selected highly for fast growth and improved feed conversion (Appleby et al. 1992; Julian 1998). The fast growth of broilers has been associated with high incidence of musculo-skeletal and cardiovascular diseases (Julian 1998). Furthermore, broilers have a low activity level, especially after 3 weeks of age (Reiter and Bessei, 1998).

Weeks et al. (1994) found that broilers fed with free-range feed (lower energy and higher fibre content than conventional feed) tended to lie down less than broilers fed with conventional commercial feed. They also described that broilers kept on free-range feed under free-range conditions (0.42 bird/m²) were initially more active than broilers kept under intensive conditions fed with conventional feed (8 birds/m²), but from 6 weeks of age activity decreased to similar levels in all groups. It is suggested that selection for feed conversion has reduced the need or desire for energy consuming behaviours such as running or long walks (Bizeray et al. 2000), just as the aggressive behaviour in broilers has been affected by selection on high growth rate (Mench 1988). Bizeray et al. (2000) also suggested that locomotor activity may have lost part of its adaptive value for broilers in the present housing systems where food and water are available within easy reach. However, locomotor activity has not disappeared completely. Daily training on a treadmill delayed the decline in activity in fast growing broilers up to 6 weeks of age (Reiter & Bessei 1995). Besides the influence of exercise on activity, it has been shown to improve leg strength and bone density and to decrease the incidence of leg deformations in broilers (Haye & Simons 1978; Reiter & Bessei 1998). Therefore, it may prevent the birds from lameness. Lameness is common among fast growing broilers (Webster 1994) and it has been found to modify behaviour (Vestergaard & Sanotra 1999; Weeks et al. 2000). In commercial reared broilers 26% (Kestin et al. 1992) to 31% (Sanotra et al. 2001) suffered leg abnormality of sufficient severity for their welfare to be considered compromised (Kestin et al. 1992). The risk of occurrence of leg problems were influenced by body weight and sex (Sanotra et al. 2001). Lameness affected birds ate more feed containing carprofen, an analgesic drug, than sound birds, and sound birds selected undrugged feed in preference to drugged feed (Danbury et al. 2000). Carprofen also improved walking speed of lame birds (Mc Geown et al. 1999), indicating that these birds had suffered pain.

Housing conditions, high body weight, leg problems and pain influence behaviour of broilers. Apart from the physical ability, little is known about the motivation to perform behaviour. The distinction between motivation and ability is relevant as a lack of motivation has consequences, e.g. for the interpretation of the observed immobility in terms of compromised welfare.

One method to study the strength of motivation is by deprivation and frustration (Fraser & Matthews 1997). Amsel (1992) defined frustration as "an aversive state that results from non-reward, reduced reward or delayed reward in the presence of a history of reward". Amsel and Roussel (1952) used a runway to measure reaction to frustration in rats. Frustrated rats walked faster through the runway than non-frustrated rats. Comparable results have been found in laying hens (Amsel & Roussel 1952; Vallortigara et al. 1990; Koene & Urff 1995). Vallortigara et al. (1990) studied runway performance in layer chicks and used cagemates and food as reinforcers. A runway may be a valuable instrument to gain more insight into motivation in relation to physical ability, especially in broilers, since the birds have to perform a physical effort (walking) to obtain a reward. Birds that cannot reach the reward may perform frustration related behaviour such as displacement preening (Duncan & Wood-Gush 1972) and vocalisations (Zimmerman & Koene 1998; Zimmerman et al. 2000).

Since males grow faster and thus have a higher body weight than females, sex differences in motivation and ability to perform behaviour may occur. The purpose of the present study was to investigate the influence of sex and body weight on motivation and ability to walk for a food reward in broilers without depriving them from feed before testing. The hypothesis was that males would be more motivated (faster growth) but less able (higher body weight) to walk a distance to a food reward than females. Two types of feed were provided with the purpose to create body weight differences within sex. Birds were tested in a 2 m long runway. Five bowls were placed in the runway, at every 40 cm one. Three runway sessions were applied within one week. 1) Control session: each bowl contained one mealworm. 2) Frustration session: the first four bowls were empty; the last bowl contained five mealworms. Frustration increases motivation, which should result in a higher, walking speed. 3) Obstacle session: each bowl contained one mealworm and between the bowls obstacles were placed. Birds were challenged to put extra effort for obtaining the reward. Birds with lower physical capacity would have less ability to obtain the reward. Since lung volume as a percentage of body weight of broilers dropped faster than those

of a laying strain when growing older (Julian 1989) and broilers have a typical stature of heavy breast mass (Julian 1998) such an extra effort may result in a lower latency to sit down or to more sitting behaviour in the runway.

4.3 Materials and Methods

4.3.1 *Animals and housing*

Forty-eight male and 48 female 1-day-old Ross broiler chicks were obtained from a commercial hatchery. They were allocated to twelve floor pens (80 cm × 125 cm per pen) covered with wood shavings. In each pen, there were four males and four females. Pens were separated by solid partitions. The experiment started at arrival of the birds and ended after 7 weeks. All birds could eat and drink ad libitum. Two types of two-phase broiler feed (meal) were provided to influence body weight without depriving the birds from feed. During the first 2 weeks of life starter feed was provided and thereafter finisher feed. In half of the pens the birds received conventional feed; in the other half free-range feed (less energy and protein, and a little higher fibre content; Table 4.1). Both types of feed were produced by TNO Nutrition (ILOB-department, Wageningen, The Netherlands) and contained no substances of animal origin. Each pen contained one feeding bin of 80-cm wide, four drinking nipples with a cup underneath and two wooden perches. The slats used for the perches measured 5 cm × 5 cm × 80 cm (wide × height × length; 20 cm/bird) and had rounded angles. Structural foots (5 cm high) supported them, which made perches 10 cm high. Artificial light (18 lux) was provided initially at a schedule of 23-h light and 1-h dark. After 3 days, a schedule of 18-h light and 6-h dark was provided. No daylight entered the house. Temperature was maintained on 32 ± 1 °C at the beginning of the rearing period, and gradually decreased every 2-3 days with 1 °C eventually to a constant temperature of 21 ± 1 °C. The Wageningen University Committee on Animal Care and Use approved the experiment.

Table 4.1: *Feed analysis*

Feed	Crude protein (%)	Metabolizable energy (MJ/kg)	Fibre (%)
Free-range starter	19.48	12.02	2.97
Free-range finisher	17.51	12.37	3.14
Conventional starter	22.98	12.68	2.81
Conventional finisher	20.52	13.46	2.78

4.3.2 Runway test

The apparatus was situated in a separate room with a similar ambient temperature to that of the home environment. It consisted of a black painted wooden start box (40 cm × 40 cm) and runway (240 cm × 40 cm × 60 cm, length × width × height). A solid guillotine door separated start box from runway. Five small, red, plastic bowls were placed in the runway every 40 cm. In the homepen, the birds learned to eat mealworms out of the same bowls. At 3 weeks of age, two males and two females of each pen were trained individually during 3 days to walk for a reward in the runway (in each bowl one mealworm). After this week of training, these 48 birds were tested individually in the runway in a pseudo-randomised order three times a week. Details of the procedure on an individual trial are as follows (a) bird is put in the start box; (b) after 5 s the door is raised; (c) the bird is allowed 3 min to eat the rewards out of each bowl and to reach the last bowl at a distance of 200 cm from the start box; (d) when the bird has eaten the reward from the last bowl it is taken out of the runway; (e) when a bird has not reached the last bowl in 3 min, it is gently forced by the observer by holding a hand behind the bird and if necessary push it slightly to walk to the last bowl to eat the reward after all. Only one trial per bird per day was performed. All sessions were carried out between 13:15 and 17:00 h.

Birds were not deprived from feed before testing. Three sessions were applied within 1 week: control, frustration and obstacle session. 1) Control session: one mealworm was put in each bowl. 2) Frustration session: no mealworms were put in the first four bowls; the last bowl contained five mealworms. 3) Obstacle session: each bowl contained one mealworm again, but now four wooden, black painted obstacles were placed between the bowls. The obstacles were 10 cm high and 5 cm from front to back. They were sufficiently wide that birds had to cross the obstacles to reach the next bowl. Between sessions, no extinction took place as the number of rewards was maintained equally in each trial and each bird always obtained the rewards in each trial.

A camera and a microphone connected to a video-recorder were placed above the runway. All trials were recorded on video and analysed with Ethovision®, an automatic visual tracking system (Noldus 1997). The observer was out of sight during the trial. Around the first four bowls, zones (1 to 4) were defined as the space between two virtual lines that were drawn runway wide 15 cm before and 15 cm behind the center of each bowl.

Latency to leave the start box, latency to reach the last bowl, walking speed (total distance moved divided by duration of the trial), walking speed in each zone (total distance moved in a zone divided by time spent in that zone), sitting and preening behaviour and number of vocalisations (distress calls and other calls, Kaufman & Hinde 1961) were measured during the runway tests.

4.3.3 Gait score, weight and feed consumption

At the age of 5, 6 and 7 weeks walking ability of each bird was assessed using the gait score (Kestin et al. 1992). The gait score has a six point scale from zero to five, where 0 = no detectable walking abnormalities, and 5 = incapable of sustained walking on its feet. Every week at the same day, each bird was weighed individually. Feed consumption per pen per week was calculated on the basis of weights of the feeding bins with content, which were weighed weekly, and the amount of feed provided every week.

4.3.4 Statistical analysis

All analyses were performed using statistical software from the SAS Institute Inc. (SAS® 1996). Latency to reach the last bowl appeared to be censored (birds that left the start box but did not reach the last bowl in 3 min) and was analysed with a survival analysis (Life-test procedure). Session, sex and type of feed effects on latency to reach the last bowl were tested with the log-rank test (χ^2). Walking speed was analysed with an analysis of variance with the factors session, week, and sex and feed nested in pen number. When there were significant main effects or interactions, a post hoc test (LSMeans with Bonferoni correction) was used to discover which effects were present. Sitting behaviour and gait score were analysed with the Kruskal-Wallis test and post hoc with the Wilcoxon two-sample test. Birds that did not leave the start box were excluded from the analysis of walking speed, walking speed in each zone, sitting and preening. Latency to leave the start box and vocalisations were analysed including the birds that did not leave the start box. The number of vocalisations was divided by the time a bird spent in start box and runway. To reach normality, a square root transformation was used for the number of vocalisations and a log transformation was used for the latency to leave the start box. Both vocalisations and latency to leave the start box were analysed with an analysis of variance for effects of sex and type of feed with session and week as repeated measurements. To study these effects over time orthogonal

polynomial contrasts were used. Weight data were analysed with an analysis of variance (GLM-procedure) to examine the effects of sex, type of feed and age. Presented results concern only birds that were trained and tested in the runway.

4.4 Results

Four birds did not eat mealworms and were excluded from the runway experiment. Two birds died in the last week of the experiment. Preening behaviour occurred too little to analyse.

In Table 4.2, latencies to reach the last bowl per sex, per type of feed and per session are shown. For latency to reach the last bowl a sex effect was found in each session and a type of feed effect was found for control and frustration sessions. Differences between sessions were found in free-range fed males and females.

Table 4.2: Latency to reach the last bowl (s) per sex and per feed over all weeks (conventional feed = C, and free-range feed = F).

Session	Control	Frustration	Obstacles	Session effect
Male (C)	58.5 ± 9.1	68.9 ± 11.0	63.7 ± 9.3	NS
Male (F)	47.1 ± 8.5	50.6 ± 9.3	72.4 ± 10.2	$\chi^2 = 6.43, P < 0.05$
Female (C)	103.7 ± 11.4	113.3 ± 12.4	129.8 ± 10.4	NS
Female (F)	67.4 ± 9.5	57.1 ± 8.8	98.8 ± 10.3	$\chi^2 = 13.00, P < 0.005$
Sex effect	$\chi^2 = 13.44, P < 0.001$	$\chi^2 = 5.78, P < 0.05$	$\chi^2 = 21.03, P < 0.001$	
Feed effect	$\chi^2 = 6.24, P < 0.05$	$\chi^2 = 4.61, P < 0.05$	NS	

Figure 4.1 displays walking speed per session per week. Analysed over all weeks a session effect was found ($F_{2,453}=37.62, p < 0.001$). Birds walked faster in frustration sessions than in control ($p < 0.001$) and obstacle sessions ($p < 0.001$) and walked faster in control than in obstacle sessions ($p < 0.001$). More specific, birds walked faster in frustration sessions than in control sessions at the age of 5 ($p < 0.001$) and 6 ($p < 0.05$) weeks and than in obstacle sessions at the age of 4 ($p < 0.001$), 5 ($p < 0.001$), 6 ($p < 0.001$) and 7 ($p < 0.01$) weeks. Over all weeks, males walked faster to the last bowl than females in control ($F_{1,140}=5.18, p < 0.05$) and obstacle sessions ($F_{1,136}=17.78, p < 0.001$) (Fig. 4.2). In frustration sessions, the same tendency was found ($p = 0.1$). In none of the sessions, a type of feed or interaction effect on walking speed was found.

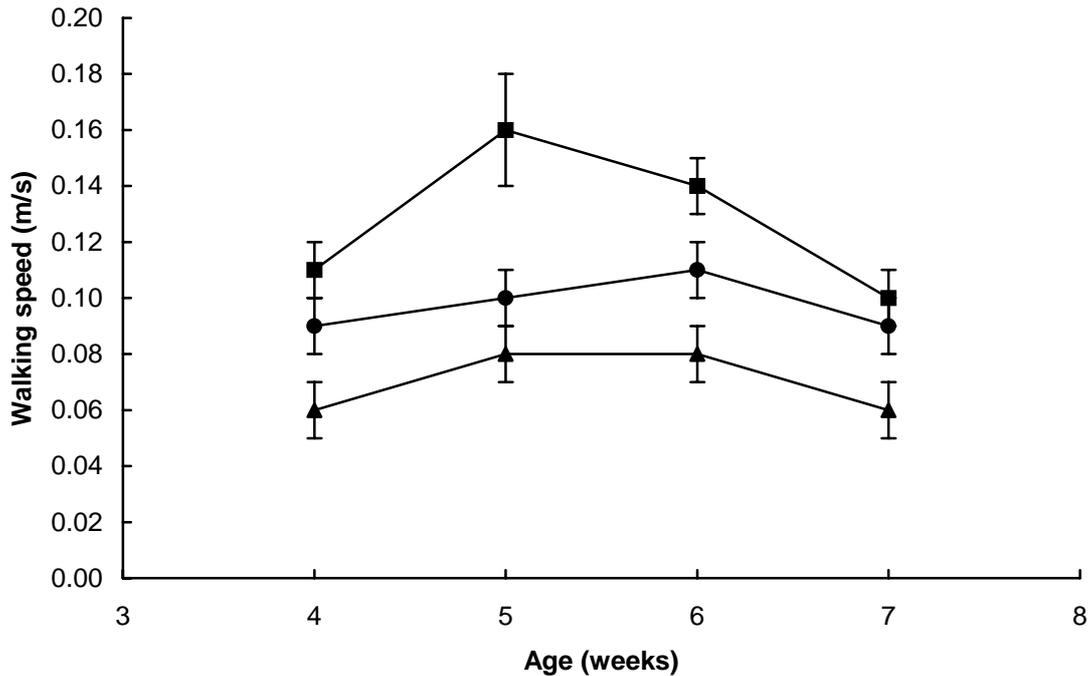


Figure 4.1: Walking speed (m/s) in control (●), frustration (■), and obstacle (▲) sessions.

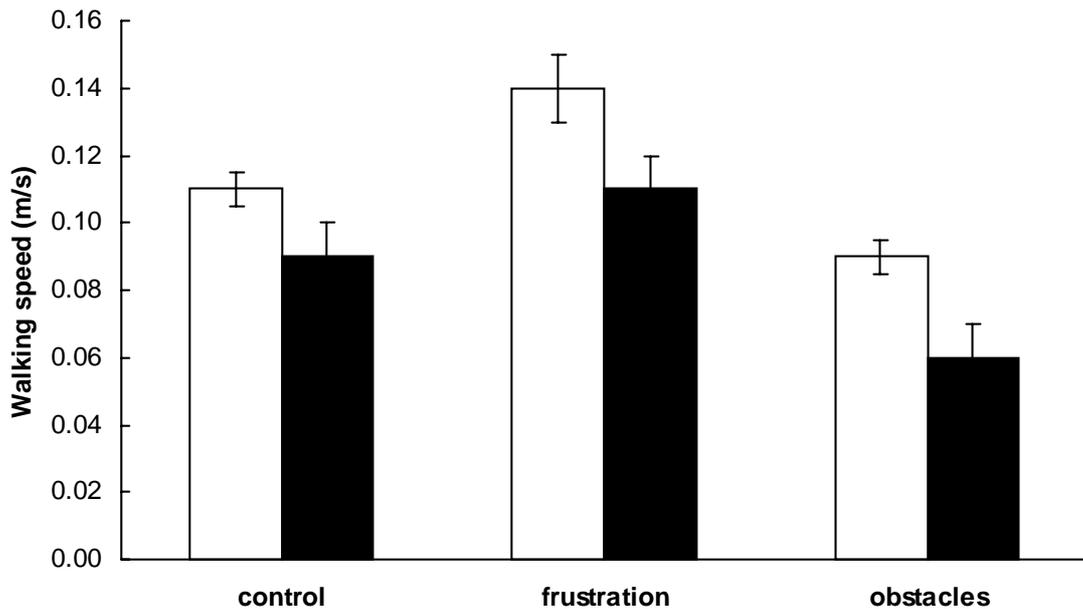


Figure 4.2: Walking speed (m/s) of males (white bars) and females (black bars) per session over weeks.

In Figure 4.3 walking speed in each zone over weeks is shown. A session effect was found in each zone ($F_{2,462}$, $p < 0.001$). In zone 1, walking speed was lower in obstacle sessions than in control and frustration sessions ($p < 0.001$). Walking speed differed between all three sessions in zone 2 ($p < 0.001$). In zones 3 and 4, walking speed was higher in frustration

sessions than in control and obstacle sessions ($p < 0.001$). In zones 2 and 3 a sex effect was found ($F_{1,462} = 4.42$, $p < 0.05$; $F_{1,462} = 5.84$, $p < 0.05$). Males walked faster than females. The same tendency was found in zones 1 and 4 ($p < 0.7$). No type of feed effect was detected. A zone effect was found in control and obstacle sessions ($F_{3,629} = 26.68$, $p < 0.001$, respectively $F_{3,613} = 4.21$, $p < 0.01$). Walking speed was higher in zone 1 than the other zones ($p < 0.001$) and was higher in zone 2 than in zone 4 ($p < 0.001$) in control sessions. In obstacle sessions, walking speed was higher in zone 1 than in the other zones ($p < 0.05$).

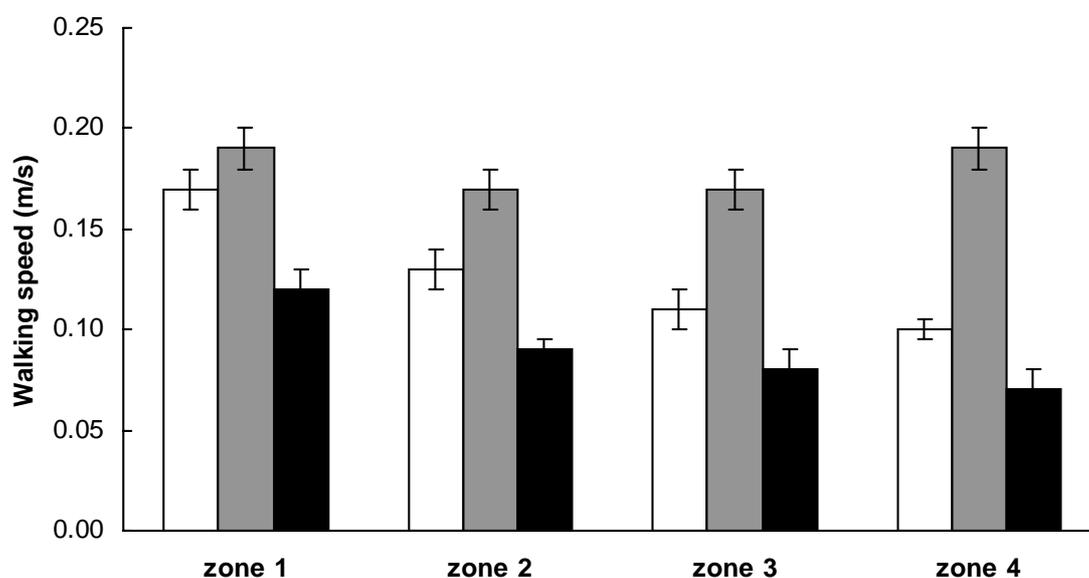


Figure 4.3: Walking speed (m/s) in control (white bars), frustration (grey bars) and obstacle (black bars) sessions per zone over weeks.

For latency to leave the start box conventionally fed birds had a higher latency to leave the start box than free range fed birds ($F_{1,36} = 4.53$, $p < 0.05$) (Fig. 4.4). Females tended to leave the start box slower than males ($p < 0.1$). No interaction between sex and type of feed was found. A mean linear increase of latency to leave the start box was found ($F_{1,36} = 16.50$, $p < 0.001$) over weeks. Over all weeks, birds had a higher latency to leave the start box in control sessions than in frustration and obstacle session ($F_{1,36} = 6.87$, $p < 0.05$, respectively $F_{1,36} = 41.41$, $p < 0.001$).

Over all weeks, birds sat more in the obstacle sessions (10.7 ± 2.3 s) than in the control sessions (4.0 ± 1.3 s) ($Z = -2.40$, $p < 0.05$). Sitting in the obstacle sessions included, besides sitting on the floor of the runway, sitting on an obstacle. Effects of sex and type of feed on duration of sitting

behaviour in the runway are reported in Table 4.3. Overall, a type of feed effect was found at the age of 6 and 7 weeks ($Z=2.63$, $p<0.01$ respectively $Z=2.87$, $p<0.005$), but no sex effect was found. Latency to sit in the runway differed per session ($\chi^2=6.54$, $df=2$, $p<0.05$). Birds had a higher latency to sit in the obstacle (15.3 ± 2.9 s) than in the control session (8.0 ± 2.4 s) ($Z=-2.45$, $p<0.05$). In frustration sessions birds sat down in 9.1 ± 2.5 s.

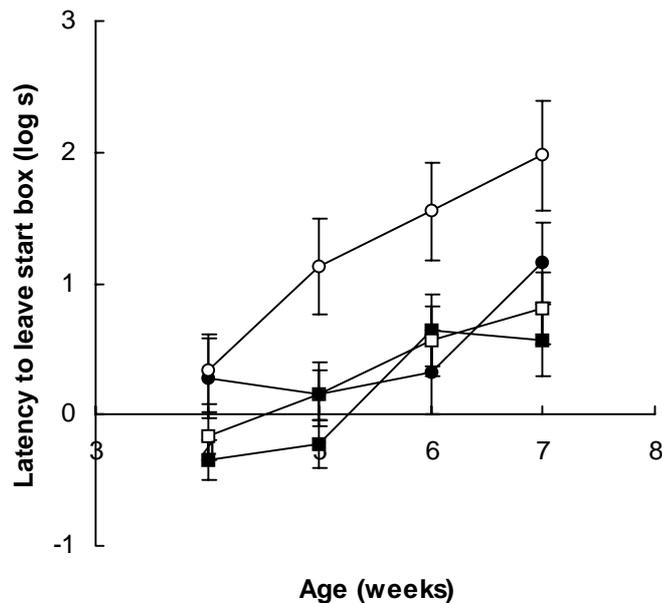


Figure 4.4: Latency to leave start box (log s) for males on conventional (□) and free range (■) feed, and for females on conventional (○) and free range (●) feed.

