Broiler Chicken Welfare: What Do They Want and What Do We Want?

I. Zulkifli
Department of Animal Science, Faculty of Agriculture, Universiti Putra Malaysia, Malaysia.
email: zulkifli@agri.upm.edu.my

INTRODUCTION

The broiler chicken industry today is a growing part of global agribusiness and the production level has achieved outstanding biological and economic performance and thus contributing powerfully to cheap, abundant food and improved quality of life. Broiler chickens are probably the most numerous farmed species: worldwide, some 44 billion are produced each year worldwide and this figure is likely to rise in the coming years (Morton, 2004). The chicken meat industry is highly automated, integrated and intensified of the animal production industries. Intensive farming refers to the number of animals per production unit, the degree of crowding to which they are kept, and the artificiality of the environment in which they are kept (Duncan, 2001). The vast changes in modern poultry production systems have had a positive impact not only on global food security but also animal welfare. Indoor confinement provides better protection against thermal extremes and predators, and improvement in disease prevention. However, the poultry industry incessant drive for efficiency and reduction of costs has resulted in numerous social and ethical concerns that diminished its exceptional achievement. The vast majority of studies have emphasised on the welfare laying hens in battery cages. Welfare concerns pertinent to broiler production have received less attention. The over intensification of broiler chicken farming, whereby large number of birds may be forced to grow super fast in overcrowded conditions, not only have serious impacts on the environment and public health but also causes scientifically proven suffering to the birds.

What is "Chicken Welfare"?

A great deal of controversy has arisen over the definition of animal welfare because it often represents an assortment of vague notions. Concerns for animal welfare seems to be determined significantly by people's perception of animal suffering and how they interpret what they see or measure in terms of animal behavior or changes in physiologicalprocesses. Like "sin" and "love", 'animal welfare' means different things to different people. Some people believe that human and animals have equal rights and thus, killing an animal for food is preposterous. They consider animals have the right not to be used for any purpose by humans. A different extreme is represented by the belief that humans have no obligation at all to consider the welfare of animals in agriculture. All that matters is productivity because animals exist specifically for humans to exploit and have no intrinsic value or internal purpose. Somewhere in the middle are those who do not oppose human use of animals but believe adequate well being of animals while they are under human care is necessary. Many people may feel that the slaughter of animals is necessary and acceptable (although they may recognise that 'some' animal suffering will be involved even with 'humane' methods) because they see no other alternative if they are to continue to eat meat. The 'welfare' of an animal refers to its quality of life, and this involves many different elements such as health, happiness, and longevity to which different people attach different degree of importance (Fraser, 1995). In the *Dictionary of Farm Animal Behaviour* (Hurnik *et al*., 1995), 'animal welfare' was defined as "A state of harmony between animal and its environment, characterised by optimal physical and psychological functioning and high quality of animals' life."

Can a Broiler Chicken Suffer?

Welfare refers to the particular kind of moral concern we have for animals as a result of their capacity for subjective feelings, particularly the unpleasant subjective feelings of suffering and pain (Dawkins, 1988). Thus, to the animals, welfare is all that matters. The idea that welfare concerns the feelings of animals needs some development because 'feelings' may mean either just sensations such as touch and sight or more complex processes such as pain and emotions. This raises a problem because all animals have at least some of the five senses, and it is less clear that all animals are capable of suffering or experiencing pleasure. Thus, the relevant question is can a chicken suffer or feel pleasure.

"It is generally accepted that welfare is a term which cannot be applied sensibly to the lower animals or to plants but only to sentient animals". (Duncan, 1996)

'Sentient' has the same spread of meanings as 'feelings'. Leahy (1991) states

"….to be sentient is to have the power of sense-perception; to see, hear, smell, taste or touch".

In this sense all animals are sentient. However, the term may be used to mean the 'capacity for suffering or enjoyment'. Poultry is definitely considered as sentient animals. Although chickens respond to stimuli that we call painful, but neither their mental nor their physical responses are necessarily the same as those of humans (Appleby, 1999). Suffering is affected by thinking, and types of thinking vary between species. A particular animal species will therefore be able to suffer in certain ways but not others: chickens probably feel pain but not grief. It can be concluded that all animals are sentient, but to varying degrees.

