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**THE IMPACT OF COUNCIL DIRECTIVE 1999/74/EC
ON LAYING HEN'S PRODUCTION AND WELFARE**

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To live is the rarest thing in the world. Most people exist, that is all. (Oscar Wilde)

DEDICATORY

I dedicate this work to my Mother, for having created and transmitted me everything that is important in this life, we will be back together one day.

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ABSTRACT

Hens are chickens kept commercially under intensive husbandry conditions with the purpose of egg production. Scientific literature on laying hens welfare in Portuguese industrial systems is scarce.

Welfare conditions and regulation in Europe has changed over the years. This research aimed to study the impact of the changes introduced in 2012 in order to improve laying hens welfare conditions. The amount of data used in this study was collected over a period of 5 years, using the records of one of the biggest producers in Portugal, bearing in mind the mortality, feed consumption, egg production and others. Environmental enrichment results were compared to old housing systems used in this farm. This study identified positive and negative impacts on animal welfare. Investments on research seem to be the only way to conduct changes on laying hen chain without reducing the quality of animals life.

Keywords: welfare, laying hen, egg production

As galinhas são frangos mantidos sob condições de criação intensiva com o objetivo de produção de ovos. A literatura científica sobre o bem-estar das galinhas poedeiras nos sistemas industriais portugueses é escassa.

As condições de bem-estar e regulação na Europa mudaram ao longo dos anos. Este estudo teve como objetivo avaliar o impacto das mudanças introduzidas em 2012 para melhorar as condições de bem-estar das galinhas poedeiras. A quantidade de dados utilizada neste estudo foi recolhida ao longo de um período de mais de 5 anos, utilizando os registos de um dos maiores produtores portugueses, tendo em conta a mortalidade, o consumo alimentar, a produção de ovos e outros. Os resultados de enriquecimento ambiental foram comparados com os sistemas de alojamento antigos usados nesta fazenda. Este estudo identificou impactos positivos e negativos no bem-estar animal. Investimentos em pesquisa parecem ser a única maneira de realizar mudanças na cadeia da galinha poedeira sem reduzir a qualidade de vida dos animais.

Keywords: bem-estar, galinhas, produção de ovos

ABBREVIATIONS AND SYMBOLS

AEB	The American Egg Board
AL	After the Law
BL	Before de Law
IEC	International Egg Commission
EFSA	European Food Safety Authority
FAO	Food and Agriculture Organization
FASS	The Federation of animal Science Societies
FAWAC	Farm Animal Welfare Advisory Council
FCR	Feed Conversion Ratio
HSUS	The Humane Society Of the United States
OIE	World organisation for Animal Health
UGPVB	Union des Groupements de Producteurs de Viande de Bretagne
WQ	Welfare quality

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1. INTRODUCTION

Egg production is one of the most intensive animal production systems. The hen industry has developed from small bands of poultry, to highly specialized companies. Over time, chickens have been genetically selected to obtain an improved nutrition conversion, a higher growth and production rate. Between 1920 and 1930 a hen produced 150 eggs/year on average, whereas nowadays this average lies between 250-300, according to the International Egg Commission (IEC), the production increased during the last year due the overall growth in consumption of eggs. Data from feed and Agriculture Organization of United Nations (FAO) indicates that egg consumption in Europe slightly increased between 2000 and 2009 to over 12kg per person. However, according to the International Egg Commission, egg consumption in Portugal has slightly decreased over recent years.

According to the FAO it is estimated that 64,9 million tons of eggs were produced in 2012. This lead to the fact that laying hens are the most numerous globally raised animal which is generating specific problems concerning not only health but also their welfare. The market and population growth is causing hundreds of millions of chickens in this industry to suffer due poor welfare conditions (The Humane Society of the United States, 2008). Throughout the different steps in the commercial egg industry, the welfare of birds is at most times severely impaired, the vast majority of hens were confined in barren battery cages, or in other words, caged in such conditions that birds would not even be able to spread their wings without touching other birds or its own cage walls. Among other inconveniences, battery cages do not allow birds to perch, nest or dust bath, all of which are part of normal bird behaviour. Potential consequences to those conditions are reproductive and liver problems or osteoporosis (HSUS, 2008). Other production practical examples that lead to poor welfare is the beak-trimming of females with a hot blade to ensure normal pecking behaviour or the slaughter of males after hatching, as they are considered byproducts of commercial hatcheries (HSUS, 2008).

The issue of animal welfare is present not only during their growth and life, but also in the processes of catching, transport and slaughter, making this a priority issue to review, not only for the economic loses that producers are experiencing, but also for the currently growing consumers concern regarding a production cycle that provides animals an acceptable degree of welfare. Consequently, from 2001 onwards, animal welfare has become in a strategic priority of the World Organisation for Animal Health (OIE). In this sense, the Council Directive 1999/74/EC of 19th of July, which stated minimum standards for the

protection of laying hens was approved. This directive bans conventional battery cages in the EU from January 1st, 2012 on, and specifies several modifications in cages to improve laying hen welfare.

1.1 WELFARE

Welfare is a complex and multidimensional concept. Broom (1986) defined animal welfare as the ability to cope with the environment. It can be described as the quality of perceptions associated with brain states. These brain states are induced by sensory inputs and cognitive processes, and are related, with the physical health since diseases and injuries do affect these perceptions. Thus, we can affirm that there is a direct relationship between animal welfare and animal health, as physical health influence welfare (eg. diseases or injuries) (Perry, 2004; OIE).

Fear or frustration are examples of unpleasant mental states, meaning that good welfare depends on the ability of each individual to cope with the environment and the constraints that it is exposed to (Welfare, 2000). Conventional battery cages are generating problems in this area, as they can be the main cause for low bone strength, fractures or inability to perform natural behaviours like perching, dust bathing, nesting and foraging (EFSA, 2005).

In fact, it is possible to assess and evaluate animal welfare through several different parameters that can be measured. Due to the fact that welfare is an individual characteristic for each chicken, Welfare Quality (WQ) and LayWel based their welfare evaluations mainly on animal-based measures (health for example), avoiding resource based measures, as these are poor direct indicators of animal welfare.