Figure 4.5 shows the total number of vocalisations in the runway. Males vocalised more than females ($F_{1,35}=7.81$, $p<0.01$). Free-range fed birds vocalised more than those fed with conventional feed ($F_{1,35}=6.43$, $p<0.05$). A mean linear decrease of vocalisations over time was found ($F_{1,35}=108.91$, $p<0.001$). Birds vocalised more in control than in obstacle sessions ($F_{1,35}=8.49$, $p<0.01$). At the age of 4, 5, 6 and 7 weeks, the proportion distress calls related to the total number of calls was 40.2, 25.5, 22.2 and 22.9% respectively. Only at the age of 5 weeks females produced more distress calls (34.3 vs. 17.5%) than males ($Z=2.79$, $p<0.01$). Free-range fed birds showed a higher proportion distress calls than conventionally fed birds (51.2 vs. 28.8%) at the age of 4 weeks ($Z=-3.21$, $p<0.01$). No session effects for proportion distress calls were found.

Over the whole experiment, feed intake did not differ between groups (39.33 ± 0.65 kg free-range feed vs. 38.43 ± 0.56 kg conventional feed).

Thus, energy intake differed: 484.84 ± 8.07 MJ for free-range fed birds versus 513.61 ± 7.49 MJ for conventionally fed birds ($F_{1,10}=6.83$, $p<0.05$), but no effect for type of feed on body weight was found. Males were heavier than females from 3 weeks of age (Table 4.4).

Table 4.3: *Sitting behaviour (s) per sex and feed (Means \pm SEM) in the runway (conventional feed: C, and free-range feed: F). Between brackets the percentage birds that sat for a certain period during a trial. Superscripts represent significant post hoc differences between groups (Wilcoxon two-sample test).*

Sex (feed)	Age			
	4 weeks	5 weeks	6 weeks	7 weeks
Male (C)	0.3 ± 0.3^b (3.0)	0.8 ± 0.7 (6.1)	8.6 ± 5.2^{ac} (12.5)	31.5 ± 9.1^a (31.3)
Male (F)	0.3 ± 0.2^{ab} (6.1)	0.0 ± 0.0 (0.0)	5.4 ± 3.5^{bc} (9.4)	12.0 ± 5.3^{ab} (18.8)
Female (C)	7.7 ± 3.4^a (18.8)	6.7 ± 4.9 (11.5)	22.7 ± 8.3^a (30.8)	33.4 ± 10.6^a (38.1)
Female (F)	0.0 ± 0.0^b (0.0)	0.1 ± 0.1 (3.0)	0.0 ± 0.0^b (0.0)	2.6 ± 1.7^b (9.4)
Kruskal-Wallis	$\chi^2 = 10.84$, $P<0.05$	$\chi^2 = 4.78$, $P>0.1$	$\chi^2 = 12.63$, $P<0.01$	$\chi^2 = 9.33$, $P<0.05$

Table 4.4: *Weight (g) per sex and per feed (means \pm SEM) (conventional feed: C, and free-range feed: F).*

Sex (feed)	Age			
	28 days	35 days	42 days	49 days
Male (C)	1213.9 ± 40.4	1801.7 ± 62.8	2429.0 ± 79.7	3001.6 ± 96.6
Male (F)	1148.7 ± 39.7	1686.6 ± 50.2	2245.3 ± 66.9	2797.5 ± 86.9
Female (C)	1036.0 ± 37.3	1509.1 ± 47.6	1984.3 ± 61.0	2384.9 ± 74.5
Female (F)	1032.9 ± 27.2	1462.6 ± 40.9	1941.6 ± 56.0	2353.0 ± 73.9
Sex effect	$F_{1,40}=16.14$, $p<0.001$	$F_{1,40}=25.65$, $p<0.001$	$F_{1,40}=31.65$, $p<0.001$	$F_{1,38}=39.92$, $p<0.001$
Feed effect	NS	NS	NS	NS
Sex * Feed	NS	NS	NS	NS

No type of feed or sex effect was found for gait scores. In general, gait scores were low. At the age of 7 weeks 41 birds (93%) had a score below two. Two birds had a gait score of 2 and one bird a gait score of 4. No significant correlations were found between walking speed, body weight and gait score.

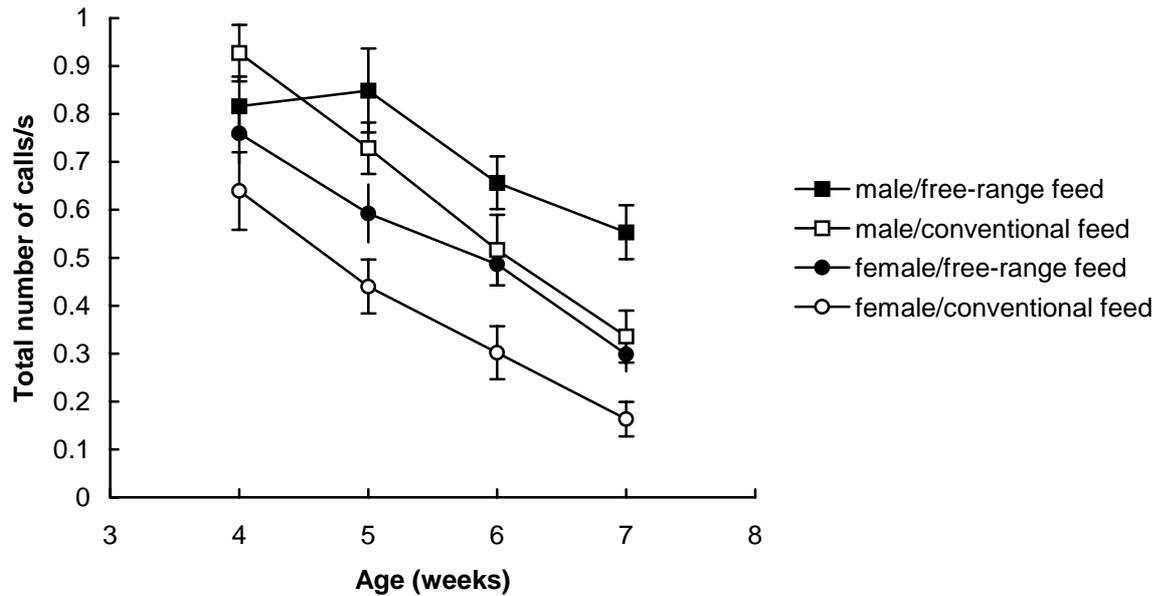


Figure 4.5: Total number of vocalisations (number/s) for males on conventional (□) and free range (■) feed, and for females on conventional (○) and free range (●) feed.

To gain more insight in the effect of frustration and obstacles, differences in walking speed between control sessions and frustration and obstacle session were calculated at individual level within one week. This difference can be expressed as a percentage of walking speed in control sessions. The difference between frustration and control can be called the “motivation” effect and the difference between obstacle and control can be called the “ability” effect. To exclude learning effects the mean of walking speed in zone 3 and 4 per trial was used. Theoretically, 48 motivation and 48 ability effects could be calculated each week. Motivation and ability effects were analysed over weeks for sex and type of feed effects (Fig. 4.6). Sex or type of feed effects were found neither for the motivation nor for the ability effect. An interaction between sex and type of feed was found for the motivation effect ($F_{1,124}=5.65$, $p<0.05$). The motivation effect was lower for conventional fed females than for free-range fed females and conventional fed males ($p<0.01$). For both motivation and ability effect a significant age effect was found ($F_{3,124}=3.71$, $p<0.05$ and $F_{3,124}=3.21$, $p<0.05$). The motivation effect was respectively 158%, 242%, 193% and 164% at 4, 5, 6 and 7 weeks of age, where the motivation effect was significant higher at the age of 5 weeks than at 4 and 7 weeks of age. The ability effect was 55% during first confrontation at 4 weeks of age, thereafter 101%, 86% and 85%

at 5, 6 and 7 weeks of age. The ability effect differed significantly between 4 and 5 weeks of age ($p < 0.05$).

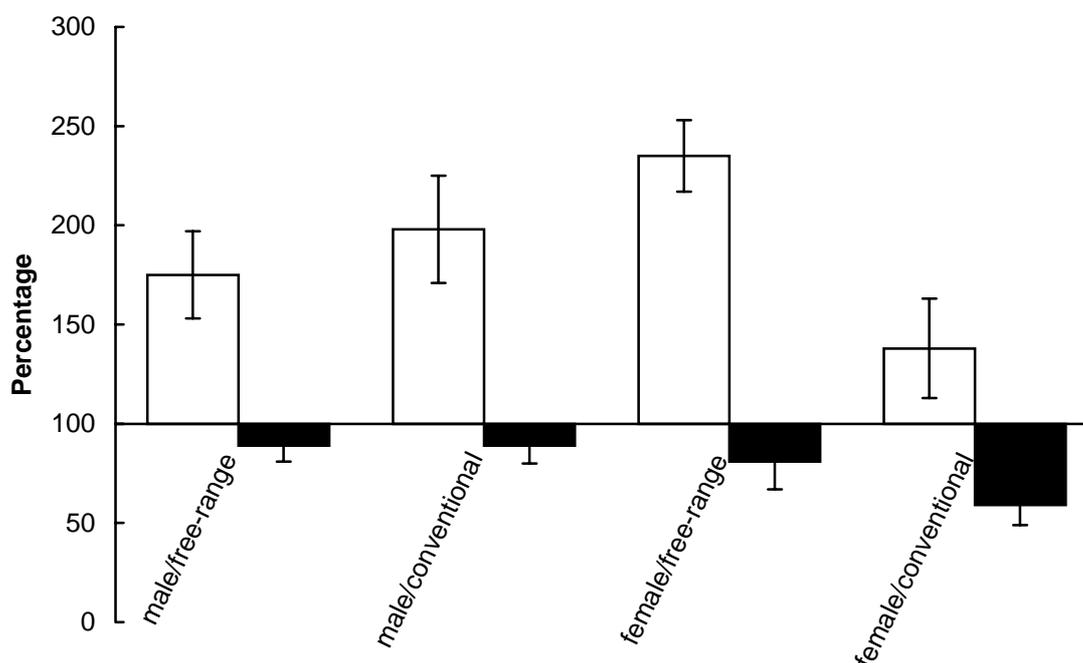


Figure 4.6: “Motivation” effect (white bar) = $100 + ((\text{walking speed in frustration session} - \text{walking speed in control session}) / \text{walking speed in control session}) * 100$ and “Ability” effect (black bar) = $100 + ((\text{walking speed in obstacle session} - \text{walking speed in control session}) / \text{walking speed in control session}) * 100$ calculated at individual level for both sexes and types of feed over weeks.

4.5 Discussion

This experiment aimed to assess the influence of sex and type of feed on motivation and ability to walk for a food reward in broilers. Birds walked faster in frustration sessions than in control and obstacle sessions. Although the birds were not feed deprived, frustration due to delayed reward - they had to walk to the end of the runway to obtain the reward - increased motivation; similar to the effect of frustration on walking speed in rats (Amsel & Roussel 1952) and laying hens (Koene & Urff 1995). In frustration sessions, birds walked with a similar speed as in control sessions through the first zone, but thereafter they walked slower through the zones in control sessions, but not in frustration sessions. In obstacle sessions birds walked only faster in zone 1 than in the other zones.

In contrast with walking speed, a type of feed effect was found for latency to reach the last bowl. Birds that did not leave the start box were excluded from walking speed analysis, which caused this difference. Most of

them were females fed with conventional feed since this group had the highest latency to reach the last bowl and to leave the start box. Male broilers had a lower latency to reach the last bowl than females. They also walked faster through the runway than females in control and obstacle sessions, despite their higher body weight. These results support the findings that male layer chicks walked faster than female layer chicks for a food reward (non-social reinforcer), whereas females walked faster for a conspecific (social reinforcer) (Vallortigara et al. 1990). Reiter and Bessei (1998) showed that male broilers could walk rather long distances, especially when they were trained. It may be expected that females walk even further in these kinds of experiments, because of better physical capacities due to lower body weight. No sex and type of feed differences were found for the motivation and the ability effect in our experiment, which indicates that frustration and obstacles had similar impact on both sexes and both types of feed. The fact that males walked faster than females is therefore probably just a physical effect (stronger and bigger). This was also reflected by latency to leave the start box: females tended to start slower than males. Latency to leave the start box was a little higher than Jones et al. (1999) found, but they used younger chicks and a social reinforcer, which could be seen through the door of the start box. It is not clear, why birds had a higher latency to leave the start box in control sessions than in both other sessions in our experiment, since motivation and ability can be assumed to be constant. The same latency to leave the start box for control and frustration sessions was expected. No distinction could be made from the point of view of birds in the start box between these sessions. In obstacle sessions, however, birds saw a different situation when the door of the start box was opened, but this did not result in higher latencies to leave the start box. The extra effort birds had to put into obstacle sessions to obtain the rewards resulted in more sitting behaviour than in control sessions. It seemed that some birds needed to rest during the trial and some birds actually stopped walking in front of an obstacle and sat down. The ability to keep walking seemed to be a limiting factor for these birds. Disadvantage of the obstacle design was that birds could sit on them. This design was chosen to prevent that birds had to jump in one go over the obstacle which could be too difficult for heavy broilers.

Birds did not vocalise more in frustration sessions than in both other sessions, although this was expected based on results of Koene and Urff (1995) who found more vocalisations when duration of frustration increased.

Both the fact that the birds were not food deprived and the lack of audience may be the reason for this difference. Investigations on sex differences in vocalisations are not consistent. We found that males vocalised more than females. Twelve-day-old male layer chicks vocalised also more than females during the first minute in a strange environment (Andrew 1975). Jones and Williams (1992) did not find sex differences in a social separation test. This in contradiction with the findings of Jones and Faure (1982) claiming that socially reared female layer chicks generally vocalised more than males when placed individually in a novel environment, which is interpreted as less fearful. In general, it is supposed that male chickens are more fearful than females (Jones & Faure 1982; Marin & Jones 1999). In our experiment, the birds were also separated from their group when they were in the runway. However, they were placed several times in the runway, even before the actual test weeks started. Therefore, the birds had time to habituate to the test environment and to the social isolation. This was confirmed by the proportion distress calls that was rather consistent in week five, six and seven. Nevertheless, the total number of vocalisations decreased over time, but sex differences were consistent.

Two types of feed were given with the intention to influence body weight of the birds without depriving them. Feed consumption of both types of feed was equal. This confirmed 1) the suggestion of Burkhart et al. (1983) that selection for increased body weight affected the hypothalamic satiety mechanisms leading to a failure to diminish the hunger drive and consequently to hyperphagia or overconsumption, and 2) the statement of Barbato (1994) that fast growing broilers consume a volume of feed approaching the full capacity of their gastro-intestinal tract. Energy and protein intake differed but this had no effect on body weight, in contradiction with the findings of Lewis et al. (1990). It seems that broilers were using free-range feed more efficiently than conventional feed, or that they were unable to use all the nutrients in the conventional feed. Nevertheless, type of feed had an effect on latency to reach the last bowl, latency to leave the start box and the number of vocalisations, but not on gait score or walking speed, indicating that the influence of type of feed on walking ability is ambiguous.

In our study, non-deprived birds were used in the runway test. The assumption was made that they had a basal motivation to walk for a food reward. It is possible, however, that some individuals had eaten just before they came into the runway test and some had not. Motivation to walk for a

food reward can therefore be slightly different per individual. On the other hand, in the runway was given not an ordinary food reward, but a reward with a high incentive value namely mealworms. Mealworms seemed to be very attractive for broilers since most of the birds like to eat mealworms comparable to the chicks of their ancestors: the junglefowl (Hogan 1966). The runway test was the only opportunity to obtain that attractive reward. Thus, motivation was probably strengthened by giving mealworms as reward. The higher risk that birds were not challenged strong enough anymore to walk for a reward at the end of the rearing period was another probable disadvantage of not depriving the birds before testing.

Concluded is that sex and type of feed have effects on different measures in the runway. Male broilers walked faster to a food reward and vocalised more than females. The role of type of feed was ambiguous. It did not influence body weight, walking speed or gait score, but conventionally fed birds sat more and had a higher latency to leave the start box and to reach the last bowl, and free-range fed birds vocalised more. Although a motivation and an ability effect were found in the last part of the runway, no sex or feed effects were found for these measures. That means that frustration and obstacles had similar impact on both sexes and both types of feed and that sex differences in walking speed probably were a result of physical differences (males are stronger and bigger).

4.6 Acknowledgements

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Motivation and ability to walk for a food reward in fast- and slow-growing broilers to 12 weeks of age



5.1 Abstract

Genetic selection for high growth rate may have such a negative impact on physical abilities of broilers that it may prevent broilers from performing behaviours even if they are motivated to do so. The aim of this study was to measure the influence of physical ability and motivation on the performance of broilers in short physical tasks. We tested birds from fast- (high body weight) and slow- (low body weight) growing broiler strains in a runway to 12 weeks of age. To manipulate motivation, half of the birds of each strain was feed deprived for 3 h and the other half for 24 h before testing. Each bird was tested in a control and a slalom runway session once a week. With a similar motivation, slow growers had a shorter latency to start walking and walked faster through the runway than fast growers in both sessions. Walking speed decreased with age in both strains; in slow growers this occurred much later than in fast growers. Slow growers vocalised more in both sessions. In slalom sessions, 24 h deprived birds vocalised more than 3 h deprived birds. Although the fast and slow growers have a different genetic background, the results indicated that motivation is the dominant determinative factor for walking in birds with a low body weight, while physical ability is the dominant determinative factor for walking in birds with a high body weight.

5.2 Introduction

Broilers are generally inactive. It has been suggested that genetic selection for high growth rate, with associated high body weight and poor leg condition, has such a negative impact on physical ability of broilers that it may prevent broilers from performing behaviours even if they are motivated to do so (Weeks et al. 1994). Limited physical ability seemed to be joined inextricably with the life of a broiler, but little is known about motivational aspects to perform behaviour in broilers. The distinction between motivation and physical ability is relevant as a lack of motivation has consequences for the interpretation of the observed inactivity in terms of welfare.

In several studies on motivation, a runway, an experimental apparatus in which animals have to walk a certain distance for a reward, has been a valuable instrument (Amsel & Roussel 1952; Vallortigara et al. 1990; Koene & Urff 1995; Jones et al. 1999; Clarke & Jones 2001; Jones et al. 2002). Motivational and physical aspects of walking for a food reward in non-deprived broilers to 7 weeks of age have been described in Bokkers and

Koene (2002), but it is not known what happens after 7 weeks of age. Insight in motivation and physical ability after 7 weeks may also yield insight in the period before 7 weeks as the disbalance between motivation and physical abilities is more clearly elucidated with increasing weight. Since body weight is an important determinant for locomotory dysfunction (Kestin et al. 2001), it seems to be a good indicator for the physical ability of broilers, especially with increasing age.

The few studies on fast-growing broilers through 12 weeks of age are focussed mainly on poor leg condition of the birds (Nielsen et al. 2000; Butterworth et al. 2002). In general, a poor physical condition results in more sitting behaviour. Sitting behaviour can therefore be used as an indicator for physical ability. It can also be an expression of frustration, when a goal cannot be reached. Behaviours such as displacement preening and vocalisations have also been used as indicator for frustration (Duncan & Wood-Gush 1972; Zimmerman & Koene 1998; Zimmerman et al. 2000).

The study described here was an experiment with an in-situ and an ex-situ part. The in-situ part about behaviour in the homepen and the physical consequences of keeping fast- and slow-growing broilers to 12 weeks of age is described in Bokkers and Koene (2003). The aim of the ex-situ part was to investigate the impact of physical ability and motivation on the performance of fast- and slow-growing broilers with a relatively high respectively low body weight at a similar age. We tested birds from both broiler strains in short physical tasks to gain insight into the effect of growth with associated body weight on the physical abilities at the same age. Tests were continued to 12 weeks of age, expecting that the increasing body weight would give more and more physical problems for the birds of both strains. To manipulate motivation, half of the birds of each strain were feed deprived for 3 h (low motivation) and the other half for 24 h (high motivation) before testing. Each bird was exposed to two different runway tasks per week, an easy task (control) and a more complicated task (slalom).

5.3 Materials and methods

5.3.1 Animals and housing

Forty-eight 1-day-old female broiler chicks of a slow-growing genetic strain (JA 657, Hubbard ISA, Wezep, The Netherlands) and 48 1-day-old female broiler chicks of a fast-growing genetic strain (HI-Y, Hubbard ISA,

Wezep, The Netherlands) were obtained from a commercial hatchery (Morren B.V., Lunteren, The Netherlands). Due to errors in gender determination, six males (five fast growers, one slow grower) were included in the experiment. Since this was discovered while the experiment was running the males were kept in the experiment and exposed to all measurements but excluded from the analyses. The chicks were allocated to sixteen floor pens (1.0 m × 1.5 m per pen): eight pens with six slow-growing birds and eight pens with six fast-growing birds. All walls of each pen were solid and 0.7 m high and the floor was covered with wood shavings. Each pen contained one feeder, drinking nipples with a cup underneath and two wooden perches. Homepen conditions were designed to allow the birds to develop and to perform their behaviour in a rather undisturbed way. Further details of the homepen conditions are described in Bokkers and Koene (2003). The Wageningen University Committee on Animal Care and Use approved this experiment.

5.3.2 Apparatus

The apparatus for the runway test was situated in a separate, sound-attenuated room with a similar ambient temperature to that of the home environment. It consisted of a start box (40 cm × 40 cm × 60 cm, l × w × h) and a runway (240 cm × 40 cm × 60 cm, l × w × h). A solid guillotine door separated start box from runway. One red, plastic bowl (r=5 cm) was placed in the runway at 220 cm from the start box containing the food reward (five mealworms). A camera and a microphone connected to a video-recorder were placed above the runway. All trials were recorded on video and analysed with Ethovision®, an automatic visual tracking system (Noldus 1997). The floor of the start box and runway was painted black to increase the contrast between bird and surrounding, which was advantageous for the video analysis. The experimenter was out of sight during a trial.

5.3.3 Procedure

In the first week of life, the birds were habituated to eat mealworms in the homepen from a similar red bowl as in the runway. In the first week of life, they were also put once into the runway for 3 min to habituate to that environment. In the second week of life, all 96 birds were trained individually two times to walk through the runway to obtain the food reward. From the third to twelfth week of life, each bird was tested individually in the runway in two different sessions each week. Sessions were not randomly assigned to a bird over the two test days for practical

reasons. In the control sessions (Tuesdays), half way the runway a partition was positioned with a passage of 25 cm. Birds had to walk through the passage, along the partition. They could not see the bowl with mealworms from the start position. In the slalom sessions (Fridays), two extra partitions were placed in the runway, one at the opposite and one at the same side of the first one. Thus, the birds had to slalom along the partitions. At 7 weeks of age, only a slalom session was performed. Only one trial per bird per day was carried out. Details of the procedure on an individual trial are as follows: (a) bird is put in the start box; (b) after 5 s the door is raised (start of trial); (c) the bird is allowed 3 min to walk to the end of the runway to obtain the reward; (d) when the bird passes the virtual line (finish line) at a distance of 200 cm from the guillotine door (start line) the trial is cut off (e) when the bird has eaten the reward, it is taken out of the runway; (f) when a bird does not reach the end of the runway to obtain the reward in 3 min, it is gently forced by the observer by holding a hand behind the bird and if necessary push it slightly to walk to the bowl and is given time to eat the reward.

To manipulate the motivation to walk for a food reward, half of the birds of each strain (2×4 pens) were feed deprived for 3 h and half of the birds of each strain (2×4 pens) were feed deprived for 24 h before testing. For that, the feeders were removed from the homepen.