Selection for Rapid Growth and Welfare Issues

Genetic selection has increased production levels of broiler chickens considerably. Since feed costs are economically the most important costs, the breeding goal in poultry is to create a population with high economic production efficiency, i.e. high production with relatively low feed intake. Through intense genetic selection during the last five decades for economic traits, and improvements in management, nutrition, and disease control, there has been a consistent decrease in the age at which slaughter weight (approximately 2 kg) is reached, by 1 day per year, as well as large relative increases in breast muscle size (Griffin and Goddard, 1994). The time required for a meat-type chicken to reach 2.0 kg live weight has been reduced from 14 weeks in 1950 to 5 weeks in 2005. It is anticipated that genetic changes resulting in enhanced performance will continue (Albers and Groot, 1998). Such selection practices have resulted in birds both genetically distant and with reduced genetic diversity compared with their red jungle fowl ancestors (Siegel *et al*., 1992). Apart from the desired effects of genetic improvements in economic traits, broiler chickens are at risk for behavioural, physiological and immunological problems.

Lameness is considered the one the most serious welfare issues in broiler chicken production. Because such problems are rare among slow-growing birds, it clearly suggests that these disorders in modern broilers strains are associated with rapid growth. Julian (2004) indicated that the tendons and bones of broilers are not strong enough to support their weight and may lead to painful conditions such as spondylolisthesis, ruptured gastrocnemius tendon and separation of the femoral epiphysis, backward bending of the proximal tibia in bones weakened by dyschondroplasia, epiphysolitis, and pressure-induced microfractures at the diaphysis of the proximal tibia. Kestin *et al*. (1992) showed that 90% of commercially raised broilers chickens had detectable gait abnormalities at market age while 26% had serious gait abnormalities, resulting in impaired locomotor abilities. These birds are unable to walk and thus unable to get to feed and water. Because birds with leg problems are likely to spend more time lying down on corrosive soiled litter, they are susceptible to potentially painful skin problems such as breast blisters, footpad dermatitis and hock burns (Berg, 2004). Apart from welfare concern, lameness is also costly to the industry. Studies in the United States indicated that leg problems were responsible for 1.1% of broiler mortality and 2.1% of carcass condemnation and downgrades annually, and cost the industry billions of dollars each year (Morris, 1993).

There are numerous reports of an increasing incidence of cardiovascular diseases such as ascites, pulmonary hypertension, and sudden death syndrome (SDS) in fast growing broiler chickens (Julian, 2004). Ascites is a condition that occurs when a fast growing bird has insufficient heart-lung capacity to supply all of the soft tissues with oxygenated blood. This leads to an increase in blood pressure, dilation and hypertrophy of the right ventricle, and leakage of serous fluids into the body cavity (Julian, 1998). In the case of SDS, well-fleshed and healthy broiler chickens die suddenly while standing, walking or feeding. They die with a short terminal wing-beating convulsion and are often found on their back (Julian, 1986). SDS has been associated with to high carbohydrate intake, rapid metabolic rate, defective cell membrane, defective cell membrane integrity, and intracellular electrolyte imbalance. In good flocks, 2-4% of males may die from SDS.

Intensive Farming and Broiler Chicken Welfare

Julian (1995) defined intensive farming as conditions where animals are confined in close proximity, where freedom or movement is restricted, where all feed is supplied and the quantity and quality regulated, where the environment is controlled (to some extent) and where the greatest number of animals are cared for by the minimum number of attendants. Intensive farming is competitive and the methods adopted are those that cut costs and increase production. Many of the conditions in which poultry live and the procedures to which they are subjected may compromise their welfare.

i. Space requirement

Birds require space to accommodate normal body functions and to access the utilities that support the function intended for a production system or simply for maintaining normal behaviour repertoires such as grooming and social behaviour (Albentosa and Cooper, 2004). Intensive animal farming emphasizes on optimising cost per unit of output from such systems. Such emphasis increases the likelihood that individual animal welfare will be compromised in favour of enterprise efficiency. The perception of acceptable floor space for both broiler chickens varies widely according to country, region, and organisation concerned, and there is no evidence that the existing recommendations are based on scientific evidence. Limited floor space is a major welfare issue in both chicken meat productions. Crowding has been shown to adversely affect growth rate, feed efficiency, survivability, feather condition, comfort behaviour, aggression, underlying fearfulness, and incidence of lameness and skin injuries in poultry (Bessei, 2006). Crowding may also affect environmental parameters such as ventilation, temperature and humidity. Even though higher stocking density is widely known to be detrimental to productivity, economic studies showed that such practices may increase the net profit of meat production. This leads to an obvious conflict between animal welfare and profitability.