This assessment can be determined by the observation and measurement of some indicators such as: mortality, panting, huddling, several pathologies, feed consumption and rate of egg laying, among others (Blokhuis, 2009). But physiological parameters can also be used as welfare indicators: the evaluation of hormonal cortisol and corticosteroids levels, heart rate, or degree of immunity response (Scientific Committee on Animal Health and Animal Welfare, 2000).

Nevertheless, the arising problem concerning welfare is not the measurement of welfare itself, but establishing the limits for evaluated variables disregarding the parameters in use. It is crucial to understand until which extent it is acceptable to maintain the animals in given circumstances, and until which extent consumers are willing to pay for the

improvement of animal welfare. In Image 1 there is a list of various studies in different vertent of welfare for laying hens.

Focus of environmental management	Example(s)	Reference
Shelter	Protection of birds from unfavourable weather conditions and predators	Austic and Nesheim, 1990
Production	Air temperature and feed consumption	Mahmoud <i>et al.</i> , 1996; Roland <i>et al.</i> , 1997
	Air temperature and feed conversion	Chepete and Xin, 2000; Yanagi <i>et al.</i> , 2002
	Air temperature and egg production	Timmons and Gates, 1988; Lokhorst, 1996; Roland <i>et al.</i> , 1996; Samara <i>et al.</i> , 1996; Okumura <i>et al.</i> , 1988
	Light colour and number of eggs	Rozenboim <i>et al.</i> , 1998
Product quality	Light schedule and egg weight	Tucker and Charles, 1993
	Air temperature and eggshell quality	Mahmoud <i>et al.</i> , 1996; Samara <i>et al.</i> , 1996
Environmental impact	Light schedule and shell thickness	Tucker and Charles, 1993
	Temperature and NH ₃ emission	Groot Koerkamp, 1994
	Airflow pattern and odour emission	Müller, 2002
Health and welfare	Temperature and dust emission	Guarino <i>et al.</i> , 1999
	High temperatures and thermal stress	Barnett and Newman, 1997
	Air velocity and sprinkling and heat stress	Bottcher <i>et al.</i> , 1991; Ikeguchi and Xin, 2001; Yahav <i>et al.</i> , 2001
	Air mixing and contaminant concentration	D'Alfonso <i>et al.</i> , 1996
	Dust, NH ₃ and bacteria and lung lesions	Appleby and Hughes, 1991
	Dust and mortality	Guarino <i>et al.</i> , 1999
Health and welfare	Light schedules and mortality	Lewis <i>et al.</i> , 1992
	Illuminance and eating behaviour	Prescott and Wathes, 2002

Image 1 - Importance of environmental management for the laying hen (Perry, 2004)

1.1.1. LAYING HENS BEHAVIOUR

Laying hens belong to the species *Gallus Gallus*, and they are those which have reached laying maturity and are kept for production of eggs not intended for hatching.

The natural behavioural repertoire of modern domestic hens, comprises ancestral behaviour patterns shown off when hens are provided with enough space and access to several resources (Lindqvist *et al.*, 2007). The following routine usually applies for a typical day of a non-caged chicken: their day start by feeding and inspecting the nest box, before laying an egg. Further on, they have a rest and take a bath in the middle of the day. The daily routine

finishes by scratching and feeding behaviour peaks (Bestman, 2011). The extent to which the behavioural patterns are perceivable in adult hens, is depending both on their housing, genetics, epigenetic effects, previous experience in rearing environment and environmental conditions in embryonic development (Lindqvist *et al.*, 2007). Whenever hens are motivated to embrace normal behaviour but they find themselves unable due to housing constraints, welfare concerns should arise. In Table 1, there is a list of behaviours and their frequency depending on the housing type.

Table 1 - Predicted levels of behavioural expression in different housing systems for commercial egg production (depending on space and resource provision) (Lay et al, 2011).

Predicted levels of behavioral expression in different housing systems for commercial egg production (depending on space and resource provision)¹

Behavioral opportunity	Conventional cage	Furnished cage		Noncage (barn) ²		Outdoor (free-range) ³
		Small	Large	Slats/litter	Aviaries	
Flying	+	+	+	++++	++++	++++
Running	+	+	++	++++	++++	++++
Walking	++	++	+++	++++	++++	++++
Wing flapping ⁴	+	++	++	++++	++++	++++
Stretching	++	+++	+++	++++	++++	++++
Preening	+++	++++	++++	++++	++++	++++
Standing	++++	++++	++++	++++	++++	++++
Sitting	+++	++++	++++	++++	++++	++++
Feeding	+++	+++	++++	++++	++++	++++
Drinking	+++	+++	++++	++++	++++	++++
Foraging	+	++	++	+++	+++	+++
Dust bathing	+	++	++	++++	++++	++++
Nesting	+	+++	+++	++++	++++	++++
Brooding ⁵	+	+	+	+	+	+
Perching	+	++	++	+++	+++	+++
Mating ⁶	+	+	+	+	+	+
Stereotyped and sham behaviors	++++	++	++	++	++	++
Cannibalism and feather pecking	++	++	+++	++++	++++	++++
Social aggression ⁷	++	+++	+++	++	++	++
Smothering ⁸	++	++	+++	++++	++++	+++

¹+ = none or incomplete, ++ = relatively low, +++ = moderate, ++++ = full or relatively high. Results heavily influenced by other factors, including strain, rearing conditions, management, and precise details of the housing, within general housing type. An increased opportunity to perform a behavior does not necessarily translate into increased performance of the behavior. Comparative data supporting the above predictions across all behaviors in all housing types are limited or lacking.

²Predictions assume that hens have access to litter and perches. In the United States, there is no legal requirement to provide litter or perches. Barn systems may have all slatted or wire floors, resulting in outcomes similar to conventional cages for foraging, dust bathing, perching, and stereotyped and sham behaviors.

³Predictions assume that hens have access to litter and perches indoors and daily access to an outdoor range primarily covered with vegetation. In the United States, there is no legal requirement for daily time spent outdoors or provision of litter, perches, or vegetation. Hens may be confined indoors for extended periods on fully slatted or wire floors, resulting in outcomes similar to conventional cages for foraging, dust bathing, perching, and stereotyped and sham behaviors.

⁴If sufficient cage height.