The runway was divided virtually into three zones. Zone 1 was from start line to the first partition (100 cm); zone 2 from first to third partition (50 cm); and zone 3 from third partition to the finish line (50 cm). In control sessions, the second and the third partition were present only virtually. Latency to leave the start box and enter zone 1 (cross the start line), latency to enter zone 2 and zone 3, and to reach the end of the runway (cross the finish line), number of times each bird reached the end of the runway, distance moved, duration of a trial, sitting and preening behaviour (frequency and duration) and number of vocalisations (distress calls and other calls, Kaufman & Hinde 1961) were measured during the runway tests.

5.3.4 Statistical analyses

Statistical analyses were performed using SAS (SAS® 1996). Number of times each bird reached the end of the runway was analysed with the GLM procedure and session as repeated measurement. Effects of strain and deprivation level were tested against the random effect of pen within strain

and deprivation level. Behaviour in the runway was analysed with the Kruskal-Wallis test and post hoc with the Mann-Whitney-U test. Walking speed from start to finish was calculated as the distance moved in the runway divided by the time spent in the runway minus latency to cross the start line. Walking speed and number of vocalisations were analysed with the GLM procedure. Effects of strain and deprivation level were tested against the random effect of pen within strain and deprivation level. Age effects (in weeks) were analysed as repeated measures using orthogonal polynomial contrasts (Sokal & Rohlf 1969, pp 468-476). Latency to reach each zone was transformed with a $10\log$ to reach normal distributions and analysed with a step-down analysis of Roy-Bargmann in a GLM procedure. In a step-down analysis, the latency to reach each zone was controlled for baseline differences by taken the latencies to reach the preceding zones as covariates in the analysis. Birds that did not reach one or more zones within 180 s were given the maximum trial duration of 180 s for the remaining zones. Effects of strain and deprivation level were tested against the random effect of pen within strain and deprivation level. Effects of age were tested against the random effect of pen within strain, deprivation level, age and session. Effects of session were tested against the random effect of pen within strain, deprivation level and session. An analysis of covariance was used to study the effect of body weight on performance in the runway.

5.4 Results

5.4.1 Percentage of finishers

The number of times each bird reached the end of the runway (finished) within three minutes, expressed as a percentage, is shown in Table 5.1. More birds finished in control than in slalom sessions ($F_{1,73}=81.52$, $p<0.001$). The test effect was different for deprivation level ($F_{1,12}=21.31$, $p<0.001$) and tended to be different for strain ($p=0.1$) and the interaction between strain and deprivation level ($p=0.07$). Slow growers finished more often than fast growers ($F_{1,12}=82.48$, $p<0.001$), and 24 h deprived birds finished more often than 3 h deprived birds ($F_{1,12}=156.32$, $p<0.001$). An interaction effect was found between strain and deprivation level ($F_{1,12}=22.42$, $p<0.001$).

Table 5.1: *The number of times each bird was successful in reaching the end of the runway expressed as a percentage.*

Broilers	Deprivation (h)	n	Control (%)	Slalom (%)
Fast growers	3	20	55.6 ± 6.1	22.8 ± 6.5
Fast growers	24	23	95.2 ± 1.5	67.6 ± 5.0
Slow growers	3	23	91.3 ± 2.3	57.0 ± 5.5
Slow growers	24	24	98.1 ± 0.9	85.6 ± 2.5

5.4.2 Latency to reach each zone

Latency to reach zone 1, zone 2, zone 3 and the end of the runway is shown for control sessions in Figure 5.1 and for slalom sessions in Figure 5.2. When latency to reach each zone was analysed without the step-down method, strain, deprivation level, week and test effects remained highly significant for all zones. When these data were controlled for baseline differences by using the step-down analysis the results changed. The main effects are presented in Table 5.2. Latency to enter zone 1, zone 2 and zone 3 was lower in control than in slalom sessions. An interaction effect between test and strain was found for latency to reach zone 2 and zone 3 ($F_{1,12}=32.26$, $p<0.001$; $F_{1,12}=7.08$, $p<0.05$). Slow growers had a lower latency to reach zone 1, zone 2 and zone 3 than fast growers. The 24 h deprived birds had a lower latency to reach zone 1 and zone 2 than the 3 h deprived birds. Latency to reach zone 1 and zone 2 decreased with age. Interaction effects were found between age and strain for latency to reach zone 1 ($F_{8,192}=9.99$, $p<0.001$), and for latency to reach zone 2 ($F_{8,192}=2.97$, $p<0.01$). No significant strain, deprivation, age, or test effect was found for latency to reach the end of the runway.

Table 5.2: *Main effects of latency to reach each zone and end of the runway analysed with a step-down analysis.*

Latency to reach	Strain ($F_{1,12}$)	Deprivation level ($F_{1,12}$)	Test ($F_{1,12}$)	Age ($F_{8,192}$)
Zone 1	$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$
Zone 2	$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$
Zone 3	$P<0.010$	$P=0.075$	$P<0.001$	$P=0.067$
End of runway	$P=0.057$	$P=0.099$	$P=0.124$	$P=0.218$

We found a positive relation between body weight (for body weight data see Bokkers & Koene 2003) and latency to reach the end of the runway ($T=3.75$, $p<0.001$), controlled for strain, deprivation level, test and age.

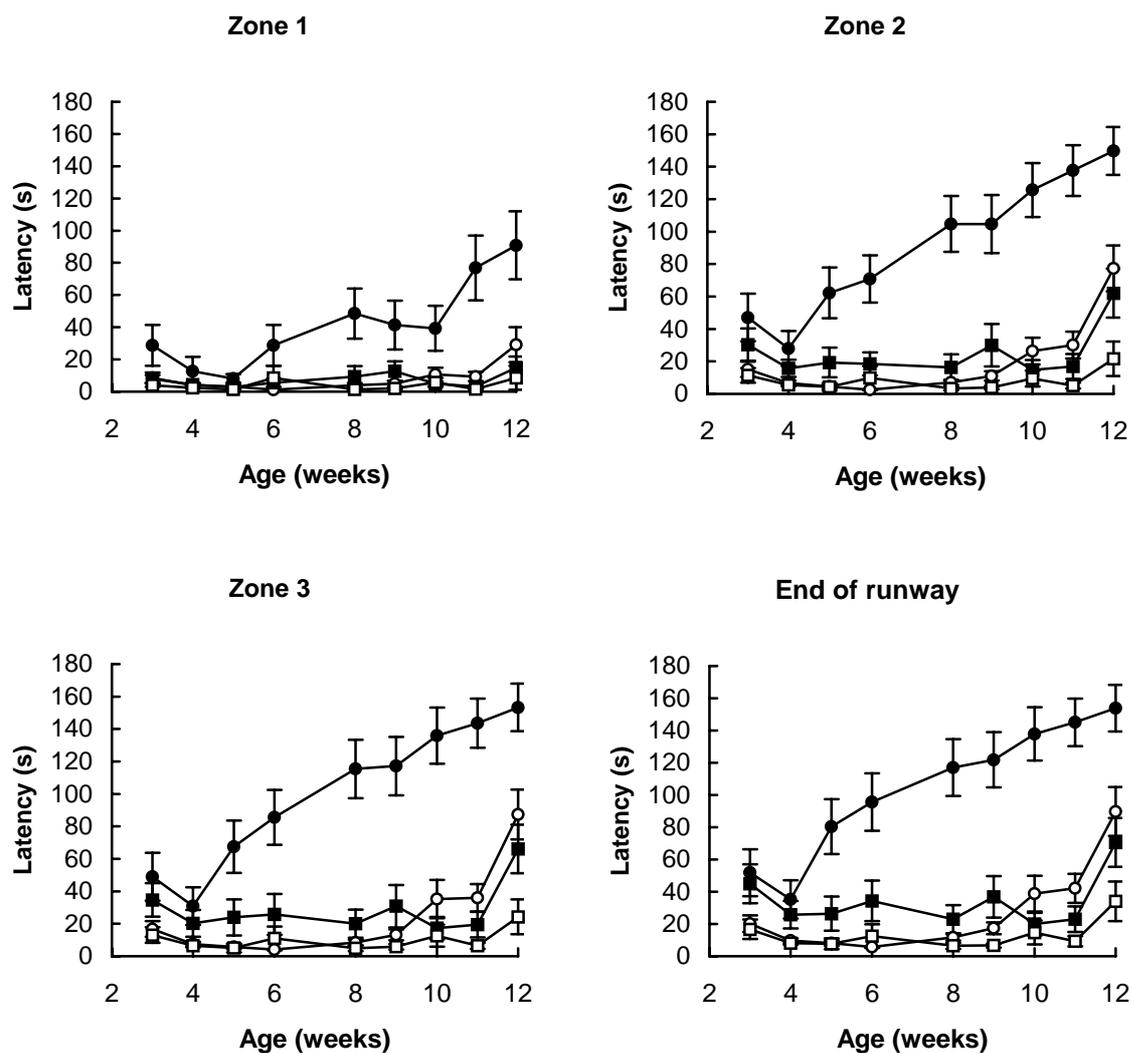


Figure 5.1: Latency (s) to reach zone 1, zone 2, zone 3 and the end of the runway in control sessions for slow growers, 3 h (■) and 24 h deprived (□), and fast growers, 3 h (●) and 24 h deprived (○).

5.4.3 Walking speed

In Figure 5.3, walking speed of the birds in control and slalom sessions is shown. Birds walked faster in control sessions than in slalom sessions ($F_{1,120}=170.57$, $p<0.001$). In both sessions, slow growers walked faster than fast growers ($F_{1,12}=92.24$, $p<0.001$) and 24 h deprived birds walked faster than 3 h deprived birds ($F_{1,12}=105.48$, $p<0.001$). No interaction effect was found between strain and deprivation level. Walking speed decreased over age ($F_{1,120}=19.19$, $p<0.001$). Walking speed decreased more with increasing age in fast growers than in slow growers ($F_{1,12}=36.04$, $p<0.001$). Within the age effect, interactions between strain and deprivation level ($F_{1,12}=9.01$, $p<0.05$) and between test and strain ($F_{1,120}=10.96$, $p<0.01$) were found.

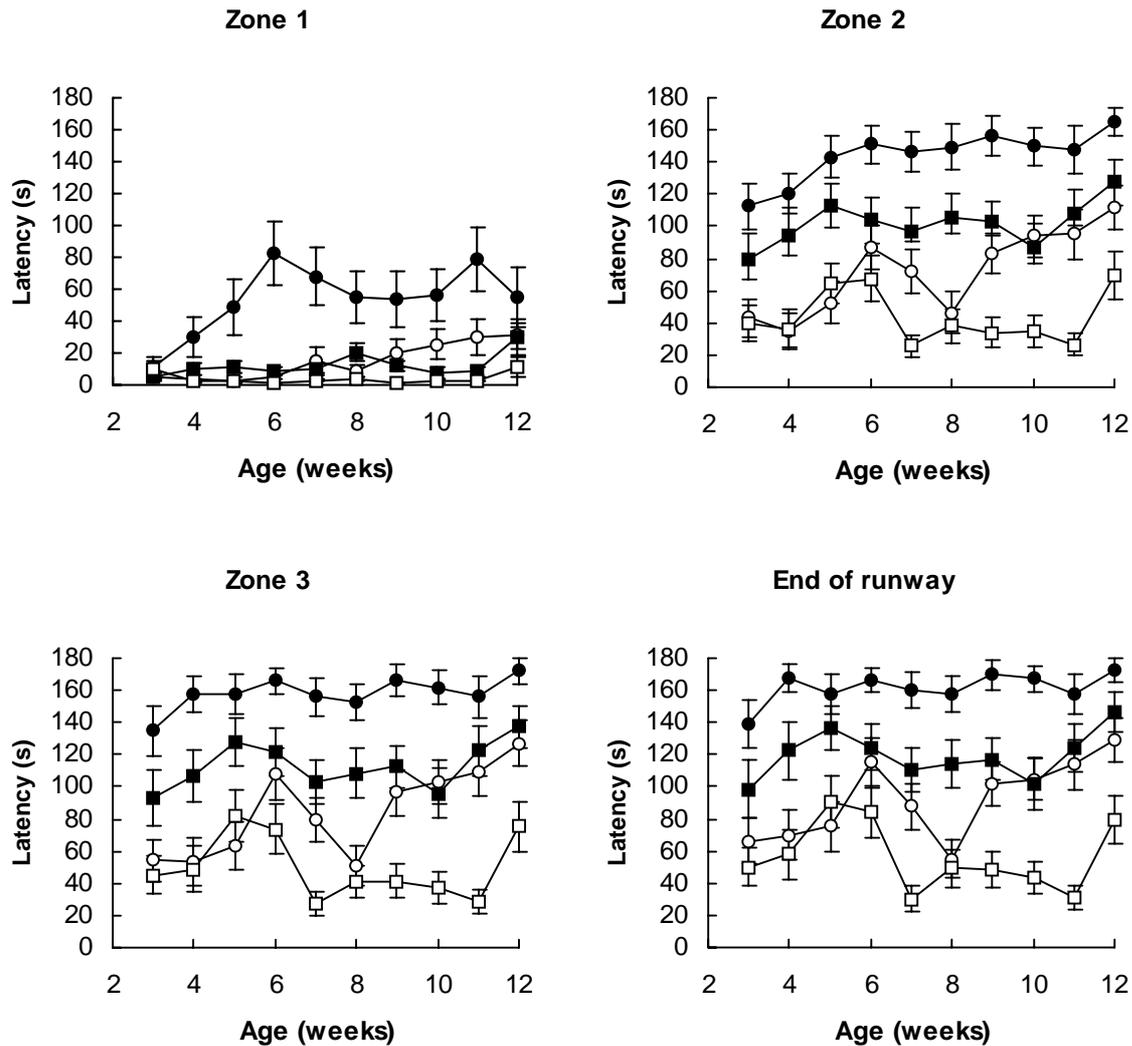


Figure 5.2: Latency (s) to reach zone 1, zone 2, zone 3 and the end of the runway in slalom sessions for slow growers, 3 h (■) and 24 h deprived (□), and fast growers, 3 h (●) and 24 h deprived (○).

5.4.4 Vocalisations and behaviour

In Figure 5.4, the total number of vocalisations per second during the runway tests is shown. Initially, 25% and 18% of the vocalisations were distress calls in fast respectively slow-growing birds. Distress calls decreased quickly with increasing age. After 6 weeks of age, no distress calls were observed anymore. No session effect, but an interaction effect between session and deprivation level was found for the total number of vocalisations ($F_{1,120}=8.46$, $p<0.01$). Slow growers vocalised more than fast growers ($F_{1,120}=100.27$, $p<0.001$). Birds that were 24 h deprived vocalised more than 3 h deprived birds ($F_{1,120}=8.46$, $p<0.05$). The total number of vocalisations decreased with increasing age ($F_{1,120}=174.64$, $p<0.001$).

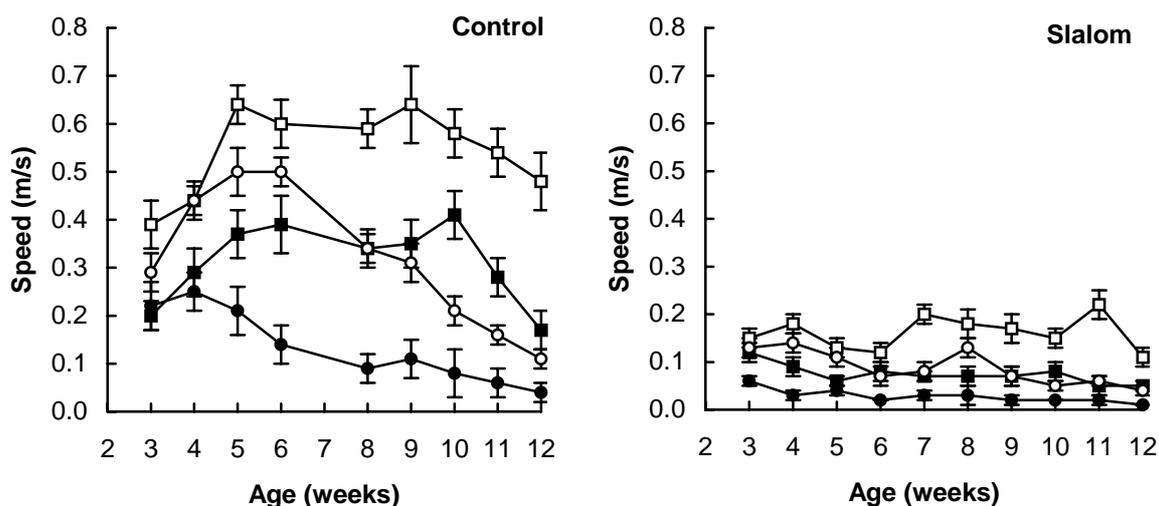


Figure 5.3: Walking speed (m/s) of slow growers, 3 h (■) and 24 h deprived (□), and fast growers, 3 h (●) and 24 h deprived (○), in control (left) and slalom (right) sessions.

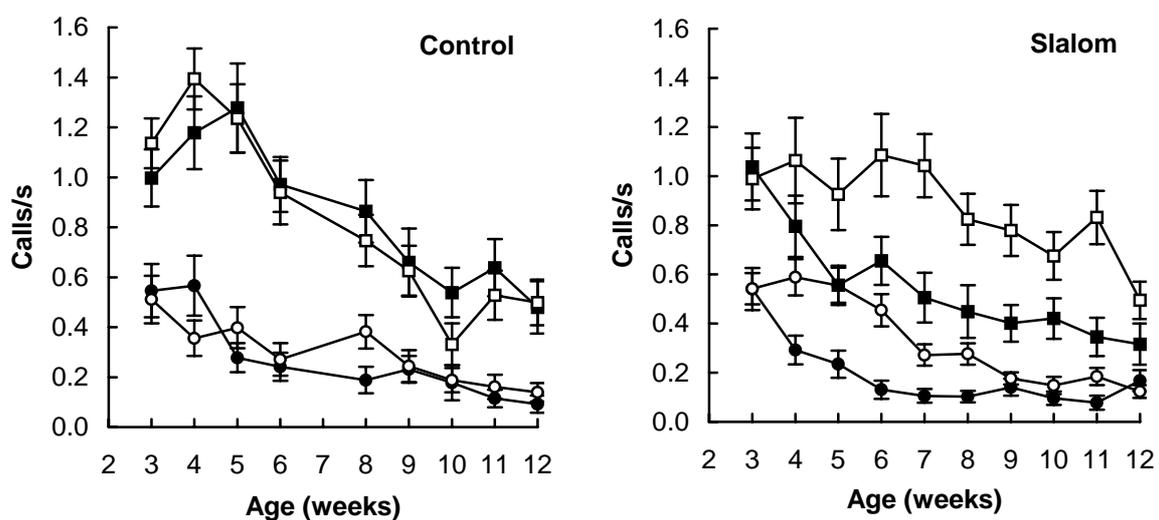


Figure 5.4: Vocalisations (calls/s) of slow growers, 3 h (■) and 24 h deprived (□), and fast growers, 3 h (●) and 24 h deprived (○), in control (left) and slalom sessions (right).

Preening and sitting behaviour in the runway as percentage of the observed time at 6 and 12 weeks of age is shown in Table 5.3. At 6 weeks of age, no differences were found for preening and sitting in control and slalom sessions. In slalom sessions, the 3 h deprived fast growers showed significantly more preening and sitting than the other groups at 6 weeks of age. At 12 weeks of age, the 3 h deprived fast growers showed significantly more preening and sitting in both control and slalom sessions than the other groups. The 24 h deprived fast growers sit more in slalom sessions than the slow growers at 12 weeks of age. The 3 h and 24 h deprived fast

growers showed an increase in preening in control sessions with age ($Z=2.41$, $p<0.05$; $Z=2.95$, $p<0.01$).

Table 5.3: *Preening and sitting behaviour in the runway as percentage of the observed time at the age of 6 and 12 weeks.*

Session	Broilers	Depriv (h)	Preening (%)		Sitting (%)	
			6 weeks	12 weeks	6 weeks	12 weeks
Control	Fast gr	3	0.4 ± 0.3	9.5 ± 4.6 ^a	4.7 ± 4.1	20.0 ± 10.4 ^a
Control	Fast gr	24	0.0 ± 0.0	4.2 ± 2.1 ^b	0.0 ± 0.0	3.7 ± 3.7 ^{ab}
Control	Slow gr	3	0.0 ± 0.0	1.2 ± 0.7 ^b	0.0 ± 0.0	0.0 ± 0.0 ^b
Control	Slow gr	24	0.0 ± 0.0	0.0 ± 0.0 ^b	0.0 ± 0.0	0.0 ± 0.0 ^b
	Df=3	$\chi^2 =$	8.2, $p<0.05$	16.0, $p<0.01$	8.2, $p<0.05$	16.1, $p<0.01$
Slalom	Fast gr	3	4.0 ± 2.1 ^a	2.6 ± 0.4 ^a	20.6 ± 8.2 ^a	25.1 ± 8.4 ^a
Slalom	Fast gr	24	1.8 ± 1.3 ^{ab}	1.0 ± 0.2 ^b	0.2 ± 0.2 ^b	10.2 ± 4.4 ^b
Slalom	Slow gr	3	0.0 ± 0.0 ^b	0.4 ± 0.2 ^b	0.0 ± 0.0 ^b	2.1 ± 2.1 ^c
Slalom	Slow gr	24	0.0 ± 0.0 ^b	0.1 ± 0.0 ^b	0.0 ± 0.0 ^b	0.0 ± 0.0 ^c
	Df=3	$\chi^2 =$	12.2, $p<0.01$	22.9, $p<0.001$	23.1, $p<0.001$	18.9, $p<0.001$

5.5 Discussion

The aim of this study was to measure the influence of body weight and motivation on the performance of broilers in short physical tasks. We tested fast- and slow-growing broiler strains supposing that the fast-growing broiler strain would have worse physical abilities than the slow-growing strain due to their faster growth with associated higher body weight at the same age. The experiment was continued to 12 weeks of age, expecting that the increasing body weight would increasingly give physical problems for the birds of both strains. To manipulate motivation, half of the birds of each strain were feed deprived for 3 h (low motivation) and the other half for 24 h (high motivation) before testing. Each bird was exposed to two different runway sessions per week, a control and a slalom session.

Slow growers that were 3 h and 24 h feed deprived and 24 h deprived fast growers had a high percentage of reaching the end of the runway in control sessions. In slalom sessions, 24 h deprived slow growers had still a high percentage of birds that reached the end of the runway, but the percentage 24 h deprived fast growers and 3 h deprived slow growers that managed to reach the end of the runway decreased. In both sessions, 3 h deprived fast growers had the lowest percentage of birds that reached the

end of the runway, and in the slalom sessions, it was much lower than in the control sessions. This group of birds performed the highest level of sitting and preening in the runway. In the homepen, no difference was found for preening and sitting idle between the strains (Bokkers & Koene 2003). This indicates that birds did react differently to the runway sessions. Since preening in such a context is suggested to be related to frustration (Duncan & Wood-Gush 1972), it seems that 3 h deprived fast growers are frustrated in the runway. Probably, because they were not able to walk to the reward.