Many studies have examined the effect of bird density on growth and slaughter quality of broiler chickens. It is now recognized that stocking densities of 500 cm^2 per bird or less or 30 kg /m^2 are detrimental to both productivity and welfare of broiler chickens (Bessei, 2004). There is a significant reduction on feed intake and reduced growth rate when stocking density exceeds 30 kg / m^2 under deep litter conditions. The detrimental effect of stocking density on growth rate was partially compensated by increased ventilation rates (Grashorn and Kutritz, 1991). These results lead to the assumption that problems of dissipating metabolic heat may be the causal factor for depression of growth rate. High stocking density impedes heat transfer from the litter surface to the ventilated room.

Hock burns, breast blisters and foot pad lesions, which may be summarized under the expression contact dermatitis, are common in broiler flocks during the last decades (Berg, 2004). It is evident, that the influence of stocking density on contact dermatitis acts through its influence on litter and air quality. High moisture content of the litter enhances microbial activity, which in turn leads to increase of temperature and ammonia in broiler houses, and thus, high incidence of contact dermatitis, breast blisters, leg weakness and soiled plumage (Weaver and Meijerhof, 1991). In a larger scale experiment with commercial farms using different breed, management systems and stocking densities, Dawkins *et al*. (2004) concluded that the management conditions (litter quality, temperature and humidity) and stockman ship were more important than stocking density in determining the welfare of broiler chickens.

ii. Feed restriction

The meat-type chickens used for breeding stock have the same voracious appetite as their progenies and thus have to be feed restricted severely to control obesity. Fertility, immunity and survivability will be adversely affected in obese birds (Siegel and Wolford, 2003). The demand for feed and water is inelastic in most animals (Dawkins, 1990). There is mounting evidence that restricting the intake of feed, water or both can result in physiological stress responses, boredom, stereotypes, aggression, and other abnormal behaviours in poultry (Zulkifli, 1999; Zulkifli *et al*., 1993; 1995a; 2006). The modern broiler breeder industry is caught in a welfare dilemma, since on one hand breeding stock appears to be chronically hungry, while on the other hand *ad libitum* feeding or less severe food restriction leads to reproductive and health problems (Savory *et al*., 1993). Evidence, however, is accumulating to show that chickens readily habituate to fasts of moderate duration (Zulkifli, 1999; Zulkifli *et al*., 1993; 2006).

iii. Handling and transportation

There is a growing concern regarding the welfare problems associated with harvesting and transport of broiler chickens. Prior to slaughter, birds are exposed to an array of factors that may evoke both stress and fear reactions (Figure 12) (Zulkifli *et al*., 2000a; b; 2009; Zulkifli, 2003; Al-Aqil and Zulkifli, 2009). These factors include feed and water deprivation, physical contact with human, social disruption, noise, overcrowding, motion and vibration, and thermal extremes (Mench, 1992). The handling method adopted may have implications for the bird welfare. Zulkifli *et al*. (2000b) reported that rough inverted handling, as practised in commercial settings, augmented both stress and fear reactions. Improper handling of chickens may result in physical injuries, pain, and mortality. Farsaie *et al*. (1983) estimated that one in four broilers processed in the USA sustained bruising of the legs, breast or wings during catching and transport. Birds that have died between catching and the moment of slaughter are termed 'dead on arrival' (DOA). Published mean DOA percentages ranged from 0.05 to 0.57% (Bayliss and Hunton, 1990). Factors that influence DOA percentage are catching crew (Bayliss and Hinton, 1990), transport time (Wariss *et al*., 1992), lairage time (Bayliss and Hinton, 1990), type of transport crates (Stuart, 1985), time of day of catching and transport (Bayliss and Hinton, 1990), stocking density per crate (Bayliss and Hinton, 1990), age and sex of the birds (Bayliss and Hinton, 1990).

Zulkifli *et al*. (2000a) compared stress and fear reactions to handling and crating; and handling, crating and transport in broiler chickens under hot climate. The authors concluded that the transport component was more traumatic. The magnitude of stress, as measured by HLR and CORT, attributed to transportation increased with transit time and this could be due to longer exposure to noxious and stressful stimuli (Al-Aqil and Zulkifli, 2009). The author showed that raising chickens in conventional open-sided houses with cyclic ambient temperatures improved heat shock protein hsp 70 expression and may lead to better ability to cope with the stresses associated with road transportation in hot, humid climate than those under environmentally controlled closed house. Mitchell and Kettlewell (1998) suggested that high ambient temperature is a major factor in the elicitation of physiological stress responses during transit. With the growing importance of broiler production among livestock industries in hot regions of the world, heat-stress related predicaments during transit are of major concern.