⁵Broodiness toward eggs occasionally seen in noncage and free-range systems.

⁶Depends on presence of roosters (roosters are housed with hens rarely in noncage systems and occasionally in free-range systems).

⁷Depends on strain, group size (groups of around 30 hens show the most aggression), density (peaks at around 600 cm²/hen), and accessibility of resources (limited, defensible resources increase aggression).

⁸Depends on strain (risk higher in flighty strains), group size (larger groups increase risk), and presence of perches and other enrichments (reduce risk).

Birds in a cage system do not display these kind of behaviours, namely: dust bathing, nesting, perching and foraging, due to the constraints involved in living in a cage, like being restricted in the movements and consequently suffering from physical abnormalities (The

Humane Society of the United States, 2008; Bestman, 2011). According to Hennen (2004) the minimum space necessary for a laying hen to express a normal behavior is shown on Table 2.

Table 2 - Space required for the different activities (Hennen, 2004)

Activity	Space required
Eating	446 cm ²
Drinking	446 cm ²
Scraping ground/foraging	799 cm ²
Cleaning	1076 cm ²
Dust bathing	1076 cm ²
Egg laying	1055 cm ²
Resting	538 cm ²

2. NATURAL BEHAVIOURS

2.1 DUSTBATHING

Sanotra & Weeks (2004) stated that dust bathing is, in fact, an important behaviour that has as a main function the removal of excess lipids from feathers, the improvement of feathers and the removal of ectoparasites. Furthermore, hens take part in these dust bathing activities also for the socialising aspect of it (Vestergaard, 1982). Vestergaard (1982) found that in environments in which litter is accessible to hens, dust bathing is a social experience for them. Also, observed that frequently if one hen starts to dust bathe, the others will follow. Thus, this behaviour can be seen as a social facilitator (Vestergaard, 1982; Olsson & Keeling, 2005). Another variable that determines this behaviour is the substrate. Hens prefer substrates with a fine structure (sand or peat) over substrates made of larger particles (wood shavings or straw) (Olsson & Keeling, 2005).

2.2 NESTING BEHAVIOUR

Nesting is the behaviour that leads to the selection and construction of a nest, increasing highly the chances of eggs hatching successfully. The behaviour patterns for nesting under natural conditions, lead to the selection of a protected nest site by building a suitable nest, and therefore, increasing the chances of egg hatching successfully (Perry, 2004). In the wild when the egg is laid outside the nest, the chances of contributing to the biological

fitness of the mother hen are reduced. This means that, if a hen is going to hatch any chicks, she usually would have to show nesting behaviour. However, hens always show some degree of nesting behaviour (Perry, 2004).

Treading, molding the substrate, pecking and searching for an adequate nest site are all behaviours to facilitate egg laying (Appleby, 2004). Hens always show some degree of nesting behaviour patterns like finding nest sites and building nests, as nesting is a behaviour pattern which is inflexible and necessary for the species. This is why even highly select modern hybrids show some degree of nesting behaviour patterns. While brooding behaviour has been selected against in the process of egg production improvement, there has not been any conscious selection against nesting behaviour (Perry, 2004). Hens that are placed in conventional cages, may show frustration as a result of not having access to a nest site (Appleby, 2004).

For all reasons exposed previously, a nestbox represents the most important physical enrichment for laying hens, as their need and motivation for nest use increase when the time comes for laying eggs (Cooper & Albentosa, 2003; John McGlone, 2010).

According to several experiments, hens are motivated to lay their egg in a nestbox (Appleby & McRae, 1986; Duncan & Kite, 1989) and further research, confirmed this (Cooper & Appleby, 1995, 1996a). When hens are not provided with a nest box, they spend a longer time in the pursuit of a nest (Cooper & Appleby, 1995; Freire *et al.*, 1996). In the cases in which access to the nest is blocked, hens increase the gavel-call, a behaviour which indicates growing frustration (Zimmerman *et al.*, 2000). The strength with which a hen pushes through a gap is used as a measurement of the desire to access a blocked nest. This motivation, has proved to be more intense than the motivation to feed after 4h of feed deprivation and actually increases with time when it gets closer to actual egg posture (Cooper & Appleby, 2003). There is evidence, that performance of nest building is more important to a hen than the fact of nest construction (Hughes *et al.*, 1989). Some hens still choose to lay their eggs outside the nest even when attractive nestboxes are provided (Sherwin & Nicol, 1993).

Whether or not this is a welfare problem for the hen, depends on the use the hen will make out of the nest. For example, if a hen decides to lay an egg outside the nest box provided because she thinks it is the most appropriate, or is not motivated to lay her egg in a protected nest, this means that the hen's perception is that her place of laying the egg is more adequate than the nest box provided. In this case, there is no welfare problem because to this hen's perspective, there is a nest. On the other hand, if a hen is motivated to lay her egg in a nest but can not find an appropriate place and ends up laying her egg in an inappropriate

place, then this would account as a welfare problem because there is no nest to this hen. There is some evidence to support both arguments. Certainly there is a large individual variation in preferences for nest design (Sherwin & Nicol, 1993). Even though there is evidence that some hens are naturally less motivated/interested to lay eggs in nestboxes (Cooper & Appleby, 1996b).

2.3 PERCHING

Perching is other main behavioural need. Chicks learn how to perch from their mother under natural conditions, however, having their mother around is not an essential requirement to learn how to perch, if perches are available during the first weeks of life, chicks will learn by themselves (Appleby *et al.*, 1988). The moment when perching is most noticeable is in the early evening. This behaviour of roosting at night time, would be caused under natural conditions by the decreasing of daylight (Kent *et al.*, 1997). Under commercial conditions, this can be manipulated by gradually dimming the lighting. Under natural conditions, perching behaviour has the functionality of avoiding the risk of predators coming from the ground and conserving body warmth in cold environments (Perry, 2004). But the utilization of perches has also a double purpose: a) minimises poultry fear and flightiness (Brake, 1987; Scott *et al.*, 1998) and b) improves performance of exercise, potentially generating bone strength (Whitehead, 2004; John McGlone, 2010). Poultry are encouraged to exercise through the implementation of perches, which promote the use of vertical space. As hens also have a tendency to develop osteoporosis, it is crucial to make sure that hens can freely move from one perch to the other without getting injured on the way (eg. breaking bones on landings) (Perry, 2004). The entire flock will make use of the provided perches at night if there is enough perch space for all (Appleby *et al.*, 1993; Olsson & Keeling, 2002; John McGlone, 2010).