After a similar deprivation period, the slow-growing birds walked faster through the runway and had a lower latency to leave the start box than the fast-growing birds. This is in accordance with an experiment of Reiter and Bessei (1998), where slow-growing broilers walked longer distances on a treadmill in 20 minutes than fast-growing broilers during the first 6 weeks of life. In our experiment, 24 h deprived birds walked faster through the runway and had a lower latency to leave the start box and enter zone 1 than 3 h deprived birds in both sessions. Latency to reach zone 2 was higher in slalom sessions than in control sessions. Since motivation of a bird during the two sessions was supposed to be similar within a week, it indicates that a bird experienced the additional partitions as an obstacle somehow and hampered them to continue walking. It happened that birds walked in zone 1 to and fro the first partition several times. The birds with the highest ability and with the highest motivation entered zone 2 the first. Latency to reach zone 3 was lower for the slow growers than for the fast growers (ability effect) and lower for the 24 h deprived birds than for the 3 h deprived birds (motivation effect). No differences were found anymore for latency to reach the end of the runway between the two strains and the two deprivations. Thus, when a bird reached the last part of the runway differences in latency could be assigned to differences occurred in the preceding zones. Since walking speed did not increase with increasing age in the slalom sessions, it seemed that birds did not adapt to the situation or that the effort did not counterbalance for the profits. Together with the results that 24 h deprived slow growers had lower latencies to reach each zone than 3 h deprived slow growers and 3 h deprived fast growers had higher latencies to reach each zone than 24 h deprived fast growers, we suggest that motivation is the determinative factor for walking in slow-growing broilers, and that ability is the determinative factor in fast-growing broilers. Although birds had a different genetic background, growth with the associated body weight was the most distinguishing characteristic between these birds. Gait scores of

these birds were low (Bokkers & Koene 2003), so there were little or no walking abnormalities. Body weight seems, therefore, to influence physical ability in such a way that the slow growers could walk faster through the runway than the fast growers. This was confirmed by the positive correlation between body weight and the latency to reach the end of the runway. Similar conclusions could be drawn from homepen observations, since no differences in walking activity was found between the two strains at 2 to 3 weeks of age (Bizeray et al. 2000; Bokkers & Koene 2003). After that age, it was shown that slow growers walked more than fast growers, but that walking activity decreased also in slow growers after 5 weeks of age (Bokkers & Koene 2003).

Walking speed of the birds in this experiment was much higher compared to birds tested under non-deprived conditions (Bokkers & Koene 2002). Walking speed decreased with increasing age, in slow growers especially after 10 weeks of age and in the 24 h deprived fast growers after 6 weeks of age. The 3 h deprived fast growers showed a decrease in walking performance after 4 weeks of age already, in accordance with Reiter and Bessei (1998). Beside decreased physical abilities, motivation to obtain food may have been lower. Feed consumption in the homepen decreased to a steady state at that age (Bokkers & Koene 2003). The fact that all birds started to eat immediately after returning into the homepen indicated that the birds were hungry. Although we do not know whether hunger feelings in the strains appeared to be the same after 3 and 24 feed deprivation. We suggest that birds of both strains were similar hungry and thus highly motivated after 24 h feed deprivation.

In control and slalom sessions, slow growers vocalised more than fast growers did. Since in both sessions this effect occurred, it seems that a genetic effect influenced the number of vocalisations. Vocalisations can be seen as an emotional expression of for example fear (Andrew 1975; Jones et al. 1995), frustration (Zimmerman & Koene 1998; Zimmerman et al. 2000), or social reinstatement (distress calls). The slow growers obtained most of the rewards. It is supposed, therefore, that they were not much frustrated in the runway. In addition, the number of distress calls, which are the clearest vocalisations of fear, decreased quickly when the birds got older. Probably the slow growers vocalised more because they were more active in searching for contact with conspecifics. In the slalom sessions, both strains vocalised more after 24 h than after 3 h feed deprivation, while in control sessions no such effect was found. Probably, birds vocalised less as a trial took longer.

Since birds spent more time in the runway during slalom than in control sessions, this could be the explanation for the difference found between sessions for the number of vocalisations. This effect clarified the interaction effect between session and deprivation level. The number of vocalisations decreased over age in both sessions, in accordance with an earlier runway experiment (Bokkers & Koene 2002). We think that this is mainly an age effect and not a habituation effect, since the birds were tested many times in the runway. Habituation should have occurred faster. No difference was found between the two sessions for the total number of vocalisations. Although the slalom sessions appeared to be more complex for the birds, they did not vocalise more.

In this study, it is shown that broilers with different motivations and different body weights performed differently in a short physical task. Although the influence of body weight and motivation on short physical tasks was measured in two genetic different strains, this study showed that birds with a lower growth rate with associated lower body weight and birds with a higher motivation walked faster over a short distance for a food reward. It seemed that motivation is the dominant determinative factor for walking in birds with a low body weight, while physical ability is the dominant determinative factor for walking in birds with a high body weight.

5.6 Acknowledgements

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Working for food under conditions of varying motivation in broilers



6.1 Abstract

Broiler chickens, *Gallus gallus domesticus*, have been selected for rapid weight gain and appear to be continuously hungry. If this is so, then energy that broilers invest in obtaining food should be insensitive to their level of feed restriction. The aim of this study was to test this hypothesis by measuring the maximum price (i.e. maximum number of key pecks) broilers with different body weights would pay for a food reward under conditions of varying food restriction. Two groups of 20 broilers were fed on 50% or 75% of the amount of feed a broiler would eat when fed ad libitum. Broilers were able to learn an operant task and were willing to work for food. Birds of the 50%-group paid a higher maximum price for a food reward and responded more quickly to food presentation than the birds of the 75%-group in the first test week and tended to pay a higher price and to respond more quickly in the second test week. Different levels of long-term feed restriction had an influence on their body weight and on their motivation to work for food. No short-term effect of changing feed restriction was found. Birds showed frustration behaviour after the last food reward had been obtained, indicating that they were still hungry. The results indicate that broilers are still sensitive to different levels of feed restriction and that they can balance their investments and profits to a certain extent.

6.2 Introduction

Broilers are kept commercially for chicken meat production. These birds are normally kept in large flocks (10 000–30 000 birds) with high population densities (18-23 birds/m²). They grow to slaughter weight in about 42 days when they weigh approximately 2.2 kg. Broilers have been selected extensively for body weight gain per day. This selection has resulted in changes in food intake, food conversion rate and growth rate (Savory 2002). Chickens from body weight selected lines voluntarily consume a volume of feed approaching the full capacity of their gastro-intestinal tract, whereas low weight selected lines consume a small percentage of total capacity (Nir et al. 1978; Barbato et al. 1984).

A typical characteristic of broilers is that they have a low activity level, especially after 3 weeks of age (Reiter & Bessei 1998). High body weight, leg problems and pain negatively influence activity levels in broilers because of impaired physical abilities (Danbury et al. 2000; Weeks et al. 2000; Sanotra et al. 2001). Little is known, however, about the motivation to perform

behaviour in broilers. The distinction between motivation and ability is relevant as a lack of motivation has consequences, e.g. for the interpretation of inactivity in broilers in terms of compromised welfare. In a study with a runway, it was clear that broilers were motivated to put effort in obtaining a food reward, despite their limited physical condition (Bokkers & Koene 2002). Food seems, therefore, to be a good incentive for eliciting activity. It is not known, however, how strong their motivation is to obtain food. We hypothesised that broilers may be insensitive for different levels of feed restriction to a certain extent, since they appear to be hungry all the time. If that is true, then there should be no differences in the energy these birds would invest to acquire food

To measure motivation, a consumer demand approach has proved to be useful in many animal species, e.g., broiler breeders, pigs, hens, mice, mink, calves and rats (Savory et al. 1993; Matthews & Ladewig 1994; Foster et al. 1997; Warburton & Nicol 1998; Cooper & Mason 2001; Holm et al. 2002; Ladewig et al. 2002). Until now, however, broilers have not been the subject of such a study. Consumer demand experiments have been used to get insight in the price an animal is willing to pay to attain access to a resource. The price is equal to the number of responses, e.g. key pecks or lever presses, required to produce a reinforcer and consumption is equal to the number of reinforcers earned (Hursh et al. 1988; Savory & Lariviere 2000). Besides water, food is the most basic reinforcer that can be used in consumer demand experiments. Food is recognised as a standard against which other items can be rated since it is clearly needed for survival (Dawkins 1983, 1990; Matthews & Ladewig 1994). Therefore, food seems the best resource to start with when it is not known how and if a broiler will react to a consumer demand test.

Since broilers have a large appetite, it was expected that it would be easy to get broilers to work for food. On the other hand, broilers are, in general, not very active and have limited physical abilities due to their high body weight (Reiter & Bessei 1998; Bokkers & Koene 2003b). This might cause problems, because they may give up very quickly.

The first aim of this experiment was to train broilers to peck a key for a food reward after the key light switched on. The second aim of this study was to measure the maximum price, in this study the maximum number of key pecks, a broiler would pay for a food reward under conditions of varying motivation and with two different body weights in a limited length of time. In consumer demand experiments both fixed ratio and progressive ratio

schedules are used (Foster et al. 1997). In a fixed ratio schedule, the number of responses required for reinforcement is always the same within a session (Lieberman 1993). In a progressive ratio schedule, the number of operant actions increment within a session with a certain number each time the reinforcer is earned (Foster et al. 1997). It has been shown that a progressive ratio schedule is a sensitive indicator of variation in feeding motivation among different feeding and deprivation treatments (Savory et al. 1993). A progressive ratio schedule fitted best, since we established two groups with different motivations and body weights by using two different feed restriction levels, and since we wanted to measure the maximum price in one session. The third aim was to observe the birds after they had paid the maximum price to see if their behaviour at this time could be described as indicating frustration and if it differed depending on feed restriction and differences in body weight.

6.3 Method

6.3.1 Subjects and housing

Forty 1-day-old female chicks of a fast growing genetic broiler line (HI-Y, Hubbard ISA, Wezep, The Netherlands) were obtained from a commercial hatchery (Morren B.V., Lunteren, The Netherlands) and housed at the research accommodation “De Haar” in Wageningen. The first week after arrival, the broiler chicks were kept in one group in a floor pen (1.0 m × 1.0 m) covered with wood shavings with ad libitum feed and water access. After the first week, the birds were weighed and divided into two stratified groups, which means that both groups had similar mean body weight at that moment. The birds of each group were allocated to twenty floor pens (0.7 × 0.7 m per pen), two birds of one group per pen. All walls of each pen were solid and 0.7 m high. The floor was covered with wood shavings. Once a week, on Fridays, part of the bedding was replaced with fresh wood shavings in order to keep it in a consistent, good condition. During the first week, birds had continuous light from a heating lamp. Thereafter, a schedule of 18-h light (20 lux) and 6-h dark was provided. No daylight entered the house. Temperature was maintained on 32 ± 1 °C at the beginning of the experimental period, and gradually decreased every 3 days by 1 °C to a constant temperature of 20 ± 1 °C.

6.3.2 Feeding procedure

Birds were fed with a conventional broiler feed produced by TNO Nutrition (ILOB-department, Wageningen, The Netherlands). To establish two groups with different body weights, birds were subjected to two feeding schedules. After the first week, ten pens were provided with an amount of feed that was about 50% of what they would normally eat with unlimited feed access (commercial manual; Savory et al. 1993; unpublished data). This group was called the 50%-group. The other ten pens were provided with an amount of feed that was about 75% of what they would eat with unlimited feed access. This group was called the 75%-group. Feed was weighed and provided immediately after birds returned from the training or testing. Birds were trained or tested each day at the same time. We supposed, therefore, that the birds' hunger level was the same each day. Feeding the birds immediately after training was supposed not to be a problem, since Ladewig et al. (2002) stated that the moment of additional access to a commodity outside the test situation was less important, as long as it does not happen within a few hours before the test. Birds had unlimited time to consume the provided amount of feed, but all birds had eaten their portion at least 18 h before a new session started.

Before feed was provided each pen was divided in two with a solid partition, which made it possible to feed the birds individually. Each part of a pen contained one water bowl. Partitions were removed after birds had eaten all the feed to minimise the time of social isolation. This was about 6 h after feed provision. Birds could eat ad libitum from Friday evening until Sunday afternoon to give them the chance to recover from the days with feed restriction. Each bird was weighed every weekday to control the condition of the growing birds conscientiously.

6.3.3 Apparatus

Three automated operant chambers were located in a sound-attenuated room with a similar ambient temperature to that of the home environment. This room was situated next to the room where the birds were housed. Each operant chamber measured 60 cm × 50 cm × 65 cm. Three side walls and the ceiling were made of transparent Perspex® and the front panel was made of wood. An round aperture located in the centre of the front panel (diameter 12 cm, the underside 2 cm above floor level) allowed access to the feeder. The birds could obtain food only when the feeder was

raised. The aperture was not lit when the feeder was raised. The feeder operated on air pressure and it produced some soft noise when it raised or lowered. The feeder was filled with the same food as the birds received in the homepen. A photocell at the side of the aperture detected the presence or absence of a bird's head in the feeder. One response key, 2 cm in diameter, was fixed on a small black box (3 cm × 3 cm × 6 cm; 1 × w × h) that was placed 5 cm beside the aperture. The box with the key stuck out of the front panel and was adjustable in height. Since the birds were small in the beginning, the box with the key was put initially 10 cm above the metal grid floor. It was put higher as the birds grew, to 25 cm above the floor during testing. In the key a red light was present that could be either on or off. Water was always available at the back of the operant chamber. A 5-W house-light was fixed 8 cm above each operant chamber and was lit only when a session was running. Each operant chamber operated through a custom-made program using LabView® software (NI 1994). Changes in key light (on/off), key (peck or no peck) and photo cell (head or no head) were automatically recorded and stored in a file on the hard disk of a personal computer which was in the same room as the operant chambers.

6.3.4 Training procedure

All three operant chambers were used for the training sessions. Training started at 8 days of age. The goal of the training procedure was to teach the birds to peck the key for a food reward after the key was illuminated. Each bird was habituated to an operant chamber for 10 min on the first day of training. On the following five days, auto-shaping was used to train the birds to press the key for a food reward. During auto-shaping the key was illuminated every 30 ± 2 s. The key was illuminated for 10 s and after that, the feeder was raised. The bird was allowed to eat for 5 s after which the feeder went down. In 5 s, a bird could eat about 1 g of food. Each session lasted 15 min. Since just a few birds made progress, we decided to switch from auto-shaping to hand-shaping. During hand-shaping, the key was illuminated continuously. The observer could give a 5-s food reward, by pressing a key on the computer. After 8 days of hand-shaping, twelve birds still paid no attention to the key and were excluded from further training. Birds who were able to peck the key, or pecked close to the key were trained in operant sessions in the following week.

Twenty-six birds were trained in operant sessions for 15 min per day. After a variable interval (30 ± 2 s), the key light switched on and a 10-s

period started in which a key peck was rewarded with a 5-s food reward. Immediately after the bird had pecked the key, the key light switched off and the feeder raised. After 5 s, the feeder went down and the next variable interval started. Each bird was trained to 6 weeks of age. At that moment, seven birds of the 50%-group and five birds of the 75%-group had reached the training criterion. A bird had to reach at least 90% correct key pecks (pecks on key when key light was on) and head in feeder within 3 s after the feeder raised. The other birds did not peck the key, but only around the key. Some extra hand-shaping training sessions did not result in effective key pecking in these birds.

6.3.5 Testing procedure

During test weeks, the twelve remaining birds were exposed to a progressive ratio schedule of +2 at 6 weeks of age, +4 at 7 weeks of age, and +2 at 8 weeks of age for a 5-s food reward. Both schedules started with a food reward for the first key peck. Thereafter, ratio values were progressively incremented by 2 or 4 each time a food reward was obtained. The number of required key responses for a food reward increased faster within a session with the +4 schedule, which can be important when session duration may be limiting. The required number of key pecks to obtain the next food reward had to be performed within 180 s, the maximum time the key was illuminated. Immediately after the required number of key pecks, the feeder raised for 5 s and the key light switched off. After the feeder went down, a 25 ± 2 s interval started before the key was illuminated again. The variable interval length was reduced compared with training sessions to give each bird more time for obtaining food rewards in one 30-min session. When a bird did not meet the required number of key pecks in 180 s to obtain the food reward anymore, it got one other chance. The session was ended when a bird again did not meet the required number of pecks during the second period of 180 s key illumination. The number of pecks for the last reward was considered the maximum price a bird would pay for a food reward. The maximum duration of a session was 30 min. The birds were subjected to three sessions within a test week on 3 successive days: a pre-control, a test, and a post-control session. For pre- and post-control sessions, birds were provided with the normal amount of food the day before testing. For the test session, feed restriction levels of the groups were swapped to manipulate motivation to work for food, while physical abilities did not change. The 50%-group was provided with 75% feed (less motivated) and the 75%-group

was provided with 50% feed (more motivated) the day before testing. At 8 weeks of age, each bird was tested twice under non-deprived condition on two consecutive days. Before testing, birds were fed ad libitum for 3 days. To avoid interference, only one operant chamber was used during the test weeks.

6.3.6 Behaviour at the end of sessions

Behaviour at the end of a session was analysed to study possible differences in frustration behaviour between the two groups after the last food reward was obtained. Typical frustration related behaviours are displacement preening, pecking at the environment, head flicks, yawning, vocalisations, and escape behaviour (Duncan & Wood-Gush 1972; Zimmerman et al. 2000). The moment a bird received its last food reward was determined from the video tapes. Observations started at the moment the key light switched on. Behaviour was recorded using continuous focal sampling. An observation lasted 180 s (key light on) plus 25 ± 2 s (interval, key light off) plus 180 s (key light on). The ethogram contained states of walking, escaping behaviour, sitting, preening, standing, and other, and events of key pecking, yawning, head flicks, vocalisations, floor pecking, wall pecking, and jumping. Behavioural recordings were conducted using The Observer[®] software (Noldus 1993).

6.3.7 Statistical analysis

Statistical analyses were performed using SAS (SAS[®] 1996). Data were analysed with the GLM procedure with group as factor, and session within a week as repeated measurement. Test effects were analysed using orthogonal polynomial contrasts (Sokal & Rohlf 1969, pp 468-476). Differences for similar sessions between testing weeks were analysed with the GLM procedure with the factors group and testing week. Behavioural data were standardised to 400 s. Of each behaviour the mean was calculated per bird over the four control sessions under deprived conditions and over the two sessions under non-deprived conditions. Thereafter data were analysed on group and deprivation effects with the Kruskal-Wallis test and post hoc with the Wilcoxon two sample test.

6.3.8 Ethical note

The impact of feed restriction on birds has been studied intensively in broiler breeders, the parent stock of broilers, but their effects are not yet

completely understood. Feed restriction is commonly used in broiler breeders that are kept commercially. Broiler breeders have to be reared and maintained on such a feed restriction to be able to reproduce. Feed restriction may range from 40% to 30% of the ad libitum feed intake between 2 and 6 weeks of age (Savory et al. 1993; De Jong et al. 2002). From 7 to 15 weeks of age feed restriction is about 25% of ad libitum feed intake and thereafter, it increases to 50% at 20 weeks of age. Such a long period of feed restriction has a negative impact on broiler breeder welfare in many ways (Mench 2002). On the other hand, if allowed free access to feed, they soon become obese and suffer from all the problems of obesity, including low fertility and reduced life expectancy, which also can be considered as welfare reducing problems (Savory et al. 1993). In spite of many studies, it is not clear at what level of restriction an optimal level of welfare for broiler breeders is reached (De Jong et al. 2003). Although the birds in our experiment received ad libitum feed for two days after five days of feed restriction, we were aware of the rather severe feed restriction, especially concerning the birds that were provided with 50% of ad libitum feed intake. To control the condition of the young, growing birds, each bird was weighed every weekday. The Wageningen University Committee on Animal Care and Use approved this experiment.

6.4 Results

6.4.1 *Body weights and feeding schedule*

In Figure 6.1, body weights and feeding schedules are shown. The different feeding schedules resulted in different body weights between the two groups after 2 days of feed restriction. The provision of 50% and 75% feed of ad libitum resulted in birds with a body weight of around 50% and 75% of the body weight a broiler normally would have.

6.4.2 *Sessions under deprived condition*

Figure 6.2 shows the maximum number of key pecks for one food reward that birds of both groups achieved during the three test weeks. In the first test week (+2 schedule), the 50%-group achieved a higher maximum number of key pecks (37 vs. 17, $F_{1,10}=14.99$, $p<0.005$, which means 361 vs. 81 key pecks in total) and obtained more food rewards (19 vs. 9, $F_{1,10}=14.90$, $p<0.005$) than the 75%-group. In the second test week (+4 schedule), the

same tendency was found for the maximum number of key pecks (41 vs. 29, $p=0.1$, which means 280 vs. 120 key pecks in total), and for the number of food rewards (11 vs. 8, $p=0.1$). In both test weeks, no effect of changing feed restriction was found. Birds achieved a higher maximum number of key pecks under the progressive ratio of +4 than under the progressive ratio of +2 ($F_{1,10}=8.95$, $p<0.05$). The 50%-group obtained more food rewards with the +2 schedule than with the +4 schedule ($F_{1,12}=5.09$, $p<0.05$), but no difference was found in the 75%-group. When working for the last food reward, the 50%-group and 75%-group had a higher pecking speed (1.02 and 0.93 pecks/s) under the progressive ratio of +4 than under the progressive ratio of +2 (0.82 and 0.78 pecks/s) ($F_{1,68}=15.78$, $p<0.001$), and the 75%-group tended to have a lower pecking speed than the 50%-group ($p=0.05$). The mean pecking speed per food reward was higher under progressive ratio +4 than under +2 ($F_{1,68}=8.77$, $p<0.01$), but did not differ between groups.

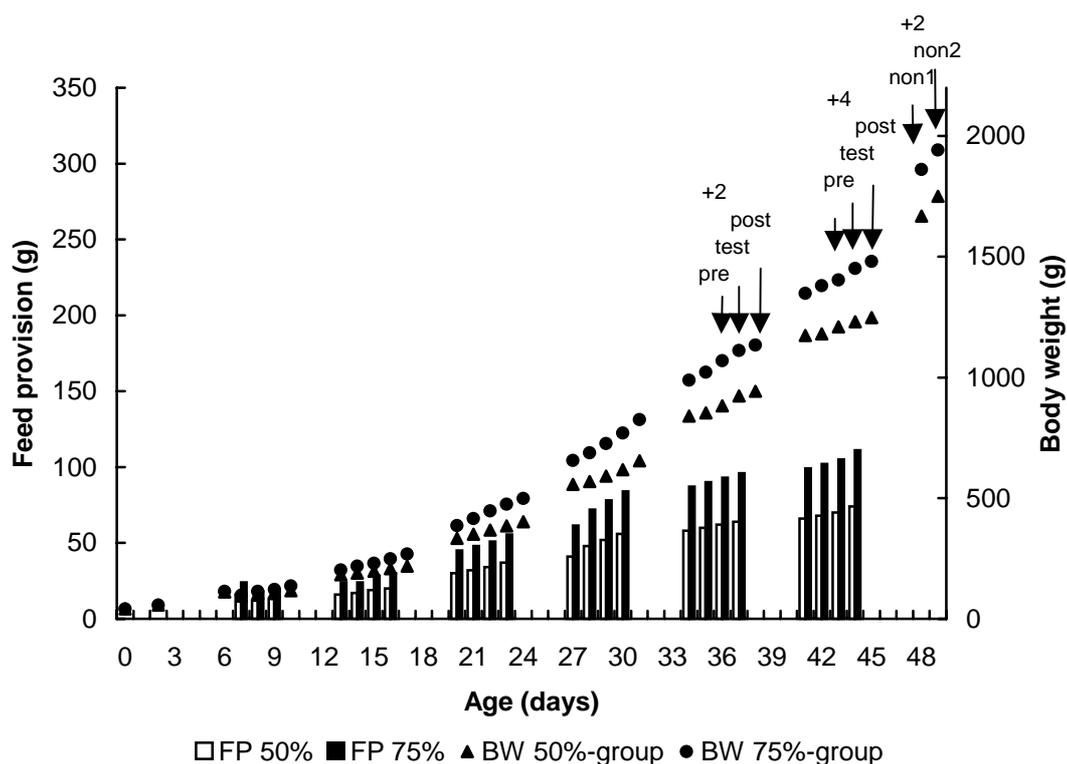


Figure 6.1: Body weight (right y-axis) and feed provision schedule (left y-axis) per group. Indicated are the days pre-control (pre), test, post-control (post), and non-deprived (non) sessions were conducted and which progressive ratio schedule was used.