How Can We Improve Broiler Chicken Welfare?

In discussing the welfare of poultry in modern production systems, Mench (1992) posed a simple but very critical question of whether we should change the bird to suit the environment or we should change the environment to suit the bird.

i. Early age stimulation

Stressful experiences may perturb homeostasis, but there can be long-term benefits in improving resistance to other forms of insults. For example, early age feed restriction improved tolerance to high ambient temperature (Zulkifli *et al*., 1994a;b; 2000c) and transportation (Zulkifli, 2003) stresses, and disease resistance (Liew *et al*., 2003) in chickens. Work by Zulkifli *et al*. (1994b; 1995b) suggested that transient perturbations of homeostasis during the neonatal stage without current increases in the synthesis and release of corticosterone may not aid an animal in responding to subsequent stressors. Thus, stress-elicited elevations in adrenal corticoid concentrations may be crucial in preparing the body in responding to subsequent stressors. Acquired enhanced heat tolerance resulting from early age feed restriction in broiler chickens could be attributed to improved hsp 70 response (Zulkifli *et al*., 2002a; 2003). Liew *et al*. (2004) indicated that hsp 70 expressions appear to be beneficial in enhancing resistance to infectious bursal disease in heat-stressed chickens. The hsp 70 play a profound role in regulating protein folding and in coping with proteins affected by heat and other stresses.

ii. Human contact

The quality of human-animal interaction can have a profound impact on many facets of an animal's physiology and behaviour. Work in poultry suggest that regular positive human contact can reduce flightiness (Hughes and Black, 1976), feather pecking and cannibalism (Zulkifli, 2008), stress and fear reactions to capture and transportation (Zulkifli *et al*., 2002b; Zulkifli and Siti Nor Azah, 2004; Al-Aqil, 2009), and improve antibody production and disease resistance (Gross and Siegel, 1982; Zulkifli *et al.*, 2002b). Gross and Siegel (1982) suggested that positive human-animal relationship reduced the resources otherwise required by the birds to respond to their human associates and that resources can be utilised to compensate for environmental insults. Recent work in our laboratory demonstrated that pleasant physical contact with human beings augmented hsp 70 expression following transportation (Al-Aqil, 2009). As measured by heterophil to lymphocyte ratios and plasma corticosterone concentration. it appears that hsp 70 played a key role in improving tolerance to transportation stress by pleasant human contact. Despite the numerous desirable effects of physical interaction on poultry, regular handling of every bird is obviously not feasible and practical to commercial flocks. Zulkifli *et al*. (2002b) reported that simply allowing chicks to see experimenter was as effective as physical contact in reducing underlying fearfulness and physiological stress responses to catching and crating. The authors showed that there was a circumscribed sensitive period for the induction of the visual contact phenomenon in the domestic fowl.

iii. ***Genetic selection***

Although genetic selection for economic traits may compromise the well-being of poultry, selective breeding could be used to improve welfare. Although there is a strong correlation between leg weakness and growth rate (Sørensen *et al*., 1999), it has been shown that progress can be made in reducing and eliminating leg disorders by genetic means. Previous studies (Wong-Valle *et al*., 1993) showed that the incidence of tibial dyschondroplasia can be effectively reduced through genetic selection.

Three of the major behavioural problems facing the poultry industry are fear, feather pecking and social stress. Mench (1992) suggested that:

"Genetic selection may prove to be a powerful tool for decreasing the incidence of behaviours associated with welfare problems."

Earlier studies have shown that these behavioural traits respond readily to genetic selection (Faure and Jones, 2004). Gross and Colmano (1971) reported the divergent selection of two line of chickens selected for adrenocortical response to social stress. Faure (1975) demonstrated that domestic chicks of the lines selected for high activity in the open field were not only less fearful but they also showed lower resting and stress-induced plasma corticosterone levels than their inactive counterparts (Faure, 1975).