The main risk associated to perches is the potential development of keel bones resulting from resting in perches, and although it is unknown if this condition is painful or not for hens, it is important to be aware of the scope of the problem. Ideally, perches should be sized with enough diameter so that toenails are not injured, free of sharp edges, appropriate size to be readily gripped by the birds claws, easily cleaned and made out of materials which are slippery free (Tauson & Abrahamsson, 1996). Another important aspect of perches is their height and location, as hens show preference for higher perches (Newberry *et al.*, 2001) and

to some extent, they also show motivation to return to similar locations of perches on consecutive evenings (Odén *et al.*, 2000).

Perches have shown to be extremely beneficial versus the lack of perches. Hens raised in environments with no perches, show a reduced ability in finding feed and water when relocated to an aviary system from floor rearing. On the other hand, research has proved that the access to perches at an early stage can potentially decrease flock mortality rate coming from cloacal cannibalism (Gunnarsson, 1999). In conclusion, providing perches to commercial hens can bring many behavioural benefits (Perry, 2004).

2.4 SCRATCHING AND FORAGING

Birds usually scratch the earth when searching for feed and with the purpose of exploring the environment. Research has proved that fowls, spend more than half of their daily time foraging. In this sense, battery cages generally do not allow hens to perform normal foraging and scratching behaviour due to the wire (Savory *et al.*, 1978; Dawkins, 1989). Adding to this, battery caged hens are fed with a concentrated diet, despite the fact that their natural motivation to forage is strong. According to research undertaken in this area, hens choose feed on the ground in loose substrate over the same feed in a feeder (Duncan & Hughes, 1972; Dawkins, 1989). The main risk associated to inappropriate foraging substrate is the development of abnormal feather-pecking behaviour (Blokhuis, 1989; The Humane Society of the United States, 2008).

2.5 EXERCISING

Hens in cages do not have the chance to perform exercise as they are not exposed to the physical forces that create a structure in their bones. The restriction of performing normal movement patterns is creating bone weakness, bone fragility and impaired bone strength (Rowland & Harms, 1970; Wabeck & Littlefield, 1972; Meyer & Sunde, 1974). Whereas hens that are bred for egg production are more likely to end up with skeletal weakness caused by osteoporosis, hens in cages are more likely to end up with skeletal weakness due to lack of exercise (Knowles & Broom, 1990; Norgaard-Nielsen, 1990). Due to the scope of this problem, conclusions of a research showed that 24% of all birds that were taken out of their cages, presented broken bones after their laying period (Gregory & Wilkins, 1989). Furthermore, preference tests demonstrated that hens chose enclosures of larger size when

presented with the option of choosing between different sizes (Dawkins, 1983). However, these tests have also demonstrated that despite the fact of size of space being important, other aspects like access to resources (littered floor for example) may be more important (Dawkins, 1977, 1981). Nevertheless, small spaces may temporarily be preferred for particular activities, such as nesting (Nicol, 1986).

2.6 EXPLORING

Exploration is natural behaviour for hens, as they are inquisitive and exploring is important for them for two reasons: a) satisfies motivation to get information about the surroundings and b) creates competency (Wood-Gush & Vestergaard, 1989; Shepherdson *et al.*, 1998). Some authors have further argued that situations that deny environmental challenge (because they are barren and devoid of natural stimulation) deprive animals of “the very core on which their physical existence is based, namely the ability to act.” (Appleby *et al.*, 2011). Unlike in other patterns of animal behaviour, exploratory behaviour has proved to be independent and not related to goals, as chickens still perform exploratory behavioural patterns even if they have available nest sites and nutritious feed, which are the main purposes in natural exploration (Wood-Gush & Vestergaard, 1989). Therefore, exploration is described as a behavioral need (Appleby *et al.*, 2011).

Battery cages do not offer to hens a psychological well being, as the environment is monotonous and predictable, and hens are not able to develop the degree of stimulation that they would in natural environments. This lack of environmental challenge results in apathy, boredom and frustration (Wood-Gush & Vestergaard, 1989; Appleby *et al.*, 2011).

3. LAW

The European Union Council Directive 1999/74/EC is the legislation passed by the European Union on the minimum standards for keeping egg laying hens which effectively bans the usage conventional battery cages. This directive, passed in 1999, banned conventional battery cages in the EU from January 1, 2012 after a 13-year phase-out. Battery cages were already banned in Germany, Austria, the Netherlands and Sweden prior to 2012. The directive does not apply to establishments with fewer than 350 laying hens or establishments rearing breeding laying hens. Such establishments are, however, subject to the requirements of Directive 98/58/EC. The directive is not supported with fines, penalties or export bans.

Before this new directive was approved the conventional floor space for battery cages ranges upwards from 300 cm² per bird.

As alternatives to battery cages, Directive 1999/74/EC allows non-cage systems and furnished cages. Furnished cages therefore represent a feasible alternative to battery cages in the EU after 2012. Under the directive, furnished cages must provide at least the following: 750 cm² per hen, of which 600 cm² is 45 cm high, a nest, a littered area for scratching and pecking, 15 cm of perch and 12 cm of feed trough per hen and a claw shortening device. Austria banned battery cages in 2009 and is set to ban furnished cages by 2020. Belgium has also banned the battery cage – and proposes to ban furnished cages by 2024. Germany has introduced a ‘family cage’, which has more space than the furnished cages used in other countries, however, consumers in Germany have been rejecting these eggs. Outside the EU, Switzerland has already banned both the battery and furnished cage systems (Kerswell, 2011).

In February 2010, the Polish government formally requested the EU to delay enacting Directive 1999/74/EC by 5 years until 2017 (Berkhout, 2010), however, this was unsuccessful.