In both groups, most key pecks were on the key when the key light was on (Fig. 6.3). Birds of the 50%-group had a shorter latency for head-in-

feeder after the feeder was raised in the first test week ($F_{1,10}=6.97$, $p<0.05$) and tended to have a shorter latency in the second test week ($p=0.06$) than the 75%-group (Fig. 6.4). Within the test weeks, no effect of changing feed restriction was found for latency to head-in-feeder. In the pre-control and test sessions, the 50%-group had a shorter latency for head-in-feeder in the first week than in the second week ($F_{1,12}=6.88$, $p<0.05$; $F_{1,12}=5.22$, $p<0.05$) and for the post-control the same tendency was found ($p=0.06$). No such differences were found for the 75%-group.

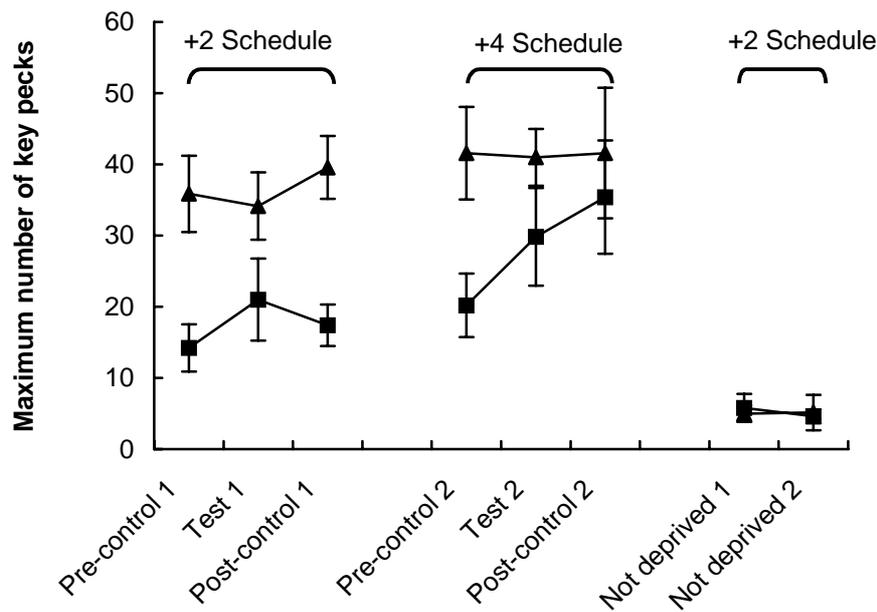


Figure 6.2: The maximum number of key pecks birds achieved for a food reward with a progressive ratio schedule of +2 and +4 under deprived (at 6 and 7 weeks of age) and non-deprived conditions (at 8 weeks of age). Under pre- and post-control sessions birds were subjected to their normal level of feed restriction and under test sessions birds were subjected to either lower (50%-group, ▲) or higher (75%-group, ■) level of feed restriction.

6.4.3 Sessions under non-deprived condition

The maximum number of key pecks birds achieved in non-deprived condition was much lower than under deprived condition (Fig. 6.2). No group effect was found anymore. All birds obtained two or more food rewards in the first non-deprived session. In the second non-deprived session, three birds of the 50%-group did not obtain any food reward. In both non-deprived sessions, the number of obtained food rewards was lower (3.0) than in the deprived conditions. As expected, latency for head-in-feeder after the feeder had raised was increased compared with the deprived conditions (Fig. 6.4). In the first non-deprived session, the percentage of key

pecks when the key light was on was lower than in all other sessions ($F_{7,77}=5.01$, $p<0.001$; Fig. 6.3).

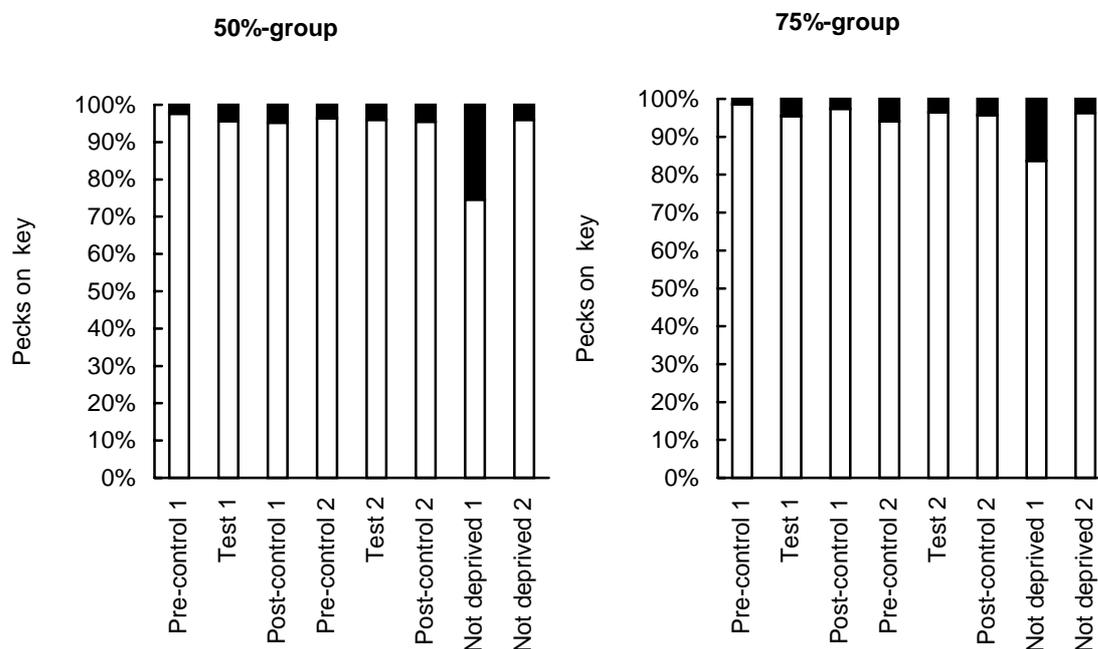


Figure 6.3: Percentage of key pecks when key light was on (white part of bar) and when the key light was off (black part of bar) for both groups.

6.4.4 Behaviour at the end of sessions

Ten birds, three in pre-control 1, three in test 1, and four in post-control 1, took the full 30 min session and did not reach the criterion to stop in the first test week. Only one bird took the full 30 min session without reaching the criterion in the second test week (post-control) and none in the third test week (non-deprived sessions). No behaviour was recorded for the birds that completed the session. Behaviour at the end of a session at the moment that a bird did not reach the required number of key pecks anymore is shown in Table 6.1. Under deprived and non-deprived conditions, the time spent in each of the different behaviours did not differ between the groups. Under deprived conditions, many frustration behaviours, such as head flicks, yawning, wall and floor pecking, vocalisations, and escaping, were found, but only two were found to be significantly different between the two groups. The 50%-group performed significant more yawning than the 75%-group ($Z=-2.11$, $p<0.05$). The 75%-group showed, however, significant more wall and floor pecking in the operant chamber ($Z=2.59$, $p<0.01$). Under non-deprived conditions, a similar effect was found for wall and floor pecking ($Z=2.11$, $p<0.05$).

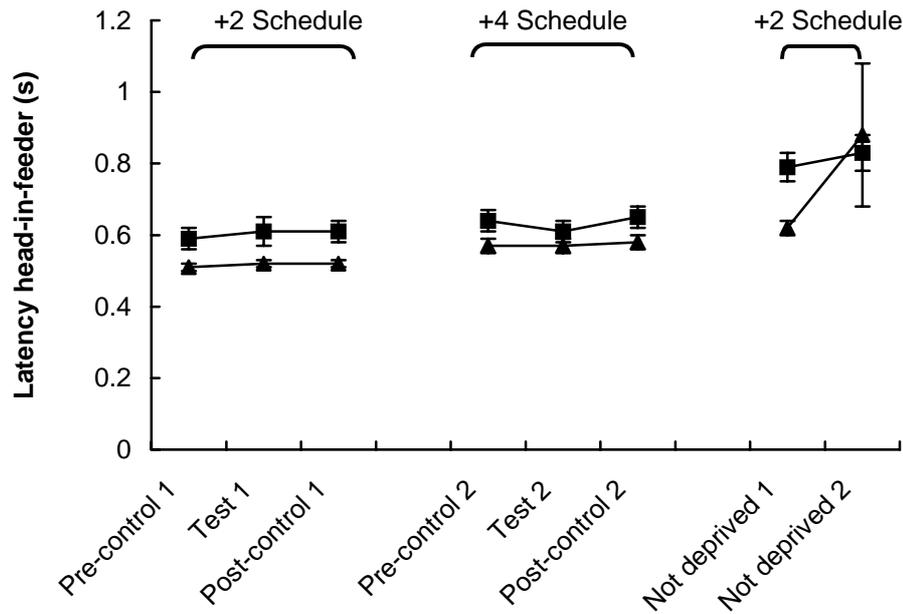


Figure 6.4: Latency to head-in-feeder (s) after the feeder was raised during different sessions with a progressive ratio schedule of +2 and +4 under deprived (at 6 and 7 weeks of age) and non-deprived conditions (at 8 weeks of age). Under pre- and post-control sessions birds were subjected to their normal level of feed restriction and under test sessions birds were subjected to either lower (50%-group, ▲) or higher (75%-group, ■) level of feed restriction.

Table 6.1: Behaviour (percentage or frequency \pm SEM) in the operant chamber during the last 400 s of the four control sessions under deprived condition and the two sessions under non-deprived condition.

Behaviour	50%-group		75%-group	
	Deprived sessions (n=7)	Non-deprived sessions (n=7)	Deprived sessions (n=5)	Non-deprived sessions (n=5)
Walking (%)	22.8 \pm 1.3	1.1 \pm 0.2	27.1 \pm 2.0	11.9 \pm 8.9
Sitting (%)	8.7 \pm 6.2	89.6 \pm 3.7	4.2 \pm 1.5	72.4 \pm 7.1
Standing (%)	44.1 \pm 4.8	8.5 \pm 3.8	51.6 \pm 3.9	12.5 \pm 4.1
Escaping (%)	10.0 \pm 2.1	0.3 \pm 0.2	7.8 \pm 2.5	0.3 \pm 0.3
Preening (%)	13.6 \pm 5.1	0.7 \pm 0.5	8.0 \pm 3.5	0.1 \pm 0.1
Yawning (freq.)	1.2 \pm 0.3	1.6 \pm 0.8	0.3 \pm 0.2	0.4 \pm 0.2
Head flicks (freq.)	5.1 \pm 2.3	2.0 \pm 0.9	2.6 \pm 1.2	0.7 \pm 0.5
Key pecking (freq.)	23.5 \pm 2.1	1.3 \pm 0.5	22.7 \pm 6.1	2.0 \pm 0.9
Vocalisations (freq.)	17.4 \pm 7.5	21.0 \pm 13.5	26.7 \pm 11.6	8.0 \pm 4.6
Wall and floor pecking (freq.)	7.7 \pm 1.2	1.4 \pm 0.7	17.6 \pm 3.9	4.3 \pm 1.1

Behaviour during the two non-deprived sessions differed significantly from the deprived sessions. Under non-deprived conditions, the birds of the 50%-group performed less walking ($Z=3.07$, $p<0.01$), standing ($Z=2.93$,

$p < 0.01$), escaping ($Z = 3.14$, $p < 0.01$), preening ($Z = 2.82$, $p < 0.01$), wall and floor pecking ($Z = 2.81$, $p < 0.01$), key pecking ($Z = 3.07$, $p < 0.01$), and more sitting ($Z = -3.08$, $p < 0.01$) than under deprived conditions. The birds of the 75%-group performed less standing ($Z = 2.51$, $p < 0.05$), escaping ($Z = 2.37$, $p < 0.05$), preening ($Z = 2.59$, $p < 0.01$), wall and floor pecking ($Z = 2.51$, $p < 0.05$), key pecking ($Z = 2.51$, $p < 0.05$) and more sitting ($Z = -2.51$, $p < 0.05$) under non-deprived conditions than under deprived conditions. No differences between deprived and non-deprived conditions were found for number of yawns and head flicks.

6.5 Discussion

The purpose of this study was to measure the maximum price (the maximum number of key pecks) broilers would pay for a food reward under conditions of varying motivation and different body weights. Conditions of varying motivation and body weights were realised by providing 50% or 75% of the amount of feed a broiler would eat compared to having ad libitum feed access. The number of key pecks required for a food reward incremented within a session according to a progressive ratio of either +2 or +4. Also studied was whether birds' behaviour, after they had paid the maximum price, could be described as indicating frustration and if it differed depending on feed restriction or body weight.

This experiment showed that broilers were able to learn an operant task and that they were willing to work for a reinforcer. Birds of the 50%-group paid a higher maximum price for a food reward than the birds of the 75%-group in the first test week and tended to pay a higher maximum price in the second test week. The maximum price broilers paid in the current experiment was lower than the maximum price laying hens fed on 80% of ad libitum paid in a test with a progressive ratio schedule of +2 and +10 (Robinson et al. 1995) and with a progressive ratio of +5 (Foster et al. 1997). The maximum price broilers paid was, however, higher than broiler breeders paid under a progressive ratio of +1 at 8 weeks of age (Savory et al. 1993). Different criteria to stop a session may have caused differences between the studies. Robinson et al. (1995) and Foster et al. (1997) continued a session until 10 consecutive minutes elapsed without a response, while Savory et al. (1993) exposed the birds to sessions of 16 min. We chose for another criterion since we wanted to test all birds in one day, in contradiction with Robinson et al. (1995) and Foster et al. (1997). In

addition, we wanted to realise that birds achieved the maximum price within a session. We took, therefore, a longer session duration than Savory et al. (1993).

The latency for head-in-feeder was lower for the 50%-group than for the 75%-group and the pecking speed for the last food reward tended to be higher. The higher maximum price, higher pecking speed and faster reaction to the raising feeder indicated that the 50%-group was more motivated or physically more capable to obtain food rewards than the 75%-group. However, changing the feed restriction for one day within a group, e.g. giving the 50%-group 75% feed of ad libitum and the 75%-group 50% feed of ad libitum, did not have a significant effect on the maximum price birds paid. It seems that a changed feed restriction on just one day was not enough to have an effect on the motivation to work for food, or did not have an effect because the birds were working to the limits of their physical abilities in both situations.

The 50%-group paid a higher maximum price for the last food reward under the progressive ratio of +4 than under progressive ratio of +2. Similar results were found in laying hens which paid a higher maximum price under a progressive ratio schedule of +10 s than under a +2 schedule (Robinson et al. 1995). The progressive ratio of +1 was, therefore, probably the reason why 8-week-old broiler breeders fed to 25% and 50% of ad libitum paid a lower price (Savory et al. 1993) than the broilers in our experiment. Although in several studies an influence of the used progressive ratio schedule was found, it was expected that the demand for food would be inelastic (Matthews & Ladewig 1994). As mentioned in the introduction, food is a basic resource that is used as a standard in consumer demand tests. When birds carried on with pecking, the 180 s that birds had for the required number of key pecks was never the limiting factor to obtain a food reward. The fact that ten birds worked up to the 30 min cut off in the first test week probably caused the lower maximum price birds paid in the first test week.

Besides different progressive ratios and cut off criterions, differences in duration of food reward, and interval between key light on may have caused differences in results. In addition, age is a factor influencing the price animals would pay for a reward. Savory et al. (1993) and Savory & Lariviere (2000) found that as the birds got older they pecked the key more. In our experiment the birds were one week older, when we used the progressive ratio schedule of +4 instead of +2 and this may have influenced

the results. Finally, testing in social isolation decreased motivation to work for food in pigs (Pedersen et al. 2002), but if this is also the case in poultry is not known.

The maximum price the 75%-group paid increased over days in the second test week. Especially the maximum price in the post-control session of that week was much higher than in the sessions before. It seemed that birds of this group were more motivated by the end of the week. Probably the feed restriction became more severe by then, although no such effect was seen in the 50%-group or in the first test week.

Although the birds in our study were hungry, they were healthy and in a good physical condition. As mentioned in the introduction, broilers voluntarily consume a volume of feed approaching the full capacity of their gastro-intestinal tract. There are indications that hunger and satiety mechanisms in broilers have changed compared with layer chickens (Bokkers & Koene 2003a). It may be that broilers, just like broiler breeders, overeat when they are fed *ad libitum*, and perhaps not as hungry as one would expect.

The task in the operant chamber was not particularly physically challenging. Although based on differences in body weight of the two groups, we expected that heavier birds would sit more and walk less after the last obtained reward, but no differences were found between the groups. Observed behaviour after the last obtained food reward showed that birds experienced a certain level of frustration. Remarkably enough, the 75%-group showed more wall and floor pecking, and the 50%-group showed more yawning. Maybe the difference in hunger caused the difference in kind of frustration behaviour. The frequencies of head flicks and yawning were similar under non-deprived and deprived conditions, indicating that birds seemed to experience some frustration even when they were not hungry. Whether this was due to exposing the birds to the operant chamber or to other aspects is not clear. Although preening is also used as measurement of frustration (Duncan & Wood-Gush 1972), we did not find differences between groups for either percentage of preening or frequencies of preening bouts.

In this study, 26 birds had to be excluded from further experimentation since they did not learn to acquire the operant task in time. Birds seemed to be hungry enough to be motivated to eat, since each bird started to eat immediately after feed was provided in the homepen after a session. Motivational aspects were, therefore, not the problem. However,

there can be several other reasons why these birds did not learn to peck the key. It might be that some birds are more sensitive to environmental cues, stimuli and changes. From our observations, it appeared to be the design of the operant chamber, especially the design and position of the key, which caused some problems for the birds. In our experiment, the box, where the key was fixed on and that was adjustable in height, stuck out of the front panel. An adaptation that was necessarily for growing birds, but also the main difference in comparison with operant chambers of Robinson et al. (1995) and Foster et al. (1997). Birds were standing close to the feeder and from that position, it was not possible to see the key light immediately. So, birds were not strongly attracted to the key light but only to the box in which the key was placed. The choice of starting the training procedure with auto-shaping, due to good experiences of Rodenburg (unpublished data), did not work out very well with young chicks. We experienced that young chicks were more responsive to the hand-shaping training procedure.

We did not measure the exact amount of food eaten during a session, but it was about 1 g per 5 s reward. It is possible that the value of a food reward decreased with satiation. The level of incitement that the accessibility of food will provide to a satiated animal will be less than to a hungry one (Killeen 1995). On the other hand, the obtainment of a food reward is an incitement to start to work for the next food reward (Wiepkema 1971). In our experiment, birds were still hungry at the end of a session. The crop was not full and when feed was provided in the homepen after a session, each bird started to eat immediately.

From this study, we concluded that it is possible to use operant conditioning schemes in broilers, although some birds did not learn the operant task in time. Broilers were motivated and able to work for food. Different levels of long-term feed restriction had an influence on their body weight and on their motivation to work for food. No short-term effect of changing feed restriction was found. Birds showed frustration behaviour after the last food reward had been obtained, indicating that they were still hungry but the price that they had to pay became too high. The results indicate that broilers are still sensitive to different levels of feed restriction and that they can balance their investments and profits to a certain extent. The knowledge gained in this experiment can be used in further experiments, in which motivation and ability to perform behavioural activity in broilers may be unravelled.

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Walking for food in broilers differing in physical ability and motivation



7.1 Abstract

Behaviour in broilers, *Gallus gallus domesticus*, and locomotion in particular, is influenced by physical ability and environmental conditions. Little is known, however, about the motivation to perform behavioural activities in broilers. The distinction between motivation and ability is relevant as a lack of motivation has consequences for the interpretation of inactivity in broilers in terms of welfare. The aim of this study was to measure the effects of motivation and physical ability on the maximum distance broilers would walk for a food reward in an operant runway in a limited length of time. Motivation was manipulated in two ways: by feed deprivation length before testing and by food access length during testing. To study the impact of physical ability, a high and a low body weight group were used. Under similar motivations, birds with a low body weight achieved a higher maximum distance than the birds with a high body weight. Unexpectedly, maximum distance was not influenced by increasing age. Within a body weight group, birds achieved a higher maximum distance after 22.5 h feed deprivation than after 17 h feed deprivation. Birds of both body weight groups achieved a higher maximum distance with 5 s than with 15 s food access. The high growth potential and feed consumption in broilers resulting in a high body weight at young age can be considered as a physical constraint for broilers to be active and probably to behave normally and can, therefore, be interpreted as a welfare reducing factor.

7.2 Introduction

Locomotion has been identified as a prerequisite for several behaviours in chickens. Broiler lines are selected for meat production. In broilers, locomotion decreases with increasing age (Newberry & Hall 1990; Reiter & Bessei 1998; Bokkers & Koene 2003). Behaviour in broilers, and locomotion in particular, is influenced by physical abilities, determined by morphology, lameness, and pain (Danbury et al. 2000; Weeks et al. 2000; Kestin et al. 2001; Corr et al. 2003). It is influenced also by environmental conditions such as space per individual, individuals per space, flock size, temperature, lighting schedule and light intensity (Newberry et al. 1988; Blokhuis & Van der Haar 1990; Gordon 1994; Keeling 1995; Prayitno et al. 1997; Davis et al. 1999; Reiter & Bessei 1999; Hall 2001; McLean et al. 2002; Sanotra et al. 2002).

Little is known about the motivation to perform behaviour in broilers. The distinction between motivation and ability is relevant as a lack of motivation has consequences for the interpretation of inactivity in broilers in terms of welfare. One way to study motivation in animals is to use a consumer demand approach. This approach, based on human economics, is used to study the price (amount of effort) an animal is willing to pay for a commodity, for example food (Lea 1978). When the price is incremented within a certain time, it is possible to determine the maximum price an animal with a certain motivation is willing to pay for a particular commodity. The moment, an individual stops working for the commodity is called the breaking point. When motivation is higher, the maximum price will also be higher. This approach has proven to be useful and effective to determine the maximum number of key pecks broilers with different body weights perform for a food reward in an operant chamber (Bokkers et al. accepted). Since the task in the operant chamber could be performed without moving from position, it was not particularly physically challenging for the birds. The role of body weight as a physical restraint for behavioural abilities could, therefore, not be detected very well. To unravel the different influences of motivation and physical ability on locomotion a next step was necessary. The maximum price had to be determined in a situation where broilers had to invest physical labour (walking) to obtain food under different motivations. Body weight seemed to be of major influence on physical ability (Kestin et al. 2001). By manipulating body weight, the impact of physical ability on the maximum price can be determined. So, body weight was used as an indicator for physical ability, and the assumption was made that when birds showed no clinical signs of disease they would have no other physical disadvantages caused by health problems.

The aim of this study was to measure the effects of motivation and physical ability on the maximum distance (the maximum price) broilers would walk for a food reward in a limited length of time. We manipulated motivation in two ways. Motivation before testing was manipulated by different durations of feed deprivation. Motivation during testing was manipulated by different presentation lengths of food reward. It is known that a size of reward can influence motivation (Collier et al. 1992), but to which side was uncertain. A higher motivation was assumed to result in a higher maximum distance. To study the impact of physical ability, a high and a low body weight group were used. Body weights of the birds of the high body weight group should be as close as possible to the normal body

weight of broilers when fed ad libitum, but hungry enough that we could still train them in an operant chamber. Therefore, we chose for a feed restriction of 90% of ad libitum. For the low body weight group, we aimed for body weights half of ad libitum fed birds. With a feed restriction of 50% of ad libitum this could be reached without affecting their health as shown in Bokkers et al. (accepted). It was expected that broilers with a low body weight would achieve a higher maximum distance than broilers with a high body weight under conditions of similar motivation.