In discussing selective breeding and animal welfare, Mills *et al*. (1997) concluded that:

"The major problems associated with such genetic improvement programmes are the need to develop measures of welfare which are compatible with selection on a commercial scale, and potential competition between selection for production and welfare-related traits."

iv. Environmental manipulation

Intensively raised chickens are often housed in barren, visually restricted and monotonous environment. This may lead to frustration, boredom and harmful abnormal behaviour (Petherick and Rushen, 1997). Even when their basic needs are met, animals will seek moderate novelty, or environmental challenge (Jones, 1996). Environmental complexities can be considered as an enrichment or extra stimulation in the house environment that may enhance behavioural repertoire, increase ability to cope with challenge, decrease fearfulness, aggression and depression, and improve health and productivity (Jones, 1996). Jones (1982) and Jones *et al*. (1991) reported that chicks and quail reared with a range of novel objects and stimuli were less fearful and more able to tolerate stress later in life than those raised in barren environment. A greater complexity of rearing conditions may attenuate reactions to subsequent environmental challenges. Environmental complexities can be considered as an enrichment or extra stimulation in the house environment of poultry that may enhance ability to cope with novelties and stressful situations (Fraser and Broom, 1997). The vast majority of enrichment studies in poultry have focused on underlying fearfulness. Birds housed in different systems have been reported to exhibit different levels of underlying fearfulness (Kujiyat *et al*., 1983). Al-Aqil and Zulkifli (2009) compared physiological stress reactions of broilers raised in open-sided and windowless houses (varied in the level of environmental stimulation) to road transportation. Birds raised in open-sided house which had experienced a greater variety of visual and auditory stimuli than those in windowless house had greater hsp 70 expression, and lower CORT and HLR responses. The visual and auditory stimuli can be considered as a form of environmental enrichment. Previous studies indicated that chickens exposed to outdoor environment (Scott *et al*., 1998) or even video stimulation (Jones, 1996) were less fearful than those deprived of extra stimulation in the home environment. Fear is a potent stress-elicitor in poultry (Jones, 1996). According to Wemesfelder and Birke (1997) environmental challenge may be considered as an integral part of behavioral development and well-being. Successful enrichment may increase the behavioral repertoire, reduce the occurrence of abnormal and undesirable behaviors, and enable animals to cope with challenges in a normal fashion (Chamove and Anderson, 1989).

Although environmental enrichment can improve poultry welfare and productivity Jones (1996) suggested that:

"..it is important to avoid applying too much environmental enrichment at any one time or to suddenly translocate an animal from a barren home environment into an unfamiliar enriched one."

CONCLUSIONS

Our relation with chickens is symbiotic and we have an obligation to take care of their interest as well as our own. Chickens are sentient animals, not machines or mere mechanical factors for production. Hence, suffering of chickens must be reduced and welfare must be seriously addressed. The vast scale on which chickens are raised may have desensitized all parties associated with poultry. Humans may also find it easier to relate to and recognize sign of pain in the larger animals, especially if these animals are our companions, such as cats and dogs. There is also a possibility that because chickens appear so different from us and other mammals that we find it difficult to empathise with their suffering. These arguments are obviously not strong enough for us to treat chickens differently from other animals. Poultry producers in the European Union (EU) are presently facing the task of ensuring higher welfare standards to comply with the regulations laid down in the EU Directive. The majority of concerns relating to the poultry industry in Malaysia and other developing nations are to do with producing cheap, plentiful food in a profitable way. However, we have to recognize that the priorities of developed, developing and underdeveloped nations differ. Countries that have difficulty feeding their people understandably put more emphasis on food security rather than animal welfare. Hence, the most difficult challenge to modern agriculture is to make intensive production systems 'animal friendly' and yet economically viable. In order to resolve the welfare problems of poultry and other farm animals, the industry must first see them as problems in animal agriculture. Major advances in understanding poultry welfare will come through scientific research and development. Scientists, and educators can provide reliable information to the society, and it is the society who ultimately dictate the direction and standards of poultry welfare. The decision is in our hands!

REFERENCES

Al-Aqil, A. 2009. Physiological Responses, fear-related behaviour and meat quality of broiler chickens subjected to transportation and other stressors. PhD Thesis, Universiti Putra Malaysia.

Al-Aqil, A. and I. Zulkifli. 2009. Changes in heat shock protein 70 expression and blood parameters in transported broiler chickens as affected by housing and early age feed restriction. Poultry Science 88: 1358-1364.

Albentosa, M.J. and J. J. Cooper. 2004. Effects of cage height and stocking density on the frequency of comfort behaviours performed by laying hens housed in furnished cages. Animal Welfare 4: 419-424.

Albers, G.A.A. and I.A. Groot. 1998. Future trends in poultry breeding. World Poultry 14: 42–43

Appleby, M.C. 1999. What Should We Do About Animal Welfare? Blackwell Science, Oxford, UK.