According to figures submitted to the European Commission in 2011, 14 countries were expected to be battery cage free by 1 January 2012. However, six states including Portugal, Poland and Romania admitted they would not be ready, while Spain and Italy, among others, did not know or would not say whether they will meet the deadline (Hickman, 2011). In France one third of egg producers have gone out of business and according to figures of the Union des Groupements de Producteurs de Viande de Bretagne (UGPVB) 5% of producers were still not compliant as of January 2012 and have had their licences withdrawn ("Le marché de l'oeuf bat provisoirement de l'aile," 2012). This has led to fears that cheaper, illegal eggs, particularly liquid egg products, from non-compliant states will flood the market undercutting compliant egg producers. John Dalli, the EU health commissioner, has issued legal warnings to 13 countries over their lack of readiness or effort to enforce the ban (Castoria, 2011). The 13 member states already found to be in breach of the directive are: Hungary, Italy, Latvia, Spain, Greece, Belgium, Bulgaria, Cyprus, Poland, Portugal, Romania, Slovakia and the Netherlands.

Compliance beyond January 2012 - It is clear that beyond the date of the law coming into effect, many hens are still being housed in battery cages. European Commission figures show that more than 47 million hens are still (January 2012) in conventional battery cages across the EU, representing 14.3% of production ("Director of Policy report - 24th January 2012,"

2012), although it has been reported this figure might be as high as 23% of EU egg production - equivalent to 84 million hens laying 70 million eggs a day (Lewis, 2012).

Fifteen EU states reported to the EU's Standing Committee on the Feed Chain and Animal Health that they had non-compliant producers. These states were Belgium, Bulgaria, Cyprus, France, Greece, Hungary, Italy, UK, Latvia, Malta, Netherlands, Poland, Portugal, Spain and Romania. Some of these countries, such as Italy and Belgium, admit to having 30% of illegal production.

3.1 FURNISHED CAGES

Furnished cages are generally larger than conventional cages, with some prototypes housing up to eighty hens. Furnished cages have brought with them an improvement increase comfort for hens. The larger horizontal space for movements allows nesting, dust bathing, perching. However, there is still some room for improvement as other behaviours like wing flapping and flying are quite limited (Appleby *et al.*, 2002).

Sometimes, furnished cages are provided with litter for activities such as dust bathing, however, this material can be wasted in a short time by dust bathing or foraging (Bubier, 1996; Lindqvist *et al.*, 2002). It has been demonstrated that even when provided litter, some hens still sham dust bath on the floor, as motivation to perform it is quite variable (Olsson & Keeling, 2005). On the other hand, the lack of litter or the restriction to it over longer periods of time can indeed create stress for hens. In other cases, dominant hens block the other from accessing the litter. This is another situation that could create stress and consequences in their welfare (Shimmura *et al.*, 2008).

In the same way as dust bathing, the motivation to use perches is also variable from hen to hen (Faure & Bryan jones, 1982), although most hens do show a degree of motivation for this activity (Olsson keeling, 2002). In cases where enough perches space are provided, up to half of the hens can be spotted perching at any poin of the day, whereas at night, almost all of them would perch at the same time (Appleby et al, 2002). There is a relationship between cannibalism and perching in furnished caged as some hens lays eggs on perches and therefore expose the cloaca (Moinard et al, 1998), on the other hand, perches have proven to reduce the risk of piling and smothering if the cage is large enough (Hansen, 1976), but data are lacking (Lay et al, 2011).

4. WELFARE INDICATORS

4.1 EGG QUALITY

Commercial chicken eggs are sorted according to exterior and interior quality into two grades established by the COMMISSION REGULATION (EC) No 589/2008. They can be classified as class A or class B and, this will be reflected on the price that the farm can sell them and on the revenue of the business.

In general class A eggs gather the characteristics which allows them to be commercialized as they are, divided in boxes of different sizes and separated by their weight. Class B eggs are the one that do not gather the characteristics of a class A egg. Normally these eggs are sold for a cheaper price to other companies that work with these products.

4.2 EGG PRODUCTION

Although feed intake and feed conversion efficiency vary between systems, no clear differences in egg production have been found. For laying hen production systems, however, a difference that does exist is loss of eggs in more extensive systems, from causes such as floor laying.

As a result, there has been a slight tendency for more eggs to be collected in cages than in other systems. Within systems, it is common for egg production to decline with increased stocking density and group size. For laying hens, this has been most clearly demonstrated in cages (Adams & Craig, 1985); it has also been recorded in a straw yard, but not in deep litter. Depression of egg production has sometimes been interpreted as an indicator of poor welfare; this is controversial (Appleby and Hughes, 1991), but in caged hens decreased egg production is correlated with more reliable indices of welfare, such as mortality (Adams and Craig, 1985).

Table 3 - Several studies compared egg numbers in cages with those in other systems, all using ISA Brown hens (Appleby, 2004).

Reference	System	Ages (weeks)	Stocking density (birds/m ²)	Year		
				1	2	3
Hughes and Dun (1986)	Free range	20–68	0.1 (3 in house)	245		
		20–72				283
	Cages	20–68	21	251		
		20–72				280
Gibson <i>et al.</i> (1988)	Strawyard	20–72	3	261		
			4	247	288	291
			5		283	
			6			285
Appleby <i>et al.</i> (1988b)	Deep litter	20–64	3	224		
			6	228		
			7		208	
			8		224	
			10		235	225
			11			232
	Cages	20–64	13	242	234	253
			18	236	230	248
McLean <i>et al.</i> (1986)	Perchery	20–44	13	133		
	Cages	20–44	18	137		

4.3 MORTALITY

Mortality is defined as the ‘uncontrolled’ death of animals (as distinct from culling/euthanasia). The animals may die from, for example, septicaemia, respiratory disease, acute infection or dehydration. Any animal which is ‘found dead’ in the house, or out on the field is considered a mortality. This is based on data collected from farm records. Using house records of animal numbers placed, died and culled (the farm in the study do not cull the animals).