7.3 Materials and methods

7.3.1 Subjects and housing

Thirty-six 1-day-old female chicks of a fast growing genetic broiler line (HI-Y, Hubbard ISA, Wezep, The Netherlands) were obtained from a commercial hatchery (Morren B.V., Lunteren, The Netherlands) and housed at the research accommodation “De Haar” in Wageningen. The first week after arrival, all broiler chicks were kept in one floor pen (0.8 m × 1.6 m) covered with wood shavings and with ad libitum feed and water access. In the first week one bird died. After the first week, each bird was housed individually in a floor pen (0.4 m × 0.8 m) with a bedding of wood shavings. Regular refreshing of the wood shavings kept the bedding in a good condition during the experiment. All walls of each pen were solid and 0.6 m high.

In the first week, birds had continuous light from a heating lamp. Thereafter, a schedule of 18-h light and 6-h dark was used. No daylight entered the house. Temperature was maintained on 32 ± 1 °C at the beginning of the experimental period, and gradually decreased every 3 days with 1 °C to a constant temperature of 20 ± 1 °C.

7.3.2 Feeding procedure

Birds were fed with a conventional broiler feed without antibiotics (Research Diet Services B.V., Wijk bij Duurstede, The Netherlands). To establish two treatment groups with different body weights, sixteen birds were fed with 50% and sixteen birds were fed with 90% of their ad libitum feed consumption. These body weight groups were called the 50%-group and 90%-group respectively. Ad libitum feed consumption was measured in the three control birds. This information was used together with a commercial

manual and data of a previous experiment (Bokkers et al. accepted) to determine the feed provision of the two body weight groups. Birds were weighed before they were assigned to a body weight group to stratify for body weight. Birds were assigned to pens in a way that birds from one body weight group were not placed next to each other. Feed was provided immediately after a bird returned from training or testing (see below).

7.3.3 Body weight and gait score

Each bird was weighed every weekday to control the condition of the birds conscientiously. Once a week, walking performance of each bird was assessed with the gait score according to the method of Kestin et al. (1992). The gait score has a six point scale from zero to five, where 0 = no detectable walking abnormalities, and 5 = incapable of sustained walking on its feet.

7.3.4 Time schedule of experiment

Birds of both body weight groups were trained in an operant chamber to peck a response key from 2 to 5 weeks of age. Birds that did learn the task were tested in an operant runway from 6 to 9 weeks of age.

7.3.5 Apparatus for training

Three automated operant chambers were located in a sound-attenuated room with an ambient temperature similar to that of the home environment. This room was situated next to the room where the birds were housed. Each operant chamber measured 60 cm × 40 cm × 65 cm (l × w × h). The walls of the right side, the back and the ceiling were made of transparent Perspex®. The front wall and the left sidewall were made of wood. One response key, 2 cm in diameter and adjustable in height, was fixed on the left sidewall, 10 cm of the front wall. The key was put initially 10 cm above the metal grid floor. It was put higher as the birds grew, up to 25 cm above the floor. In the key, a red light was present that could be either on or off. A round aperture located in the centre of the front wall (diameter 12 cm, the underside 2 cm above floor level) allowed access to the feeder. The birds could obtain food only when the feeder was raised. The feeder ran on air pressure and it produced some soft hissing when it was raised or lowered. The feeder was filled with the same food as the birds received in the homepen. A photocell at the side of the aperture detected the presence or absence of a bird's head in the feeder. Water was always available at the back of the operant chamber. A 5-W house-light was fixed 8

cm above each operant chamber and was lit only when a session was running. Each operant chamber was operated through a custom-made program using LabView® software (National-Instruments 1994). Changes in key light (on or off), key (peck or no peck) and photocell (head or no head) were automatically recorded and stored on a computer.

7.3.6 Training procedure

Training of all birds of the two body weight groups started at 10 days of age. Each bird was habituated to an operant chamber for 10 min on the first day of training. On the following nine days, hand-shaping was used to train the birds to press the key for a food reward in sessions of 15 min per bird per day. When a bird had learned the task, sessions were reduced to 3 min each day. During hand shaping, the key was illuminated continuously. The observer could give 5-s food access, by pressing a key on the keyboard of the computer, to direct a bird towards the key. Birds that were able to peck the key were subsequently trained in automated operant sessions (15 min per bird per day) during the following 6 days to learn to peck the key adequately. After a variable interval (15 ± 2 s), the key light switched on and a 10-s period started in which a key peck was rewarded with 5-s food access. Immediately after the bird had pecked the key, the key light switched off and the feeder was raised. After 5 s, the feeder was lowered and the next variable interval started. At least 90% of the key pecks had to be performed when the key light was on and the birds' head had to be in the feeder within 3 s after the feeder was raised. At the age of 29 days, ten birds of the 50%-group and nine birds of the 90%-group had reached the training criterion. These birds were used for further testing. The other birds were kept in the experiment on the same feeding schedule. They served as extra controls for body weight development of the birds that were exposed to test sessions.

7.3.7 Apparatus for testing

The apparatus for testing was a combination of a runway and the operant chamber as described above. We called it the operant runway. It was placed in a sound-attenuated room next to a control room with the computer. The operant runway was 430 cm \times 44 cm \times 50 cm (l \times w \times h). The sidewalls were made of plywood and the bottom was made of steel plate covered with synthetic wire mesh to provide a homogeneous, non-slippery surface for the birds to walk on. A rail was mounted on the left sidewall at

15-cm height from the front panel of the operant chamber to the end of the runway. The response key where the birds had to peck on was similar to the response key in the operant chamber and was fixed on the rail at 25 cm above the floor. It could move along the rail via a steel wire, driven by an electric motor. The moveable key was controlled by the observer in the adjacent control room. Movement of the key was manually operated by the observer via a control box. On this control box, a counter displayed the distance (cm) the key had moved along the rail. Food access was realised with a similar feeder as in the operant chamber.

Two colour cameras and a microphone connected with video recorders and televisions made it possible to record and to control each session from the control room. With the exception of the key movement, the operant runway operated through a custom-made program using LabView® software (National-Instruments 1994).

7.3.8 Testing procedure

Birds were habituated to the operant runway in 20 min sessions for five days. Birds had to peck the key for 5-s food access, according to the procedure of the operant chamber, but now the key moved from position when the bird was with its head in the feeder. The key moved to and fro with steps of 5 cm and not further away than 50 cm of the feeder. Birds adapted very quickly to the noises of the moving key and no external signs of disturbance were observed after the first habituation session.

After habituation, birds were tested in the operant runway for three weeks, five days per week, in one session a day. Each bird was tested at about the same time each day. At 6, 7, 8 and 9 weeks of age on Mondays, the birds were tested after being fed their initial daily ratio (50% respectively 90% of ad libitum) for three days. At 6, 7 and 8 weeks of age on Tuesday, Wednesday, Thursday and Friday, birds were tested with two treatments according to a 2×2 factorial arrangement. For that purpose, birds were randomly assigned to four batches and the batches were assigned to the treatments with help of a Latin Square (Table 7.1). One treatment was applied to manipulate the motivation before testing by depriving the birds 22.5 h and 17.0 h from feed. That meant that the birds could eat ad libitum for 1.5 h or 7.0 h the day before testing. These feeding periods were chosen to be about the equivalent of 50% and 90% of ad libitum feed access. Birds with different body dimensions could eat to their own physical capacity. The amount of feed eaten was measured by weighing the feeder in the homepen

before and after feed provision. The other treatment was applied to manipulate the motivation during testing in the operant runway by giving the birds food access of 5 s or 15 s per key peck. At 9 weeks of age, birds were tested without key movement to detect the number of food rewards birds could obtain in 20 min without walking (0-test).

Table 7.1: Schedule used to manipulate motivation before and during testing. The two treatments, 17.0 h vs. 22.5 h feed deprivation (Depriv) and 5 s or 15 s food access length (Access), were assigned to the four batches according to this schedule at 6, 7, and 8 weeks of age. Each batch consisted partly of birds of the 50%-group and partly of birds of the 90%-group.

Batch	Tuesday		Wednesday		Thursday		Friday	
	Depriv	Access	Depriv	Access	Depriv	Access	Depriv	Access
	(h)	(s)	(h)	(s)	(h)	(s)	(h)	(s)
1	22.5	5	17.0	5	22.5	15	17.0	15
2	17.0	5	17.0	15	22.5	5	22.5	15
3	17.0	15	22.5	15	17.0	5	22.5	5
4	22.5	15	22.5	5	17.0	15	17.0	5

Details of the testing procedure on an individual trial were as follows: (a) bird is taken out of the homepen, weighed, and is placed into the operant runway in front of the feeder; (b) the session is started; (c) key light is switched on and the bird has 60 s to peck the key; (d) after the key is pecked the feeder raises and the bird has 60 s to walk to the feeder; (e) when the head of the bird is in the feeder the feeding time starts; (f) meanwhile the key is moved 5 cm further away from the feeder; (g) when the feeder is lowered, the key light is switched off and after an interval of 2 ± 1 s the procedure continues at (c); (h) when the bird does not peck the key in 60 s or does not reach the feeder in 60 s then the procedure continues at (c) until the session time of 20 minutes is completed; (i) after the end of the session, the bird is taken out of the operant runway and receives its feed in the homepen. The 20 min of a session were always fully completed.

The maximum distance was the distance between feeder and key at the moment a bird had not pecked the key for 3 min (breaking point). When a bird continued walking for the whole session the maximum distance was censored and an estimation of the maximum distance was made by measuring the distance between feeder and key after 20 min.

The total distance walked was related to the maximum distance, following the equation:

$$y = \sum_{n=1} 2(n \times i)$$

where,

y = total distance walked

n = number of food rewards

i = distance (5 cm) that the key is moved away from the feeder per reward

Since the maximum distance between key and feeder was 415 cm, the total distance walked could be 34860 cm at maximum. Note that the total distance walked was not necessarily the real distance walked, because birds could walk through the runway without executing their task.

7.3.9 Statistical analysis

All analyses were performed using statistical software from the SAS Institute Inc. (SAS® 1996). Effect of body weight group (50%-group vs. 90%-group) on maximum distance was analysed with an analysis of variance (GLM procedure) with age, feed deprivation (17.0 versus 22.5 h) and food access length (5 versus 15 s) as repeated measures. To study age effects orthogonal polynomial contrasts were used (Sokal & Rohlf 1969, pp 468-476). Data were square root transformed to obtain homogeneity of variances.

Maximum distance in the tests on Mondays when birds had received 50% and 90% feed for 3 days, and body weight were analysed in a similar way with only age as repeated measurements. The 0-test was analysed with the factor body weight group using the GLM procedure. Feed consumption was analysed with the factors body weight group and duration of feed provision and age as repeated measurement.

7.3.10 Ethical note

Although in an earlier experiment a feed restriction of 50% did not give any health or other problems for broilers besides hunger (Bokkers et al. accepted), we were aware that such a feed restriction was rather severe. The birds were followed attentively each day to control their condition. Additionally, body weight of each bird was measured each weekday. The established principles of laboratory animal use and care were followed, as well as, the Dutch law on animal experiments, which complies with the

ETS123 (council of Europe 1985) and the 86/609/EEC directive. The Wageningen University Committee on Animal Care and Use approved this experiment.

7.4 Results

7.4.1 Body weight and gait score

Body weights of the 50%-group were significantly lower than those of the 90%-group and the control group (ad libitum fed birds) from 12 respectively 13 days of age (Fig. 7.1). The 90%-group was significantly lighter than the ad libitum fed birds from 16 days of age on. At 61 days of age (end of the experiment), birds of the 50%-group weighed 2080.3 ± 40.6 g and birds of the 90%-group 2536.0 ± 31.4 g. This was, respectively, 63.4% and 77.3 % of the control group that weighed 3282.5 ± 31.8 g. The influence of the deprivation schedule on body weight development in the 50%- and 90%-group is illustrated in Figure 7.1. Six birds of the 50%-group and six birds of the 90%-group, that were not tested in the operant runway, but were kept on the diet of the group they originally belonged to, weighed, respectively, 52.9% and 84.0% of the ad libitum fed birds at 61 days of age.

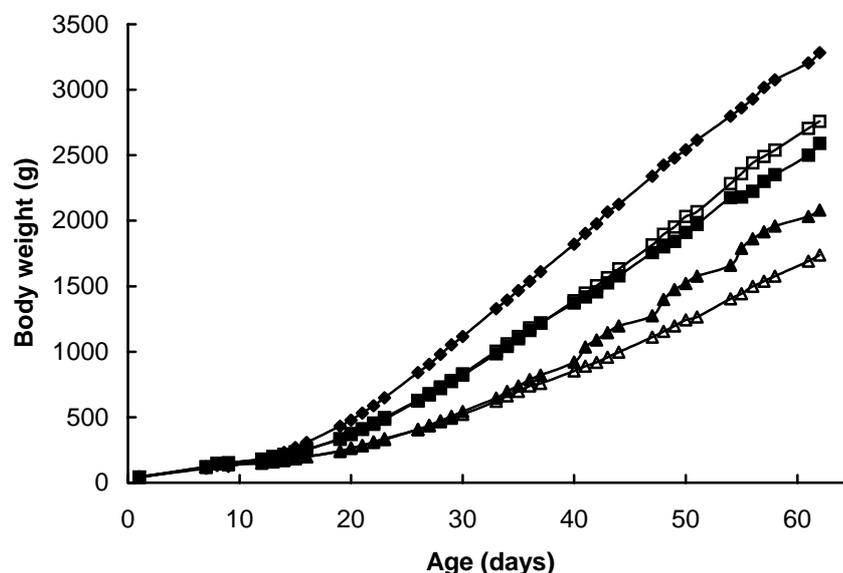


Figure 7.1: Body weights of the test (solid triangle) and the control (open triangle) birds of the 50%-group, of the test (solid square) and control (open square) birds of the 90%-group and of the ad libitum fed control birds (solid rhomb).

The assessed gait score of all individuals tested was zero, except for one bird of the 90%-group that showed a gait abnormality (gait score = 2) on three days in the second test week. This bird was excluded from maximum distance analysis on those days.

7.4.2 Feed consumption

Feed consumption before testing when the birds were provided with 1.5 h and 7 h feed is shown in Figure 7.2. Feed consumption increased linearly with age ($F_{1,32}=108.27$, $p<0.001$). In 7 h, the birds consumed more feed than in 1.5 h ($F_{1,32}=376.83$, $p<0.001$) and an interaction effect between duration of feed provision and group was found ($F_{1,32}=14.91$, $p<0.001$). In 1.5 h, the 50%-group consumed more feed than the 90%-group at 6 and 7 weeks of age ($p<0.05$). In 7 h, the 90%-group consumed more feed than the 50%-group at 6 weeks of age ($p<0.05$).

The feed consumption in the homepen during the 12 testing days was 1350 and 1352 g for the 50%- and 90%-group, respectively. The total feed consumption in the homepen of a test bird of the 50%-group and 90%-group was 3513 g and 5287 g from 15 to 61 days of age, which was 58% and 86% of the feed consumption of the control birds.

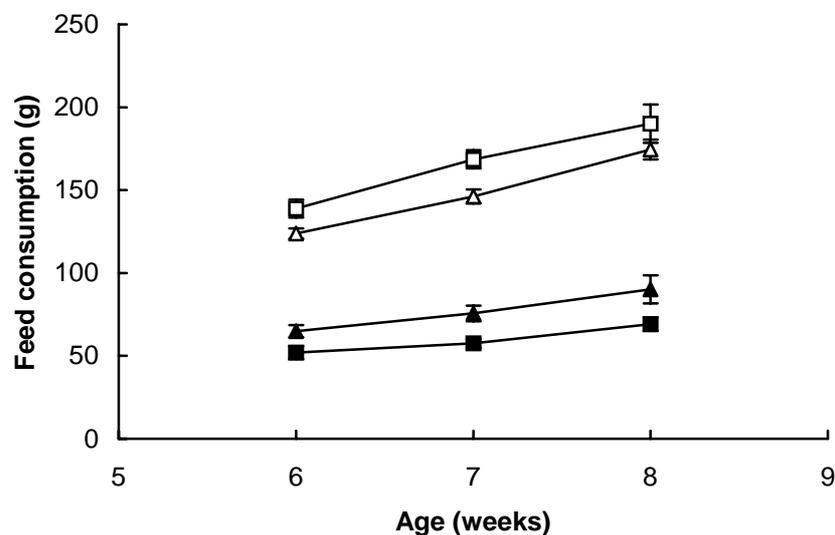


Figure 7.2: Feed consumption (g) before testing of the birds of the 50%-group with 1.5 h (solid triangle) and 7 h (open triangle) feed provision and of the birds of the 90%-group with 1.5 h (solid square) and 7 h (open square) feed provision.

The total feed consumption in the homepen of the 50%, the 90% and the ad libitum fed control birds was 2930 g, 5325 g and 6093 g from 15 to

61 days of age. The 50% and 90% control birds consumed, respectively, 48% and 87% of the ad libitum fed control birds.

Feed consumption in the operant runway could not be measured, but an estimation was made by measuring the feed consumption in the homepen when providing feed for 5 respectively 15 s. Although this was a rather rough estimation, we found that a bird consumed about 1 g of feed in 5 s and about 2 g of feed in 15 s.

7.4.3 Maximum distance

After 3 days of the normal feed restriction schedule, birds of the 50%-group achieved a higher maximum distance than the birds of the 90%-group ($F_{1,17}=91.71$, $p<0.001$), with no age effect (Fig. 7.3).

In the tests with the two additional treatments (feed deprivation and food access length), birds of the 50%-group achieved a higher maximum distance than birds of the 90%-group ($F_{1,17}=5.85$, $p<0.05$). For both treatments, no age effect was found ($p=0.45$), which means that the maximum distance that the birds achieved did not change with increasing age and body weight. Maximum distance over treatments was 155.0 ± 8.6 , 157.2 ± 9.2 , and 149.6 ± 9.4 cm at 6, 7, and 8 weeks of age.

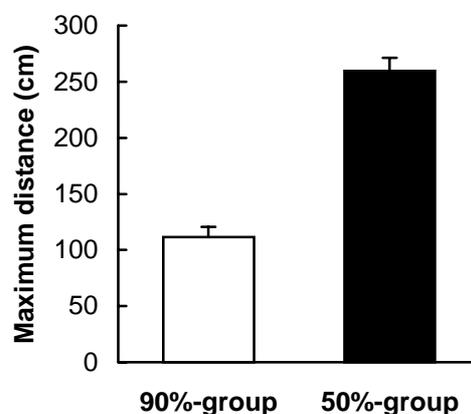


Figure 7.3: Maximum distance (cm) achieved by the birds of the 90%-group and 50%-group after three days of normal feed restriction schedule.

An overall feed deprivation effect was found for the maximum distance ($F_{1,17}=7.10$, $p<0.05$). Birds of both groups walked significantly more after 22.5 h than after 17.0 h feed deprivation before testing (Fig. 7.4). No group effect for the maximum distance was found.

An overall effect for food access length ($F_{1,17}=62.92$, $p<0.001$) and a group effect ($F_{1,17}=20.79$, $p<0.001$) were found for the maximum distance

(Fig. 7.4). Birds achieved a higher maximum distance with 5 s than with 15 s food access and that this effect was stronger in the 50%-group than in the 90%-group.

To illustrate how far the birds walked in total, the total distance walked is given in Table 7.2. The statistics of total distance walked were consistent with the statistics of maximum distance and therefore not given here. The maximum number of food rewards obtained with walking was 69. This was achieved by an individual of the 50%-group in a test with the normal feeding schedule. This bird achieved a maximum distance of 345 cm, which means a total distance of 241.5 m.

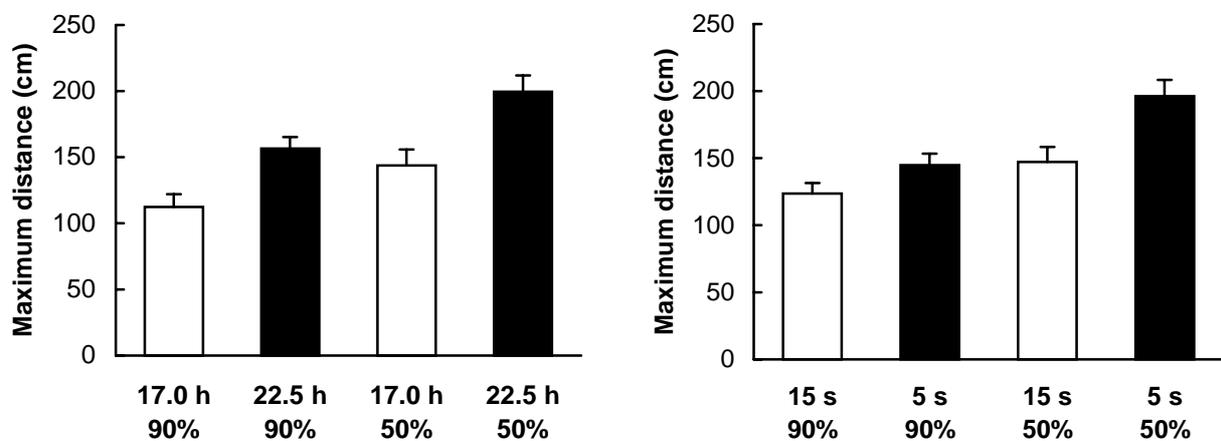


Figure 7.4: Maximum distance (cm) achieved by the birds of the 90%-group and 50%-group with 17.0 h and 22.5 h feed deprivation before testing (left) and with 15 and 5 s food access during testing (right).

Table 7.2: Total distance walked (m) over the weeks in both body weight groups under different motivations. Normal feed restriction means that birds were provided with 50% (50%-group) respectively 90% (90%-group) of ad libitum during three days.

Group	After normal feed restriction	Deprivation before testing		Food access length	
		17.0 h	22.5 h	5 s	15 s
50% (n=10)	154.3 ± 11.4	56.7 ± 7.9	95.4 ± 8.5	96.4 ± 9.0	55.8 ± 6.0
90% (n=9)	37.7 ± 5.1	35.1 ± 4.2	60.4 ± 6.6	57.5 ± 6.9	37.9 ± 3.9

7.4.4 The 0-test

In the test where the key did not move away from the feeder (0-test), the 50%-group tended to obtain more food rewards (114.7 ± 8.0) than the 90%-group (92.6 ± 10.4) ($F_{1,18}=2.99$, $p=0.1$).

7.5 Discussion

The aim of this study was to measure the effects of motivation and physical ability on the maximum distance broilers would walk for a food reward in a limited length of time. Birds were tested in an operant runway, while their motivation was manipulated in two ways. Motivation before testing was manipulated by different durations of feed deprivation. Motivation during testing was manipulated by different duration of food access. Different physical abilities were realised by using two body weight groups, one with a low body weight (fed 50% of ad libitum) and one with a high body weight (fed 90% of ad libitum).

In both treatments, deprivation length and food access length, the birds of the 50%-group achieved a higher maximum distance in the operant runway than the birds of the 90%-group when tested with a similar motivation. We suggest, therefore, that birds' performance (physical ability) was hampered by body weight. In which way body weight hampered the birds in our study was not investigated. Although body weight has been indicated earlier as an important factor for the development of lameness in broilers (Kestin et al. 2001) and fast growth altered the gait of broilers (Corr et al. 2003), we did not observe visible gait abnormalities or other clinical signs of diseases.

As expected, birds of the 50%-group reached a higher maximum distance than the 90%-group after three days on their normal feed restriction schedule. This result showed that keeping birds on 50% of ad libitum feed increased their motivation or ability as compared to keeping birds on 90% of ad libitum.