Bayliss, P.A. and M.H. Hinton. 1990. Transportation of broilers with special reference to mortality rates. Applied Animal Behaviour Science 28:93-118.

Berg, C. 2004. Pododermatitis and hock burn in broiler chickens. In: C. Weeks and A. Butterworth (eds) Measuring and Auditing Broiler Welfare, CABI Publishing, Wallingford, UK, p. 37-50.

Bessei, W. 2006. Welfare of broilers: a review. World's Poultry Science Journal 62:455-466.

Chamove, A.S.; Anderson, J.R. 1989. Examining environmental enrichment. In: E.F. Segal (ed) Housing, care and Psychological Well-Being of Captive and laboratory Primates. Noyes Publications, New Jersey, USA, p. 183-199.

Dawkins, M.S. 1988. Behavioural deprivation: a central problem in animal welfare. Applied Animal Behaviour Science 20:209-225.

Dawkins, M.S. 1990. From an animal's point of view: motivation, fitness, and animal welfare. Behavioural and Brain Sciences 13: 1-9.

Dawkins, M.S., C. A. Donnelly and T.A. Jones 2004. Chicken welfare is influenced more by housing conditions than by stocking density. Nature 427:342-344.

Duncan, I.J.H**.** 1996. Animal welfare defined in terms of feelings. Acta Agriculturae Scandinavia 27:29-35.

Duncan, I.J.H. 2001. Animal Welfare Issues in the Poultry Industry: Is there a lesson to be learned? Journal of Applied Animal Welfare Science 4:207-222

Farsaie, A.L., E. Carr and C.J. Warbeck. 1983. Mechanical harvest of broilers. Transactions of the ASAE 26:1650-1653.

Faure, J.M. 1975. Etude génétique de l'activité précoce en open-filed du jeune poussin. Annales de Génétique and Sélection Animale 7:123-132.

Faure, J.M. and R.B.Jones. 2004. Genetic influences on resource use, fear and sociality. In: G.C. Perry (ed) Welfare of the Laying Hen, CABI Publishing, Wallingford, UK, p. 99-108.

Fraser, A.F. and D.M. Broom. 1997. Farm Animal Behaviour and Welfare. CABI Publishing, Wallingford, UK.

Fraser, D. 1995. Science, values and animal welfare. Exploring the 'inextricable connection'. Animal Welfare 4:103-117.

Grashorn M. and B. Kutriz. 1991**.** Effect of stocking density on performance of modern broiler breeds**.** Archive für Geflügelkunde 55:84-90.

Griffin, H.D. and C. Goddard. 1994. Rapidly growing broiler (meat-type) chickens: their origin and use for comparative studies of the regulation of growth. International Journal of Biochemistry 26:19-28.

Gross, W.B. and G.C. Colmano. 1971. Effects of infectious agents on chickens selected for plasma corticosterone response to social stress. Poultry Science 50:1213-1217.

Gross, W.B. and P.B. Siegel. 1982. Socialization as a factor in resistance to infection, feed efficiency, and response to antigen in chickens. American Journal of Veterinary Research 43:2010-2012.

Hughes, B.O. and A.J. Black. 1976. The influence of handling on egg production, egg shell quality and avoidance behaviour of hens. British Poultry Science 17:135-144.

Hurnik, J.F., A.B. Webster and P.B. Siegel. 1995. Dictionary of Farm Animal Behaviour, Iowa State University Press, Ames, USA.

Jones, R.B. 1982. Effects of early environmental enrichment upon open-field behavior and timidity in the domestic chick. Developmental Psychobiology 15:105-111.

Jones, R.B. 1996. Fear and adaptability in poultry: insights, implications and imperatives. World's Poultry Science Journal 52:131-174.

Jones, R.B., A.D. Mills and J.M. Faure. 1991. Genetic and experimental manipulation of fear-related behaviour in Japanese quail chicks (Coturnix coturnix japonica). Journal of Comparative Psychology 105:15-24.