The equation to do this calculation was:

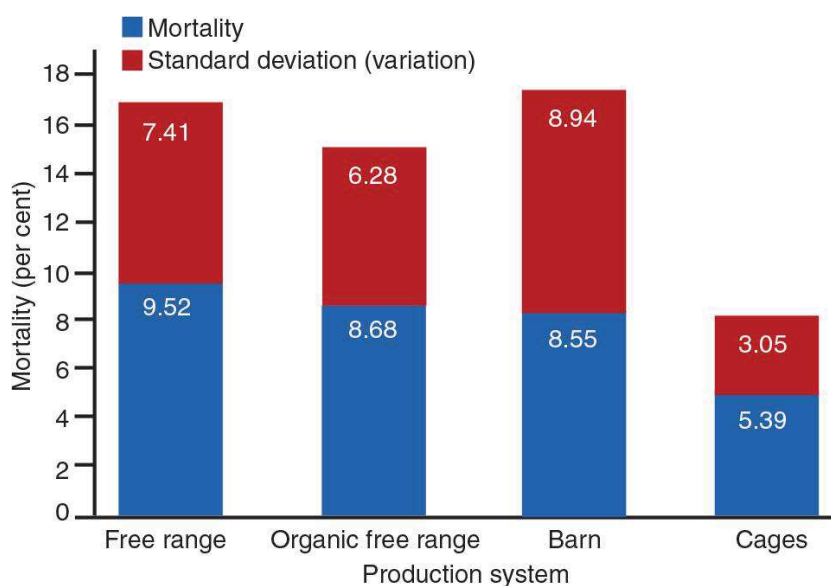
$$\text{Percentage of mortality} = (M/A) \times 100$$

A - Number of animals placed in house from previous animal unit

M - Total number of animals which died and were found dead during the flock cycle

According to Bruch (2012), the expected mortality is 5.39% on a caged system, variations on this value may be caused by diseases, environment changes, failures on the feed or water supply systems. Any big variation on the expected mortality value shall be evaluated to determinate its cause. Table 4 show how mortality percertages vary with the production system used.

Table 4 – Hen average mortality (per cent) by system and the standart deviation(sd) or variation in the diferent production systems Bruch (2012)



4.4 NUTRITION AND FEED CONSUMPTION

The hen's feed consumption rate is governed by several factors, including body weight (or age), rate of egg production, egg weight, effective ambient temperature, feed texture, dietary nutrient imbalances, and dietary energy content. Accurate and frequent estimates of actual flock feed intake are critical to effective feed formulation. Because the hens feed consumption rate can vary with age of the bird, effective ambient temperature, and dietary energy content, the diet's concentration of energy and nutrients should be carefully considered such that the diet provides the recommended grams or miligrams of nutrient intake.

Bodyweight at point of lay influences yolk size, which, in turn, influences egg weight. Therefore, changing the pullet feeding and management program to increase body weight at point of lay can increase the egg size throughout the laying period and vice versa.

During the laying period, egg weight can be influenced by changing the consumption of balanced protein or amino acids (of these, methionine has traditionally been used to affect egg weight), linoleic acid, and supplemental fat or oil. Rather than changing just methionine, it is recommended to change all the amino acids to influence egg weight. Consumption of energy content should normally not be change in an attempt to influence egg weight. Note that if these nutritional strategies are used to influence egg weight to avoid excessively heavy eggs, it is important to start egg-weight control early in the production cycle (i.e., 2 to 3 before the disered egg weight). Once the eggs are above the desired weight, it is difficult- if not impossible – to reduce egg weight without also reducing egg production (Perry, 2004).

4.5 STRAINS IN THIS STUDY

In this study there were two strains ISA and Hy-line. The change in the breed is due to some problem with the supply of new specimens of the ISA strain, as their representative company was discontinued in Portugal. So in order to have a continued, fast and stable resource of new specimens when needed, the company changed their supplier to Hy-Line. Based on their standard performance studies, it is possible to verify that this breeds are very similar in performance levels, which would not affect the results of our study.

4.5.1 SELECTION OF WELFARE INDICATORS

Bellow there is a summary of the welfare indicators used in this study.

Mortality rate	Yes
Productivity	Yes
Parasites infestions and treatments	Not enough data
Egg Shell quality	Yes
Daily feed consumption	Yes
Air quality	Note enough data
Feet injuries (slaughter house)	No data available

5. OBJECTIVES OF THE STUDY

This research has as a main objective to evaluate the welfare degree and the production level of laying hens, which are produced, in an intensive system in continental Portugal. Then a comparison was undertaken between welfare and production parameter in traditional and enriched cages, in order to assess the impact of the implemented Council Directive (1999/74/EC).

6. MATERIALS AND METHODS

6.1 SAMPLE SELECTION

This study's sample was elected from a caged hens's facility in Ferreira do Zêzere, Santarém, having been chosen two pavilions as study subject. In this facility, which is an intensive production system, distinctive densities of animals were legally authorized, as different dimension cages were used, as shown in the annex 1 and annex 2.

Distinct groups have been chosen for evaluation periods before and after the new law, as the group could be affected by the changes in the environment during the period of adaptation to the new cages. The only difference after the new law, since the cages were already made in the dimensions of the new legislation, was the introduction of nests, scratching area and perches.

All hens included in this study had a fast growing genotype and the conditions – temperature, humidity, luminosity, ammonia and light cycles – were the same in every group, using state of the art technological equipment. A total of 614.830 hens were evaluated.

The flocks CM3B3, CM3B4, CM3B5, RM2B2, RM2B3, RM2B4 are ISA breed, the remaining flocks in this study are Hy-Line breed (all the flock ID codes will be explained on the next sections).

To compare flocks before and after the new legislation, it was important to determine if all flocks before legislation and all flocks after legislation were similar. An heterogeneous sample could be a limiting factor for this study.

6.2 STRAINS IN THIS STUDY

In this study there were two strains ISA and Hy-line. The change in the strain is due to some problem with the supply of new specimens of the ISA strain, as their representative company was discontinued in Portugal. So in order to have a continued, fast and stable resource of new specimens when needed, the company changed their supplier to Hy-Line. Based on their standard performance studies, it is possible to verify that this breeds are very similar in performance levels in the annex 3 and 4, which would not affect the results of our study.

6.3 SELECTION OF WELFARE INDICATORS

Bellow there is a summary of the welfare indicators used in this study.