In the operant runway, birds did not stop walking for the next food reward because their crop was filled, since they started to eat immediately after their food was provided in the homepen after a session. In addition, in the 0-test the number of obtained food rewards was much higher than in the sessions where birds had to walk to obtain food rewards and even then they started to eat immediately in the homepen. It seemed that the birds in the sessions with walking put a maximum effort to obtain food rewards.

Body weights of both groups were higher (50%-group) and lower (90%-group) than aimed for. This was an effect of the feed deprivation to manipulate motivation before testing as shown in Figure 7.1. Two days per week, birds of the 50%-group could eat for 7.0 h. During that period, they could consume more feed than the other two test days when they were

provided with feed for 1.5 h, or the days that they were provided with 50% of their daily ad libitum intake. In a similar way, birds of the 90%-group consumed less feed than normal on the days they were provided with feed for only 1.5 h. The total feed consumption in the homepen was about equal for both groups during testing days. Remarkably, birds of the 50%-group consumed more feed in 1.5 h than birds of the 90%-group and that birds of the 90%-group consumed more feed in 7.0 h than the 50%-group. Birds of the 50%-group seemed to be more used to fill their crop and intestines in a short period. Differences in performance in the operant runway between the two body weight groups may be expected to be greater when body weight differences increased.

In our experiment, the increasing body weight with increasing age had no influence on the maximum distance. It seemed that the daily physical training in the operant runway compensated for the increasing body weight and probably prevented the birds from developing gait abnormalities. Reiter and Bessei (1998) showed that repeated training improved total distance walked, but also bone strength of the legs. They tested fast growing broilers (high body weight) and slow growing broilers (low body weight) on a treadmill to walk for food after 4 h feed deprivation in 20-min sessions. With that study in mind, we expected an improvement of physical abilities due to training in our experiment, but we did not expect to find no age effect. We considered to use fast- and slow growing strains in this experiment, but we preferred to study birds with the same genetic background and to manipulate body weight within this group.

The total distance walked we measured in this experiment was probably an underestimate of the real distance that the birds had walked. In reality, most birds walked more since they sometimes walked to and fro between feeder and key without obtaining a reward. Although, compared to Reiter and Bessei (1998), we deprived the birds longer from feed and birds spent time on consuming food rewards, the total distance walked in 20 min in our experiment was rather comparable with their results. It is interesting to note that the long and short feed deprivation before testing had a similar effect than the short and long food access length on total distance walked. It seemed that motivation was influenced with a similar strength with 17.0 h feed deprivation and 15 s food access, and with 22.5 h feed deprivation and 5 s food access. In the 90%-group, 17.0 h deprivation and 15 s food access resulted in a similar total distance walked as after three days of 90% feed restriction, while 22.5 h feed deprivation and 5 s food access did not result

in a similar distance in the 50%-group after three days of 50% feed restriction. It seemed that the birds of the 50%-group were more hungry and, therefore, more motivated to obtain food rewards after three days of 50% feed restriction. So, they continued longer with walking in the operant runway.

Different feed deprivations before testing resulted in different motivations in both body weight groups. Such a result was not found in a similar experiment where birds of 50% and 75% body weight groups had to peck a key without walking between food rewards according to progressive ratio schedules (Bokkers et al. accepted). In that study, a one-day change of feed restriction did not result in a higher or lower performance in the operant chamber. In the light of the present study, those results may be interpreted as a body weight effect. All birds worked to their maximum capacity, but the physical ability of birds with 75% body weight seemed to be worse than of birds with 50% body weight.

Manipulating motivation during testing had also an influence on both body weight groups, although the effect was stronger in the 50%-group. Five seconds food access resulted in a higher maximum distance than 15 s food access. In literature, there seems to be a conflict between the classical principle that greater reinforcement produces greater response strength, with the findings that such a relation does not necessarily exists (Collier et al. 1992). Pecking itself and the rewards could give a positive feedback (Sterrit & Smith 1965; Wiepkema 1971). Our experiment showed that a short access to food gave a stronger positive feed back to continue to work for the next food reward than a longer access to food. In a study of Zimmerman et al. (2000), a similar effect was examined. They found no reduction of the number of gavel-calls, an indicator for the intensity of frustration, was found for extra food access time. Both in our experiment and the experiment of Zimmerman et al. (2000), the bonus of extra access length did not result in a higher motivation.

It is stated that the high growth potential and feed consumption in broilers resulting in a high body weight at a young age have increased metabolism beyond the physiologic ability of the heart, lungs, liver and skeleton to perform normally and to keep growth in balance (Julian 1994). Indicative is the fact that broiler breeders, the parent stock of broilers, are kept on severe feed restriction schedules since rearing, to protect these birds from obesity (Savory et al. 1993). It is known from human literature that a high body weight as a consequence, for example, of obesity has an influence

on respiratory functioning, physical functioning and heart and vascular system (Ebbeling et al. 2002). In our study is shown that broilers are motivated to walk long distances for food and that their motivation can be manipulated. In addition, with similar motivation, broilers with a low body weight achieved a higher maximum distance in the operant runway than broilers with a high body weight. High body weight as an indicator for physical ability can be considered as a constraint for broilers to be active and probably to behave normally. Parallel to the effect of high body weight on the quality of life in humans (Kushner & Foster 2000), the abnormal high body weight at a young age can be interpreted as a welfare reducing factor in broilers.

7.6 Acknowledgements

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General discussion



8.1 Introduction

Broilers show a pronounced decrease in activity over a period of a few weeks. The genetic selection for high growth rate, with the associated high body weight, may have such a negative impact on the physical ability of broilers that it hampers the birds in the expression of behaviours for which they are motivated. The aim of this thesis was to gain more insight into the influence of both motivation and ability on behavioural activity in broilers. The distinction between motivation and ability is relevant for the interpretation of behavioural activity in broilers in terms of welfare, as was indicated in the EU report on the welfare of broiler chickens (EU 2000). If broilers are not motivated to perform various behaviour patterns, the welfare implications will be limited. However, if broilers are motivated to behave, but the expression of behaviour is hampered due to physical or environmental limitations, the welfare implications will be major. In this last Chapter, the most important results of this thesis and the implications of these results will be discussed.

8.2 Environmental conditions

In Chapter 1, the determinative factors for physical ability and environmental conditions that have an influence on behavioural activity in broilers were described. In Chapter 2, it was shown that when broilers are kept in environmental conditions with enough space, litter of good quality, and well-designed perches, they displayed the complete behavioural repertoire of chickens (*Gallus gallus*), even until 12 weeks of age, when the broilers had grown to extremely high body weights. Based on the results of Chapter 2 and experiments in which the environment was more or less enriched (see Table 8.1), the general assumption that broilers are not motivated to perform other behaviours than eating, drinking and resting can be rejected. However, broilers performed many behaviours in a sitting posture instead of in a standing posture, which is not normal for chickens. In addition, the time budget of broilers was different from that of slow-growing broilers (Chapter 2) and layer chickens (Bokkers et al. 2000). Differences in behavioural performance between broilers and these other types of chicken increased with age. Thus, even when the facilities in the environment are sufficient and of a good quality, behavioural activity decreases with age in broilers. In this perspective, it is important to notice that broilers maintained to perform two typical chicken behaviours,

dustbathing and perching. The motivation to perform these behaviours was apparently so strong that birds kept on performing them, in spite of their high body weight. Enough space, availability of well-designed perches and bedding of good quality are essential prerequisites for the performance of behaviours such as perching and dustbathing.

Table 8.1: *Some experiments in which the environment was more or less enriched and the influence on the behaviour of broilers.*

Reference	Environmental change	Result
Hughes & Elson (1977)	Perches	Usage of perches
Blokhuis & Van der Haar (1990)	Low stocking density	More walking, pecking and scratching
Weeks et al. (1994)	Extra space outdoors	More running and ground pecking
Newberry (1999)	Intermittently accessible area with different facilities	Motivated to seek opportunities and exploration of novel stimuli
Kells et al. (2001)	Straw bales	Exploring bales and perch on it. Increased activity, such as walking and running
Knierim (2001)	Sand, cut straw	Dustbathing on sand and more ground pecking on sand and straw
Bizeray et al. (2002)	Barriers	Perching, greater variety of locomotor patterns
Dawkins et al. (2003)	Extra space outdoors	Use of outdoor area depends on furnishing and weather

In general, it can be concluded that broilers are still able to display all chicken behaviours when environmental conditions are not restrictive. Thus, even for one of the most on production traits selected animals is shown that behavioural modifications which occurred during domestication were more quantitative than qualitative, as was stated by Price (1999). Although, it could be argued that performing behaviours in a sitting posture that are normally performed in a standing posture is a qualitative modification. The criteria for environmental conditions still have to be determined for broilers. A first attempt is made by determining the floor area that is needed by a broiler to perform different behavioural patterns and to function in a social environment (Bokkers et al. unpublished). Preliminary results showed that the current commercial stocking densities are much too high for broilers to perform all behaviour patterns undisturbed. Several behaviours cannot be performed because the design of the housing is lacking some essential utilities such as perches and useful bedding.

8.3 Physical ability

In this thesis, we tried to gain insight into the role of physical ability on behavioural activity in several ways. According to literature, body weight is a determinative factor for restricting the physical abilities (Kestin et al. 2001). Body weight itself is a handicap, but it is also associated with skeletal and metabolic abnormalities (Chapter 1). Results of Chapter 5 showed that a slow-growing broiler strain with a low body weight walked faster through a runway than a fast-growing broiler strain with a high body weight. A similar result was found in a runway experiment with broilers (high body weight) and layer chicks (low body weight) from 5 to 7 weeks of age (Bokkers & Koene 2000). Although these studies revealed interesting results, the disadvantage was that the comparison between strains incorporated unknown genetic effects. A comparison between birds with a similar genetic background would give better indications of the role of body weight and physical ability on behavioural activity. Therefore, we conducted some experiments with only one strain of fast-growing broilers (Chapter 4, 6 and 7). In Chapter 4, we tried to manipulate body weight, and thus physical ability, without depriving the birds from feed by providing two types of feed. Half of the birds were provided with feed with a low energy and protein content and half of the birds with feed with a high energy and protein content. Unexpectedly, type of feed had no effect on feed intake or growth. The latter finding was surprising because with a similar amount of feed intake, the higher energy and protein content was supposed to have an effect on body weight. On the other hand, this result was in line with the results of Chapter 3. Broilers eat to their maximum physical capacity, because their hunger and satiety mechanisms have changed. In addition, type of feed had also no effect on behavioural activity in the homepen (Bokkers, unpublished data).

In Chapter 5, slow- and fast-growing broiler strains were feed deprived for 3 h or 24 h before testing to manipulate motivation. Walking speed in the runway decreased with increasing age in both 3 h and 24 h deprived birds. In that experiment, a positive correlation was found between body weight and latency to reach the end of the runway, indicating that the physical ability of the birds to fulfil a short task was reduced with a higher body weight. In Chapter 6 and 7, we chose for feed deprivation to establish diverging body weight groups. Feed deprivation, however, may also induce hunger feelings in the birds and thus influence the motivation to work for

food. In Chapter 6, broilers had to peck a key for a food reward according to an incrementing schedule. They had to work harder (give more key pecks) after a food reward to obtain the next food reward. In Chapter 7, broilers had to walk an increasing distance to obtain a next food reward. The experiment of Chapter 6 was not particularly physically challenging, in contrast to the experiment described in Chapter 7. In Chapter 7, we showed that with a similar motivation, birds with a high body weight walked a shorter distance than birds with a low body weight. This indicates that body weight may be a physical handicap for the birds.

In general, our experimental birds did not develop serious gait problems. Several factors must have had a positive influence on the development of a good skeleton and strong muscles in our experiments. In Chapter 2, post mortem analysis showed that even at 12 weeks of age not many serious physical abnormalities were found. The favourable housing conditions in that experiment may have helped to prevent the birds from serious disorders. The feed restriction that was used to manipulate motivation and body weight in some *ex situ* experiments also have had a positive influence on leg condition and walking ability of these birds. These effects were probably mainly a result of reduced body weight as was shown by Su et al. (1999). The exercise in *ex situ* experiments like walking in the runway must have had a positive influence on leg condition, as was found by Thorp and Duff (1988) and Reiter and Bessei (1998). The fact that we did not find gait abnormalities in the experiments of Chapter 6 and 7 indicates that the effect of body weight on performance in the operant chamber and operant runway was not confounded by leg problems. The birds in those experiments were not restricted by leg disorders, but seemed to be more hampered by restrictions due to body weight with the associated consequences of getting tired more quickly.

8.4 Motivation

The most remarkable result of Chapter 3 was that no relationship was found between meal length and subsequent interval to the next meal (postprandial correlation) in broilers. This was in contrast to the layer chickens in that experiment, but also in contrast to animals studied by other researchers. In both broilers and layer chickens, a positive relationship was found between interval length and successive meal length (preprandial correlation). The results indicated that the satiety mechanism

is dominant over the hunger mechanism in broilers, while in layer chickens these mechanisms are in balance. Broilers seemed to have an abnormally high motivation to eat, which was already indicated by Siegel and Wisman (1966). This may explain why broilers were willing to put a short physical effort (walking) for a food reward under non-deprived conditions (Chapter 4). Motivation to eat is probably the only motivational aspect that has changed due to selection on fast growth and low feed conversion. This is reflected in the changed balance between hunger and satiety mechanisms. However, the motivation to obtain food rewards could still be manipulated by different feed deprivation levels, as was shown in Chapter 5, 6 and 7. The longer birds were deprived from feed the faster they walked (Chapter 5), the more they pecked on a key in an operant test (Chapter 6) and the longer distance they walked (Chapter 7) for a food reward.

The runway experiments in Chapter 4 and 5 and more clearly the operant experiments in Chapter 6 and 7, showed that the learning capacities of broilers are similar to those of, for example, laying hens (Olsson 2001; Jarvis et al. 2002; Rodenburg et al. 2002; Cooper & Appleby 2003). The consumer demand approach as described in Chapter 6, revealed useful information about motivational aspects. We showed that broilers were willing and able to execute an operant task. The fact that just a small amount of birds did learn the task in that experiment could be blamed on the used training procedure and the design of the operant chamber. In Chapter 7, the gained experience was used to choose a training method and develop an operant environment more tailored to young broilers, which resulted in much better training results. This indicated that it is not always the animal that could be blamed for unsuccessful training in learning experiments. In many cases, it will be the imperfections of the experimental design or training procedures that causes difficulties.

The results of Chapter 6 showed that motivation of broilers can be manipulated by long-term feed restriction. The birds, however, did not react with more or less key pecks on the motivational manipulation, even though the difference between the two groups in maximum key pecks remained the same. It is suggested that birds in both situations worked to their maximum physical ability. The heavier birds were not able to obtain as many rewards as the lighter birds did. After birds had achieved their breaking point (stopped pecking on the key for the next food reward), they showed frustration behaviour, indicating that they were not full, but stopped because the effort became too large. In Chapter 7, we let the birds work in a

task that was physically more demanding. We tested birds under different motivations until they stopped walking for food rewards. It was shown that birds with a higher motivation walked longer distances for a food reward than birds with a low motivation.

In all *ex situ* tests, food was used as reward. The advantage of using food is that it is a primary need for every living animal and therefore a strong reinforcer. It has been widely used by many researchers in operant experiments with different animals. Broilers perhaps react extra strong to a food reward because of their disturbed hunger and satiety mechanisms and high motivation to eat. Even in non-deprived conditions, broilers walked for a (luxury) food reward. In Chapter 2, we showed that broilers are also motivated to use perches, and bedding. Furthermore, broilers were motivated to be close to conspecifics and live in a social environment, illustrated by the large number of vocalisations when birds were isolated from the group for *ex situ* experiments (Chapter 4 and 5). However, we did not challenge them in an *ex situ* experiment to measure the exact strength of their motivation for these kinds of commodities. Such experiments can give valuable results as already is shown in laying hens (Cooper & Appleby 1996; Olsson 2001).

8.5 Animal welfare and implications

A report of the Scientific Committee on Animal Health and Animal Welfare of the European Union made clear that broiler welfare has political attention (EU 2000). However, it is actually not the general public concern that has made broiler welfare a major political issue recent years. An ordinary consumer of poultry meat does not know how chicken meat is produced and that the meat originates from such a young animal with an amazing growth speed. Animal protection organisations evoked the political attention to broiler welfare in several countries (Fraser et al. 2001; RSPCA 2001; De Jong-Timmerman 2003; Turner et al. 2003). But also the producers may have drawn the attention to animal welfare problems in the broiler industry unintentionally, because of high mortality rates due to production diseases, and many leg problems (Baxter et al. 1995). Studies conducted on commercial farms showed clearly that, for example, leg problems, contact dermatitis, and mortality are general phenomena (Thorp & Maxwell 1993; Olkowski & Classen 1995; Ekstrand et al. 1998; Hall 2001; Hellig 2001; Sanotra et al. 2001; Sanotra et al. 2003). Physical ability

seemed to be affected by unfavourable environmental conditions at commercial farms. The unfavourable conditions at commercial farms and the consequences for birds' welfare become even more evident when birds have to be kept longer than expected, as was shown by Butterworth et al. (2002). In our small-scale experiments, the birds were almost never affected by leg problems, and mortality was always very low. Monitoring of birds and management is much easier when birds are kept in small groups with low stocking densities like in the experiments of this thesis.

In the Netherlands, the political attention for animal welfare in the intensified animal production has resulted in several future scenarios published by groups with different interests (LTO 2001; Remmers 2001; RLG 2001; Wijffels 2001). In some reports, special attention is given to the future of poultry production (Alders 1999; De Jong-Timmerman 2003; Van Horne et al. 2003). In these reports, the concern about the welfare of broilers is clearly described, especially in relation to housing conditions, high growth rate and leg problems. According to the Animal Health and Animal Welfare Act in the Netherlands, regulations have to be made for animal husbandry of both agricultural and companion animals. These minimum standards should cover the basic needs of these animals. A first attempt was also made for broilers (RDA 1999), but has not been implemented successfully till now.

The results of this thesis contribute to the discussion about animal welfare and can be used to define minimum standards for keeping broilers. As Fraser (1999) described, the three key issues that cover the concept of animal welfare are: an animal should feel well (motivation), should function well (physical ability) and lead a natural life (environmental conditions). It was shown in this thesis that broilers will perform all normal chicken behaviours when the environmental conditions are not restrictive. Favourable environmental conditions should give the birds opportunities to behave, and, according to Chapter 2 and literature mentioned in Table 8.1, these opportunities will be used by broilers. However, it has to be kept in mind that broilers are young chicks, which under natural conditions explore the environment under guidance of a mother. In commercial broiler production, mothers are lacking. Thus, birds need to learn themselves to use opportunities in the environment or they need to learn it from each other. That may need more time than learning it from a mother, or opportunities may never be used. We also showed that broilers are motivated to work for rewards and that they are able to learn operant tasks.

Thus, broilers are normal functioning animals in a biological sense, with normal motivations to behave and normal learning capacities. However, the motivation to eat seems to have become a dominant motivation. Furthermore, the motivation to perform behaviours seemed to be suppressed by their genetic predetermined high motivation to eat, which is associated with fast growth and high body weight. The latter seems to reduce the physical ability. This handicap together with the limited environmental opportunities impairs the welfare of the broiler, because a bird is blocked to perform behaviour for which it is motivated (frustration).

When birds would have shown no motivation to display behaviour, there would have been no welfare implications. However, this would have raised another ethical dilemma. Do we, as a modern society, want to keep animals that have lost their species-specific behaviour? At least, modern broilers are not the birds that people think: non-motivated, inactive birds. The ethical debate must be held now on environmental restrictions and reduced physical abilities (see for example Rauw et al. 1998; Sandøe et al. 1999; Emmans & Kyriazakis 2000). Although broilers do not live very long, the problems are serious and the size of the broiler industry (in the Netherlands about 330 million birds per year, PVE 2003) ensures that the welfare problems are on an immense scale. An ethical discussion about broilers and their welfare is therefore relevant.

The changed hunger and satiety mechanisms seemed to have strengthened the motivation to eat. Many problems in broilers are a consequence of eating too much. They grow too fast, are too heavy for their age, develop metabolic and skeletal disorders. A rather simple solution for most of these problems is, therefore, to select birds that are less motivated to eat. When besides the adapted breeding goal, environmental conditions are optimised by giving the birds opportunities to behave normally, it seems that broilers can be kept without serious welfare problems. Selection on less motivation to eat would be an advantage for the parents of the broilers, the broiler breeders, as well. Broiler breeders have to be reared and maintained on a feed restriction schedule to be able to reproduce (Savory et al. 1993). After all, broiler breeders have the similar strong eating motivation as broilers. Broiler breeders kept commercially are chronically hungry. The feed restriction gives physiological stress and increased incidence of abnormal behaviour. However, when fed ad libitum, they will become obese, which has also negative consequences. Thus, both the feed restriction as the ad libitum feeding have negative welfare aspects for the birds (Mench 2002). Selection

for less eating motivation would therefore have beneficial effects for these birds. Another option is to use dwarf mothers, as, for example, is done in some slow-growing strains. These dwarf mothers do not have to be fed restricted to be able to reproduce.

8.6 Obesity in humans as a model for broilers

In an attempt to understand better what broilers experience due to their high body weight, a parallel is drawn between broilers and obesity in humans. Obesity in humans is defined as a condition in which there is an excess of body fat resulting in excessive overweight (Inoue et al. 2000). Simply can be said that obesity arises when energy intake is higher than energy expenditure. Obesity in humans is associated with numerous medical and psychological complications and increased mortality (Carpenter et al. 2000; Inoue et al. 2000).

Table 8.2: *Similarities between consequences of obesity in human and of high eating motivation, fast growth and high body weight in broilers on welfare.*

Category	Affecting quality of life in human*	Affecting welfare in broilers
Psychosocial	Poor self-esteem, depression, eating disorders, social inept, discrimination	Eating disorder, frustration
Pulmonary	Sleep-disordered breathing, asthma, exercise intolerance, shortness of breath	Oxygen shortage, panting
Gastrointestinal	Gallbladder disease, fatty liver	Fatty liver
Renal	Kidney diseases	?
Musculoskeletal	Pain of weight-bearing joints, osteoarthritis in knees and hips, decreased mobility, altered gait	Inactive, bone deformities, pain, altered gait
Skin	Heat stress (sweating), hygiene	Heat stress, dirty birds
Neurological	Pseudotumor in the brains	?
Cardiovascular	Dyslipidaemia, hypertension, endothelial dysfunction, heart attack	Heart abnormality and failure, ascites
Endocrine	Type 2 diabetes, precocious puberty	Indications of precocious puberty based on sexual ornaments and vocalisations

*(based on Inoue et al. 2000; Kushner & Foster 2000; Ebbeling et al. 2002)

A general assumption is that someone is obese when he/she is more than 20% above normal weight. Broilers are 9 times heavier than their ancestors at a similar age. So, the consequences of high body weight could be expected similar or even worse than in humans. In Table 8.2, an overview

is given of the consequences of obesity for the quality of life (welfare) in humans and of what we know about the consequences of eating too much and high body weight for the welfare of broilers. In large part, the poorer overall quality of life perceived in humans is due to worse physically functioning (Kushner & Foster 2000). When the parallel is drawn, the welfare of broilers is seriously affected by their physical ability. The various combinations of metabolic and morphologic risk factors and diseases are known as the 'metabolic syndrome' (Inoue et al. 2000), and looks very similar to morphological and metabolic disorders found in broilers. Although we do not know much about the mental state of broilers, we found some indications that broilers showed frustration related behaviours when they were not able to perform behaviour they were motivated to, probably due to the physical restrictions. In general can be concluded that the symptoms of the strong motivation to eat and the physical consequences in broilers, have a remarkable similarity with the symptoms of obesity in humans.