Julian, R.J. 1986. The effect of increased mineral levels in the feed on leg weakness and sudden death syndrome in broiler chickens. Canadian Veterinary Journal 27: 157–160.
Julian, R.J. 1995. Hepatitis-liver hemorrhage syndrome in laying hens. In: Proceeding of the 67th Northeastern Conference on Avian Diseases, Mystic, CT, USA. P. 17.
Julian, R. J. 1998. Rapid growth problems: Ascites and skeletal deformities in broilers. Poultry Science 77:1773–1780.
Julian, R.J. 2004. Evaluating the impact of metabolic disorders on the welfare of broilers. In: C. Weeks and A. Butterworth (eds) Measuring and Auditing Broiler Welfare, CABI Publishing, Wallingford, UK, p. 51-59.
Kestin, S.C., T.G. Knowles, A.F. Tinch and N.G. Gregory. 1992. The prevalence of leg weakness in broiler chickens and its relationship with genotype. Veterinary Record 13:190-194.
Kujiyat, S.K., J.V. Craig and A.D. Dayton. 1983. Duration of tonic immobility affected by housing environment in White Leghorn hens. Poultry Science 62(11):2280-2.
Leahy, M.P.T. 1991. Against Liberation: Putting Animals in Perspective. Routledge, London, UK.
Liew, P.K., I. Zulkifli, M. Hair-Bejo, A.R. Omar and D.A. Israf. 2003. Effects of early age feed restriction and thermal conditioning on heat shock protein 70 expression, resistance to infectious bursal disease and growth in male broiler chickens subjected to chronic heat stress. Poultry Science, 82:1879-1885.
Mench, J.A. 1992. The welfare of poultry in modern production systems. Poultry Science Review 4:107-128.
Mills, A.D., R.G. Beilharz and P.M. Hocking. 1997. Genetic selection. In: M.C. Appleby and B.O.Hughes (eds) Animal Welfare, CABI International, Wallingford, UK, p. 219-232.
Mitchell, M.A. and P.J. Kettlewell, P.J. 1998. Physiological stress and welfare of broiler chickens in transit: solutions not problems! Poultry Science 77:1803-1814.
Morton, D.B. 2004. Does broiler welfare matter, and to whom? In: C. Weeks and A. Butterworth (eds) Measuring and Auditing Broiler Welfare, CABI Publishing, Wallingford, UK, p. 241-250.
Morris, M.P. 1993. National survey of leg problems. Broiler Industry 93:20-24.
Petherick, J.C. and J. Rushen. 1997. Behavioural restriction**.** In: M.C. Appleby and B.O. Hughes (eds) Animal Welfare, CABI Publishing, Wallingford, UK, p. 89-106.
Sanotra, G.S., L.G. Lawson, K.S. Vestergaard. 2001. Influence of stocking density on tonic immobility, lameness, and tibial dyschondroplasia in broilers. Journal of Applied Animal Welfare Science 4:71-87.
Savory, C.J., K. Maros and S.M. Rutter. 1993. Assessment of hunger in growing broiler breeders in relation to a commercial restricted feeding programme. Animal Welfare 2:131-152.
Scott, G.B. B.J. Connell, and N.R. Lambe. 1998. The fear levels after transport of hens from cages and a free-range system. Poultry Science 77: 62-66.
Siegel, P.B., A. Haberfeld, T.K. Mukherjee, L.C. Stallard, H.L. Marks, N.B. Anthony and E.A. Dunnington. 1992. Jungle fowl–domestic fowl relationships: a use of DNA fingerprinting. World's Poultry Science Journal 48:147-155.
Siegel, P.B. and J.H. Wolford. 2003. A review of some results of selection for juvenile body weight in chickens. The Journal of Poultry Science 40:81-91.
Sørensen, P., G. Su and S.C. Kestin. 1999. The effect of photoperiod/scotoperiod on leg weakness in broiler chickens. Poultry Science 78:336-342.
Stuart, C. 1985. Ways to reduce downgrading. World Poultry Science 41:16-17.
Warriss, P.D., E.A. Bevis, S.N. Brown and J.E. Edwards. 1992. Longer journeys to processing plants are associated with higher mortality in broiler chickens. British Poultry Science 33:201-206.
Weaver, W.D.Jr. and R. Meijerhof. 1991. The effect of different levels of relative humidity and air movement on litter conditions, ammonia levels, growth, and carcass quality for broiler chickens. Poultry Science 70:746-755.
Wemesfelder, F. and L. Birke. 1997. Environmental challenge. In: M.C. Appleby and B.O.Hughes (eds) Animal Welfare, CABI International, Wallingford, UK, p. 35-48.
Wong-Valle J, G.R. McDaniel, D.L. Kuhlers, and J.E. Bartels**.** 1993. Divergent genetic selection for incidence of tibial