Mortality rate	Yes
Productivity	Yes
Parasites infestions and treatments	Not enough data
Egg Shell quality	Yes
Daily feed consumption	Yes
Air quality	Note enough data
Feet injuries (slaughter house)	No data available

6.4 DATA COLLECTION

Each pavillion was evaluated daily during the whole productive cycle of each group. Due to logistics and clearness of data interpretation data collection was done weekly. Data collection included weekly record of mortality, egg production and feed consumed, among others.

The data was collected from facility's to guarantee data reliability. For data standardization purposes, week one for each group is labelled as the beginning of egg production. The final week is labelled as the week before initiating the process of collecting the animals to the slaughterhouse. Table 5 summarizes the general informations regarding the ten flocks under analysis.

Table 5 – Pavillions and flock information

Laying hen Pavillion	Flock number	Strain	Start Date	Exit Date	Productive weeks	Directive 1999/74/CE
TS	1	Hy-Line	22/07/13	02/11/14	65	After
	2	Hy-Line	27/02/12	13/03/13	55	After
	3	ISA	08/09/08	28/03/10	79	Before
	4	ISA	26/03/07	20/05/08	53	Before
	5	ISA	01/08/05	04/02/07	79	Before
RM	6	Hy-Line	29/07/13	09/11/14	66	After
	7	Hy-Line	27/07/12	17/03/13	55	After
	8	ISA	23/02/09	04/07/10	71	Before
	9	ISA	03/10/07	21/12/08	64	Before
	10	ISA	13/03/06	09/09/07	78	Before

If should be noted, although with still to be analyzed statistical relevance, that the flocks longevity varies between before and after the legislation. Such difference is likely to be derived from the allowed induction of metabolic stress that existed before the new law (which aimed to improve their egg posture numbers).

6.5 STATISTICAL ANALYSIS

For the statistical analysis Microsoft Office Excel 2007 (in which all the data was firstly registered) and SPSS 22 have been used.

The first part of the statistical analysis included descriptive statistic test of the relevant variables (table 6) data normality analysis.

Accepting the normality of data distribution (due to the sample dimension) one-way ANOVA tests were made to verify the existence of significant differences between variance and the mean of the relevant variables. Some Pearson correlation tests were also run.

The statistical base unit was the productive week, so all the daily data is distributed in weekly unit (feeding, number of animals, number of eggs and quality of eggs). Even though the descriptive and ANOVA analysis have been based in groups and comparisons between groups, pavilions and legislative periods, the productive week has always been considered as the statistical unit were all the other factors are organized and registered.

Table 6 – Identification of flocks and variables

Name of Variable	Content	Key or Unity
ID	ID of the origin group	CM3B8; CM3B7; CM3B5; CM3B4; CM3B3; RM2B7; RM2B6; RM2B4; RM2B3; RM2B2
Flock	Numerical ID of the origin flock	1 = CM3B8; 2 = CM3B7; 3 = CM3B5; 4 = CM3B4; 5 = CM3B3; 6 = RM2B7; 7 = RM2B6; 8 = RM2B4; 9 = RM2B3; 10 = RM2B2

Pavilion	Origin Pavilion ID	Casal Mourão 3 = (flock 1 to 5) Ribeira da Mata 2 = (flock 6 to 10)
AL/DL	Legislative period ID	BL = before implementation of Directive 1999/74/EC (Groups 3 to 5 and 8 to 10) AL = after implementation of Directive 1999/74/EC (Groups 1, 2, 6 and 7)
Productive week	Productive week ID	Basic statistical unit
Feeding	Total of feeding in a productive week	Kilograms
NrAnimals	Total of animals per group.	Whole Number
NrEggs	Total of eggs produced	Whole Number
Egg Weight(g)	Average Egg weight	Grams
Eggs/Animal	Ratio NrEggs/NrAnimals	Decimal number
Feeding/Animal	Ratio feeding/NrAnimals	Decimal number
Eggs/Feeding	Ratio NrEggs/Feeding	Decimal number
Classification A	Total of eggs with classification A	Whole number
Dirty (class B)	Total of eggs with classification B (dirty)	Whole number
Broken (class B)	Total of eggs with classification B (broken)	Whole number
Total class B	Total of eggs with classification B	Whole number
B/A	Ratio eggs Total Class B / Class A	Decimal number

Due to a big proportion of absent data or not conclusive data, the Egg Weight (g) variable was not considered in this analysis.

7. RESULTS

As a way to make the statistical analysis easier and also the interpretation of results, the number of the groups will be sequentially numbered as shown in Table 7.