8.7 Conclusions

In this thesis, more insight is gained into the influence of motivation and physical ability on behavioural activity in broilers. Broilers show all normal juvenile chicken behaviours, but with another time budget and many behavioural patterns are shown in a sitting posture. Behaviour changed with increasing age and associated body weight, indicating that body weight may be a handicap for broilers to perform behaviour. Motivation to work for food still can be manipulated and be used in operant learning experiments. Apart from having an abnormal high motivation to eat, broilers are normal, biologically functioning animals. Although many of them experience poorer welfare due to the restrictions of motivated behaviours imposed by their fast growth with associated high body weight or by the environment.

Let us go back now to the initial basic question with regard to broiler behaviour: do they want to behave like a chicken and/or can they behave like a chicken? The answer is: broilers do want to behave like chickens, but are not always able to do so.

8.8 References

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Summary

Summary

Broilers are chickens that are kept commercially under intensive husbandry conditions for poultry meat production. They grow from 50 g to about 2.5 kg in six weeks, their slaughter age. Broilers show a pronounced decrease in activity over these weeks. The genetic selection for high growth rate, with the associated high body weight, may have such a negative impact on the physical ability of broilers that it may hamper the birds in the expression of behaviours for which they are motivated. The aim of this thesis was to gain more insight into the influence of both motivation and ability on behavioural activity in broilers. The distinction between motivation and ability is relevant for the interpretation of behavioural activity in broilers in terms of welfare.

In Chapter 2, the aim was to study the behaviour of fast-growing broilers (standard commercial broilers) and slow-growing broilers (special strain with a growth rate half of ordinary broilers) to 12 weeks of age. They were kept in 16 pens (6 birds per pen) with facilities, such as well-designed perches, enough space, and bedding of good quality. In this way, they could express their behaviour without serious environmental restrictions. Behaviour, posture (sitting or standing) and position (floor or perch) of each individual were recorded several times a day. After 12 weeks, birds were killed and post-mortem examination was conducted to detect physical consequences of the prolonged growth period. Fast and slow growers showed the same behavioural patterns and repertoire, but time budgets of fast and slow growers were different and fast growers performed more behaviours in a sitting posture. Slow growers perched, walked and scratched more than fast growers. Fast growers performed more sitting on the floor, eating and drinking than slow growers. No differences were found for resting, preening, stretching, ground pecking, or dustbathing. With increasing age, time spent on several behaviours changed, and behaviours were performed in sitting position rather than in standing position. Although several physical abnormalities were found in both lines, no correlations were found between physical abnormalities and behaviour. Physical abnormalities seemed not to be so severe to have hampered behavioural activity. The study showed that fast- and slow-growing broilers are motivated to perform the normal behavioural repertoire of chickens, also after 6 weeks of age. The ability to perform some behaviours is more and more hampered with increasing age most probably due to their weight.

Since feed intake and growth have increased, and feed conversion has decreased in broilers, it can be expected that some characteristics of eating behaviour have changed as well. In Chapter 3, individual eating behaviour of broilers and layer chickens was studied to gain more insight into hunger and satiety mechanisms. The satiety mechanism for eating can be expressed as the correlation between meal length and the length of the preceding (preprandial) interval; the hunger mechanism for eating as the correlation between meal length and the length of the succeeding (postprandial) interval. Individually housed birds were observed in deprived and non-deprived conditions from 4 to 7 weeks of age. Preprandial and postprandial correlations were calculated based on data of the non-deprived condition. Body weight gain and feed consumption during observation were measured. Under the non-deprived condition, the broilers initially spent more, but at a later age less time on eating. The broilers had fewer meals per hour, consumed more feed per hour, and had longer meal and interval lengths than the layer chickens. After 24-h feed deprivation, the broilers had a longer first meal, consumed more feed per hour and spent more time on eating than the layer chickens. Significant preprandial correlations but no postprandial correlations were found in the broilers. In the layer chickens, both significant preprandial and postprandial correlations were found. This indicates that for regulating eating behaviour, the satiety mechanism is dominating the hunger mechanism in broilers, and satiety and hunger mechanisms are equally involved in layer chickens. The typical eating behaviour of broilers and the calculated preprandial and postprandial correlations showed that hunger and satiety mechanisms in broilers have changed compared with layer chickens.

In order to study the influence of sex and type of feed (low versus high energy and protein content) on motivation and ability to walk for a food reward (mealworm), a runway experiment was conducted (Chapter 4). In the 2-m-long runway, five small bowls were placed at each 40 cm. The broilers in this experiment were not deprived from feed before testing. Three sessions were applied within one week 1) control session: each bowl contained one mealworm, 2) frustration session: the first four bowls were empty, the last bowl contained five mealworms, and 3) obstacle session: each bowl contained one mealworm and 10 cm high obstacles were placed between the bowls. Birds walked faster in frustration sessions than in control or obstacle sessions and faster in control than in obstacle sessions. Birds sat more in obstacle than in control sessions, indicating that walking was affected by

the difficulty of the task. Males walked faster in control and obstacle sessions than females, despite their higher body weight. The number of vocalisations in the runway decreased over time and males vocalised more than females. Differences between frustration and control sessions and obstacles and control sessions at individual level within a week were calculated and called the motivation and the ability effect. No sex or feed differences were found for the motivation and the ability effect, respectively. That means that frustration and obstacles had similar impact on both sexes and both types of feed and that sex differences in walking speed probably were a result of physical differences (males are stronger and bigger).

For the experiment described in Chapter 5, a runway was used again, but now to measure physical ability and motivation to walk for a food reward of birds from a fast- and slow-growing broiler strain to 12 weeks of age. To manipulate motivation, half of the birds of each strain was feed deprived for 3 h and the other half for 24 h before testing. Each bird was tested in a control and a slalom task once per week and had to walk 2 m to obtain five mealworms at the end of the runway. Under similar motivation, slow growers had a shorter latency to start walking and walked faster through the runway than fast growers in both sessions. Walking speed decreased with age in both strains, although in slow growers this occurred much later than in fast growers. Slow growers vocalised more in both sessions. In slalom sessions, 24 h deprived birds vocalised more than 3 h deprived birds. Although the fast and slow growers have a different genetic background, the results indicate that in slow growers motivation seems to be the distinctive factor for walking, while in fast growers that seems to be physical ability.

In Chapter 6, the aim was to measure the maximum number of key pecks broilers with different body weights would show for a food reward. Two groups of 20 broilers were fed on 50% or 75% of the amount of feed a broiler would eat when fed ad libitum, and trained in an operant chamber to peck a key for a 5 s food presentation. Birds of the 50%-group showed a higher maximum number of key pecks for a food reward and responded more quickly to food presentation than the birds of the 75%-group in the first test week and the same tendency was found in the second test week. Different levels of long-term feed restriction had an influence on their body weight and on their motivation to work for food. No effect of a one-day change of feed restriction was found on the maximum number of key pecks. Birds showed frustration behaviour after the last food reward had been

obtained, indicating that they were still hungry. The results indicate that broilers were able to learn an operant task and were willing to work for food. They are still sensitive to different levels of feed restriction and they can balance their investments and profits to a certain extent.

In Chapter 7, we studied the effects of motivation and ability on the maximum distance broilers would walk for a food reward in an operant runway in a limited amount of time. Motivation for testing was manipulated in two ways: by feed deprivation length before testing and by food access length during testing. To study the impact of physical ability, a high and a low body weight group were used. Under similar motivations, birds with a low body weight walked a longer distance than the birds with a high body weight. Unexpectedly, distance walked was not influenced by increasing age. Within a body weight group, birds walked a longer distance after 22.5 h feed deprivation than after 17.0 h feed deprivation. Birds of both body weight groups walked a longer distance with 5 s than with 15 s food access. In this study, it was shown that broilers are motivated to walk long distances for food and that their motivation can be manipulated. High body weight as an indicator for physical ability can be considered as a constraint for broilers to be active and probably to behave normally. Parallel to the effect of high body weight on the quality of life (welfare) in humans, the abnormal high body weight at a young age reduces the welfare of broilers.

In this thesis, more insight is gained into the influence of motivation and physical ability on behavioural activity in broilers. Broilers showed all normal juvenile chicken behaviours, but with another time budget and many behavioural patterns were shown in a sitting posture. Behaviour changed with increasing age and associated body weight, indicating that body weight is a handicap for broilers to perform behaviour. Performance in short physical tasks depended on motivation and physical ability. Motivation to work for food still can be manipulated and can be used in operant learning experiments. Apart from having an abnormal high motivation to eat, broilers are normal, biologically functioning animals. Although many of them experience poorer welfare due to the restrictions of motivated behaviours imposed by their fast growth with associated high body weight or by environmental restrictions.

Samenvatting

Samenvatting

Vleeskuikens zijn jonge kippen die gehouden worden om kippenvlees te produceren. In zes weken groeien ze van 50 g naar ongeveer 2.5 kg en worden dan geslacht. Vleeskuikens vertonen een opmerkelijke vermindering in hun activiteit gedurende deze weken. De genetische selectie op snelle groei met het daaraan gekoppelde hoge lichaamsgewicht van vleeskuikens zouden een dermate negatieve invloed op hun fysieke mogelijkheden kunnen hebben dat ze gehinderd worden in het uitvoeren van de gedragingen waartoe ze gemotiveerd zijn. Het doel van dit proefschrift was om meer inzicht te krijgen in de mate waarin vleeskuikens nog allerlei gedragingen willen vertonen en kunnen vertonen. Het onderscheid tussen willen en kunnen is relevant voor de interpretatie van gedragsactiviteit van vleeskuikens in relatie tot hun welzijn.

Het doel van Hoofdstuk 2 was om het gedrag van langzaam- en snelgroeiende vleeskuikens te bestuderen vanaf 1 week oud en totdat ze een leeftijd van 12 weken hadden bereikt. Snelgroeiende vleeskuikens zijn vleeskuikens die normaliter commercieel gehouden worden. Langzaamgroeiende vleeskuikens groeien half zo snel en worden bijvoorbeeld gebruikt in de biologische vleeskuikenhouderij. In het experiment werden de dieren gehouden in 16 hokken, 6 dieren per hok. Met het oog op een omgeving waarin de dieren hun gedrag zo goed mogelijk tot expressie zouden kunnen brengen, waren de hokken uitgerust met goed ontworpen zitstokken, veel ruimte, en strooisel van goede kwaliteit. Verschillende keren per dag werd het gedrag, de houding (zitten, staan) en de positie (vloer, zitstok) van elk individu geobserveerd. Na 12 weken werden de dieren gedood en werd sectie verricht om de fysieke consequenties van de verlengde groeiperiode inwendig te kunnen bestuderen. Snel- en langzaamgroeiende vleeskuikens vertoonden dezelfde gedragspatronen en hetzelfde gedragsrepertoire, maar de tijdsbesteding aan de verschillende gedragingen verschilde. Tevens bleek dat snel groeiende vleeskuikens veel meer gedragingen in een zittende houding uitvoerden dan de langzaam groeiende vleeskuikens. Langzaamgroeiende vleeskuikens zaten meer op de zitstokken, en liepen en scharrelden meer dan de snelgroeiende vleeskuikens, terwijl de snelgroeiende vleeskuikens meer aten, dronken en op de vloer zaten dan de langzaamgroeiende vleeskuikens. Geen verschillen werden gevonden voor rusten, veren poetsen, uitrekken, grondpikken of stofbaden. De tijd die aan verschillende gedragingen werd besteed veranderde naarmate de dieren ouder werden.

Ook werden steeds meer gedragingen in een zittende houding uitgevoerd. Hoewel in beide lijnen verschillende post-mortem afwijkingen werden gevonden waren er geen correlaties tussen deze afwijkingen en gedrag. De post-mortem geconstateerde afwijkingen leken niet ernstig genoeg om de dieren te hebben gehinderd in hun gedrag. De mogelijkheden om gedrag uit te voeren leken meer gehinderd te zijn door het toenemende gewicht.

Aangezien bij vleeskuikens voeropname en groei hoger zijn geworden en de voederconversie lager is geworden, kan verwacht worden dat het eetgedrag van vleeskuikens ook is veranderd. In Hoofdstuk 3 is gekeken naar het individuele eetgedrag van vleeskuikens en legkuikens om meer inzicht te krijgen in honger en verzadigingsmechanismen van deze dieren. De correlatie tussen maaltijdlengthe en de daaraan voorafgaande intervallengte (preprandiaal) wordt wel gedefinieerd als het verzadigingsmechanisme. Het hongermechanisme wordt wel gedefinieerd als de correlatie tussen maaltijdlengthe en de opvolgende intervallengte (postprandiaal). De individueel gehuisveste dieren werden geobserveerd op een leeftijd van 4 tot 7 weken na 24 uur van voer gedepriveerd te zijn geweest en zonder gedepriveerd van voer te zijn geweest. Preprandiale en postprandiale correlaties zijn berekend op basis van data uit de ongedepriveerde omstandigheden. Gewichtstoename en voeropname tijdens observatie werden gemeten. Tijdens de observaties onder ongedepriveerde omstandigheden spendeerden de vleeskuikens aanvankelijk meer tijd, maar later minder tijd aan eten dan de legkuikens. De vleeskuikens hadden minder maaltijden per uur, maar aten meer voer per uur en hadden langere maaltijden en intervallen dan de legkuikens. Na 24 uur voerdeprivatie hadden de vleeskuikens een langere eerste maaltijd, aten meer voer per uur en besteedden meer tijd aan eten dan de legkuikens. Voor de vleeskuikens werden wel significante preprandiale correlaties gevonden, maar postprandiale correlaties werden niet gevonden. Voor de legkuikens werden beide correlaties gevonden. Dit duidt erop dat bij vleeskuikens het verzadigingsmechanisme dominant is over het hongermechanisme en in legkuikens deze twee mechanismen evenveel invloed hebben op het eetgedrag. De kenmerken van het eetgedrag van vleeskuikens en de berekende preprandiale en postprandiale correlaties laten zien dat de honger- en verzadigingsmechanismen bij vleeskuikens zijn veranderd ten opzichte van legkuikens, maar ook ten opzichte van andere dieren.

Om de invloed van sekse en voersamenstelling (laag versus hoog energie en eiwitgehalte) op motivatie en fysieke mogelijkheden om te lopen te

bestuderen is een loopgangexperiment uitgevoerd (Hoofdstuk 4). In dit experiment moesten vleeskuikens 2 meter lopen voor voerbeloningen (meelwormen) zonder dat ze van tevoren gedeprimeerd waren van voer. De beloningen zaten in bakjes die op elke 40 cm in de loopgang stonden. Binnen een week werden drie sessies uitgevoerd 1) een controlesessie, waarbij in elk bakje een meelworm aanwezig was; 2) een frustratiesessie, waarbij in de eerste vier bakjes geen meelworm en in de laatste vijf meelwormen aanwezig waren; 3) een hindernissessie, waarbij in elk bakje weer een meelworm lag, maar nu stond er tussen de bakjes een 10 cm hoge hindernis. Het experiment werd gedurende 4 weken herhaald. De vleeskuikens liepen harder in frustratiesessies dan in elk van de andere sessies en harder in controle- dan in hindernissessies. De kuikens gingen meer zitten in de hindernis- dan in de controlesessies, hetgeen erop duidt dat het lopen door de loopgang beïnvloed werd door de moeilijkheidsgraad van de taak. De haantjes liepen harder in de controle- en hindernissessies dan de hennetjes, ondanks hun hogere gewicht. Het aantal vocalisaties nam af naarmate de dieren ouder werden en de haantjes vocaliseerden meer dan de hennetjes. Het verschil in loopsnelheid tussen de sessies is op individueel niveau en per week berekend. Het verschil tussen frustratie- en controlesessie werd het motivatie-effect genoemd en het verschil tussen hindernis- en controlesessie het fysieke-mogelijkheden-effect. Er werden geen sekse- of voersamenstellingsverschillen gevonden voor het motivatie-effect en fysieke-mogelijkheden-effect. Dat betekent dat frustratie en de hindernissen dezelfde impact hadden op beide seksen en voertypen. Sekseverschillen in loopsnelheid kunnen waarschijnlijk toegeschreven worden aan het feit dat hanen groter en sterker waren dan hennen.

In het experiment, beschreven in Hoofdstuk 5, werd wederom een loopgang gebruikt. Het doel was om de invloed van motivatie en fysieke mogelijkheden op het lopen voor een voerbeloning te meten bij zowel snel- als langzaamgroeiende vleeskuikens. In dit experiment werd de motivatie om te lopen voor een voerbeloning gemanipuleerd door de helft van de dieren van beide lijnen 24 uur en de andere helft 3 uur voor een sessie geen voer te geven. Elk dier werd elke week getest in een controle- en een slomsessie tot en met een leeftijd van 12 weken. Bij een gelijke motivatie hadden de langzaamgroeiende vleeskuikens in beide sessies een kortere latentietijd om de startbox te verlaten en liepen ze sneller door de loopgang dan de snelgroeiende vleeskuikens. De loopsnelheid nam af in beide vleeskuikenlijnen naarmate de dieren ouder werden, maar bij de langzaam-

groeïende kuikens begon die afname veel later. De langzaamgroeïende kuikens vocaliseerden meer in beide sessies. In de slalomsessies vocaliseerden de 24 uur gedepriveerde kuikens meer dan de 3 uur gedepriveerde kuikens. De resultaten geven aan dat in de langzaamgroeïende kuikens motivatie de doorslaggevende factor is voor lopen terwijl de fysieke mogelijkheid dat is bij de snelgroeïende kuikens.

Het doel van Hoofdstuk 6 was om het maximale aantal knopdrukken te bepalen dat een vleeskuiken voor een voerbeloning wil geven. Hierbij werden vleeskuikens met verschillende lichaamsgewichten met elkaar vergeleken. Om twee groepen vleeskuikens met verschillende lichaamsgewichten te krijgen werd één groep gevoerd op een niveau van 50% van wat een kuiken zou eten bij onbeperkte voeropname en de andere groep kreeg 75% van onbeperkte voeropname. De dieren werden getraind om op een knop te pikken voor een voerpresentatie van 5 sec. De kuikens op 50% van onbeperkt eten pikten vaker op de knop voor een voerbeloning en reageerden sneller op de presentatie van voer dan de kuikens op 75% van onbeperkt eten. Verschillende niveaus van voerbeperving hadden een invloed op lichaamsgewicht en op de motivatie om te werken voor voer. Er werd echter geen effect gevonden op het maximaal aantal knopdrukken bij een eenmalige omdraaiing van het voerschema. De kuikens vertoonden frustratiegedrag nadat ze gestopt waren om te werken voor de volgende beloning. Dit gaf aan dat ze nog wel honger hadden, maar dat de inspanning voor het verkrijgen van voer te groot werd. De resultaten van dit experiment laten zien dat de motivatie om te eten nog steeds te beïnvloeden is bij vleeskuikens en dat vleeskuikens ook nog steeds tot op zekere hoogte een afweging kunnen maken tussen kosten en baten om iets te krijgen.

In Hoofdstuk 7 is bestudeerd hoe ver een vleeskuiken wil lopen voor een voerbeloning en wat de invloed is van motivatie en fysieke mogelijkheid op die prestatie. De motivatie om te lopen werd gemanipuleerd op twee manieren: 1) door verschillende lengtes van voerdeprivatie (17.0 uur en 22.5 uur) voor het testen; 2) door verschillende lengtes van voerpresentatie (5 sec en 15 sec) tijdens het testen. Twee gewichtsgroepen, 50% en 90% van het normale gewicht, werden gebruikt om de invloed van fysieke mogelijkheid te meten. Met een gelijke motivatie liepen de kuikens met een laag lichaamsgewicht een grotere afstand dan de kuikens met een hoog lichaamsgewicht. Tegen de verwachting in nam de gelopen afstand niet af naarmate de dieren ouder werden. Binnen een gewichtsgroep liepen de kuikens een grotere afstand na 22.5 uur dan na 17.0 uur voerdeprivatie. De

kuikens van beide gewichtsgroepen liepen een grotere afstand met een voerbeloning van 5 sec dan met een voerbeloning van 15 sec. Het bleek dat vleeskuikens gemotiveerd zijn om grote afstanden voor voer af te leggen en dat hun motivatie gemanipuleerd kan worden. Een hoog lichaamsgewicht, als indicator voor fysieke mogelijkheid, kan gezien worden als een belemmering voor vleeskuikens om actief te zijn en om zich normaal te gedragen. Parallel aan het negatieve effect van overgewicht op de kwaliteit van het leven bij mensen, kan het hoge gewicht van vleeskuikens op jonge leeftijd geïnterpreteerd worden als negatief voor het welzijn van deze dieren.

In dit proefschrift is inzicht verkregen in de motivationele en fysieke aspecten van gedragsactiviteit bij vleeskuikens. Vleeskuikens vertonen alle normale gedragingen van jonge kippen. Echter naarmate de dieren ouder worden veranderd de tijdsbesteding aan verschillende gedragingen en de hoeveelheid gedrag dat in zittende houding wordt uitgevoerd neemt toe. Het toenemende lichaamsgewicht lijkt daarbij een doorslaggevende rol te spelen. De motivatie om te werken voor voer kan nog steeds gemanipuleerd worden, hetgeen gebruikt kan worden voor operante leerexperimenten. Afgezien van het feit dat vleeskuikens een abnormale motivatie tot eten hebben, zijn het normaal biologisch functionerende dieren. Vele van hen zullen echter een verminderd welzijn ervaren als gevolg van beperkingen om gedrag uit te voeren waartoe ze gemotiveerd zijn. Deze beperkingen komen voort uit de hoge motivatie om te eten met de daaraan gekoppelde snelle groei en hoog lichaamsgewicht en de beperkende omgeving waarin deze dieren doorgaans gehouden worden.

Curriculum vitae

Eddie Bokkers werd geboren op 1 oktober 1969 te Ruurlo en groeide op in de omgeving van Keijenburg. In 1988 behaalde hij zijn VWO diploma aan het St. Ludger College te Doetinchem. In datzelfde jaar begon hij met de studie Zoötechniek, oriëntatie Veehouderij aan de toenmalige Landbouwniversiteit Wageningen, waarbij zijn interesse uitging naar ethologie, dierenwelzijn en duurzame landbouw. In 1994 studeerde hij af en werkte hij, in het kader van zijn vervangende dienstplicht, als beleidsondersteunend onderzoeker op het gebied van dierenwelzijn en duurzaamheid bij de Nederlandse Vereniging tot Bescherming van Dieren in Den Haag. In 1996 en 1997 verrichtte hij vervolgens onderzoek voor de Raad voor Dierenaangelegenheden, onder ander in het kader van de Gezondheids- en Welzijnswet voor Dieren. In 1997 keerde hij terug naar de Landbouwniversiteit en werkte korte tijd als toegevoegd onderzoeker bij de leerstoelgroep Dierlijke Productie Systemen. In datzelfde jaar begon hij als onderzoeker bij de leerstoelgroep Ethologie een project waarbij drie vleeskalverhouderijsystemen op verschillende manieren werden vergeleken om een uitspraak te kunnen doen over het niveau van dierenwelzijn. Van 1998 tot november 1999 werkte hij bij dezelfde leerstoelgroep als toegevoegd docent om onderwijs te verzorgen. In die periode zijn ook de ideeën voor een promotieonderzoek uitgewerkt en enkele pilot-experimenten gedaan. Van november 1999 tot december 2003 was hij aangesteld als assistent in opleiding bij de leerstoelgroep Ethologie van Wageningen Universiteit om onderzoek te doen naar vleeskuikens en hun motivaties en mogelijkheden om gedrag uit te voeren. Sinds januari 2004 is hij werkzaam als postdoc bij de leerstoelgroep Dierlijke Productie Systemen van Wageningen Universiteit op het onderwerp mens-dier relaties in de hobby- en zorgdierhouderij.

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