dyschondroplasia in broilers at seven weeks of age. Poultry Science 72(3):421-8.
Zulkifli, I. 1999. Heterophil/lymphocyte response and performance of feed and water restricted broiler chickens under tropical conditions. Asian-Australasian Journal of Animal Science 12:951-955.
Zulkifli, I. 2003. Effects of early age feed restriction and dietary ascorbic acid on heterophil/lymphocyte and tonic immobility reactions of transported broiler chickens. Asian-Australasian Journal of Animal Science 16:1545-1549.
Zulkifli, I. 2008. The influence of contact with humans on physiological and behavioural responses in commercial broiler chickens and red jungle fowl when reared separately or intermingled. Archive für Geflügelkunde 72:250-255.
Zulkifli, I. and A. Siti Nor Azah. 2004. Fear and stress reactions, and the performance of commercial broiler chickens subjected to regular pleasant and unpleasant contacts with human beings. Applied Animal Behaviour Science 88: 77-87.
Zulkifli, I., A. Al-Aqil, A.R. Omar, A. Q. Sazili, M.A. Rajion. 2009. Crating and heat stress influences blood parameters and heat shock protein 70 expression in broiler chickens showing short or long tonic immobility reactions. Poultry Science 88:471-476.
Zulkifli, I., E. A. Dunnington, W. B. Gross and P. B. Siegel. 1994a. Food restriction early or later in life and its effect on adaptability, disease resistance, and immunocomptence of heat-stressed dwarf and nondwarf chickens. British Poultry Scienc, 35:203-213.
Zulkifli, I., E.A. Dunnington, W.B. Gross and P.B. Siegel. 1994b. Inhibition of adrenal steroidogenesis, food restriction and acclimation to high ambient temperatures in chickens. British Poultry Science 35:417-426.
Zulkifli, I., E. A. Dunnington, W. B. Gross, A. S. Larsen, A. Martin and P. B. Siegel. 1993. Responses of dwarf and normal chickens to feed restriction, Eimeria tenella infection and sheep red blood cell antigen. Poultry Science 72:1630-1640.
Zulkifli, I., E.A. Dunnington and P.B. Siegel. 1995a. Age and psychogenic factors in response to food deprivation and refeeding in White Leghorn chickens. Archive für Geflügelkunde 59:175-181.
Zulkifli, I., H.S. Siegel, M.M. Mashaly, E.A. Dunnington and P.B. Siegel. 1995b. Inhibition of adrenal steroidogenesis, neonatal feed restriction and pituitary-adrenal axis response to subsequent fasting in chickens. General and Comparative Endocrinology 97:49-56.
Zulkifli, I., I. Norazlina, K. Juriah and Nwe Nwe Htin. 2006. Physiological and behavioural responses of laying hens to repeated feed deprivation and frustration. Archive für Geflügelkunde, 70: 22-27.
Zulkifli, I., M.T. Che Norma, C.H. Chong and T.C. Loh. 2000a. The effects of crating and road transportation on stress and fear responses of broiler chickens treated with ascorbic acid. Archive für Geflügelkunde 65:33-37.
Zulkifli, I., M.T. Che Norma, C.H. Chong and T.C. Loh. 2000b. Heterophil/lymphocyte and tonic immobility reactions to pre-slaughter handling in broiler chickens treated with ascorbic acid. Poultry Science 79:402-406.
Zulkifli, I., M.T. Che Norma, D.A. Israf and A.R. Omar. 2000c. The effect of early age feed restriction on subsequent response to high environmental temperatures in female broiler chickens. Poultry Science 79:1401-1407.
Zulkifli, I., M.T. Che Norma, D.A. Israf and A.R. Omar. 2002a. The effects of early-age food restriction on heat shock protein 70 response in heat-stressed female broiler chickens. British Poultry Science 43:141-145.
Zulkifli, I., J. Gilbert, P.K. Liew and J. Ginsos. 2002b. The effects of regular visual contact on tonic immobility, heterophil/lymphocyte ratio, antibody and growth responses in broiler chickens. Applied Animal Behaviour Science 79:103-112.
Zulkifli, I., P.K. Liew, D.A. Israf, D.A., A.R. Omar and M. Hair-Bejo. 2003. Effects of early age feed restriction and thermal conditioning on heterophil/lymphocyte ratio, heat shock protein 70 and body temperature of male broiler chickens subjected to acute heat stress. Journal of Thermal Biology 28:217-222.
Zulkifli, I., I. Norazlina, K. Juriah and Nwe Nwe Htin. 2006. Physiological and behavioural responses of laying hens to repeated feed deprivation and frustration. Archive für Geflügelkunde.70: 22-27.