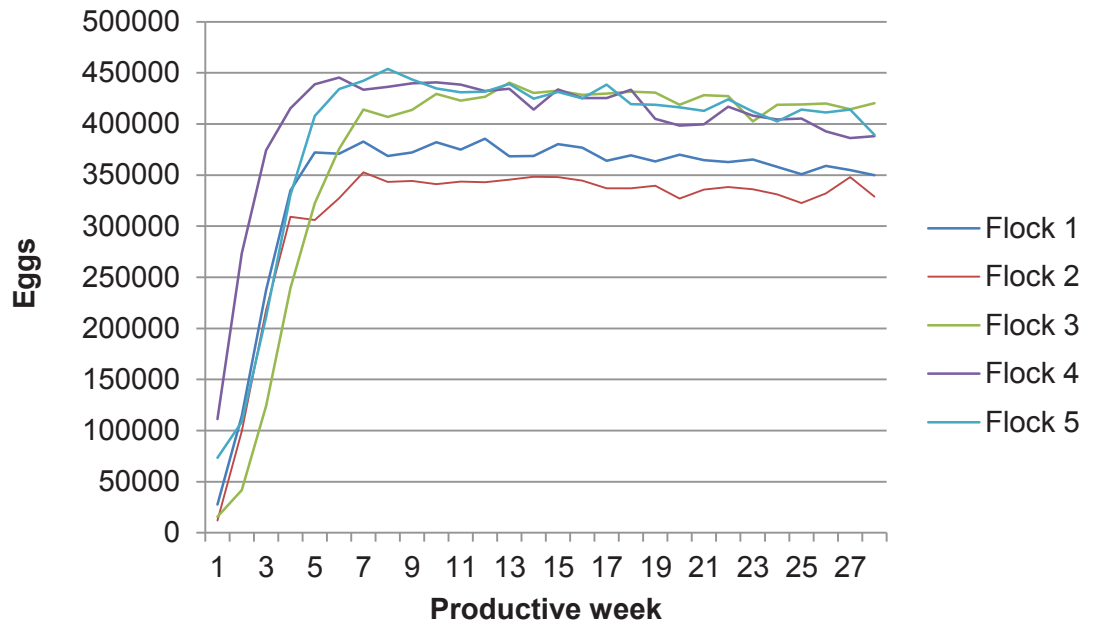
Table 7 – Flock information

Flock n°	Flock of origin	Pavilion	N° initial animals	Legislative period
1	CM3B8	TS	56564	AL
2	CM3B7	TS	51522	AL
3	CM3B5	TS	66460	BL
4	CM3B4	TS	67340	BL
5	CM3B3	TS	67452	BL
6	RM2B7	RM	39062	AL
7	RM2B6	RM	34500	AL
8	RM2B4	RM	46366	BL
9	RM2B3	RM	48936	BL
10	RM2B2	RM	49100	BL

The complete data base of all data obtained is available by request, once that it's full description in this text would not be clarifying.

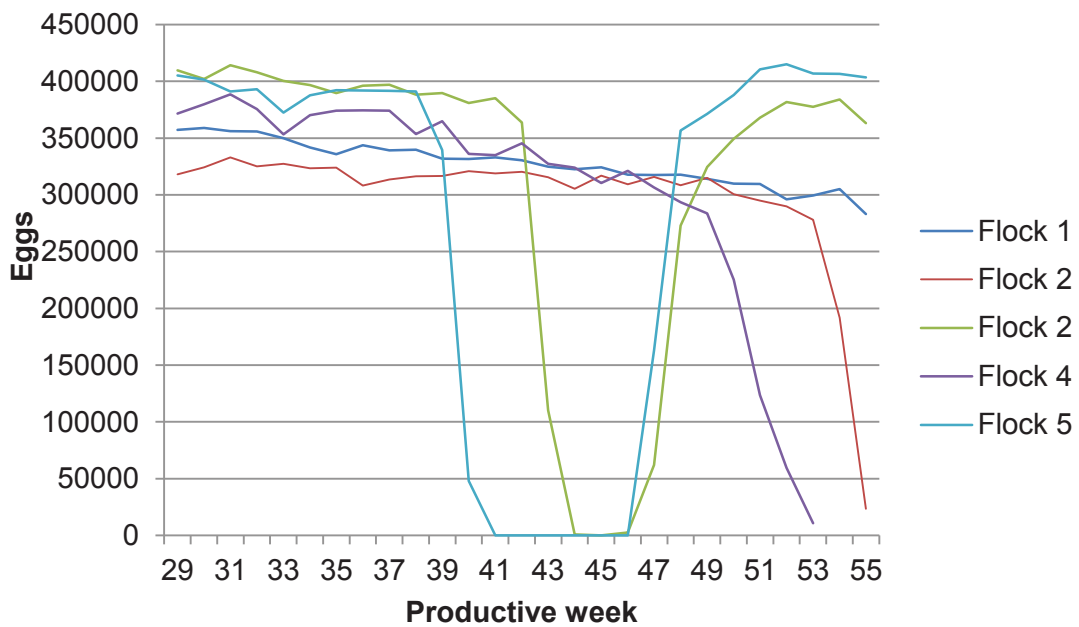
The most relevant data concerns the number of produced eggs. Graphics 1 to 6 will show the evolution of the number of eggs produced in each week during the whole reproductive period, being this period divided in three gags, making the graphic presentation easier.

Number of Eggs per Productive Week Gap 1

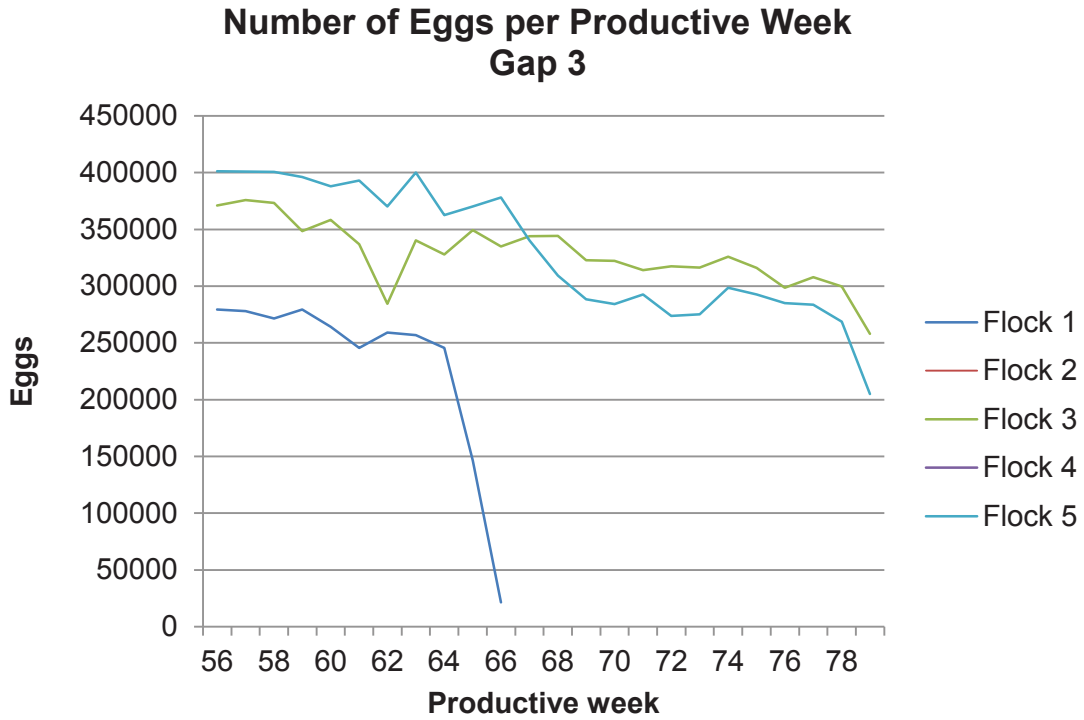


Graphic 1 - Number of eggs per productive week Gap 1.

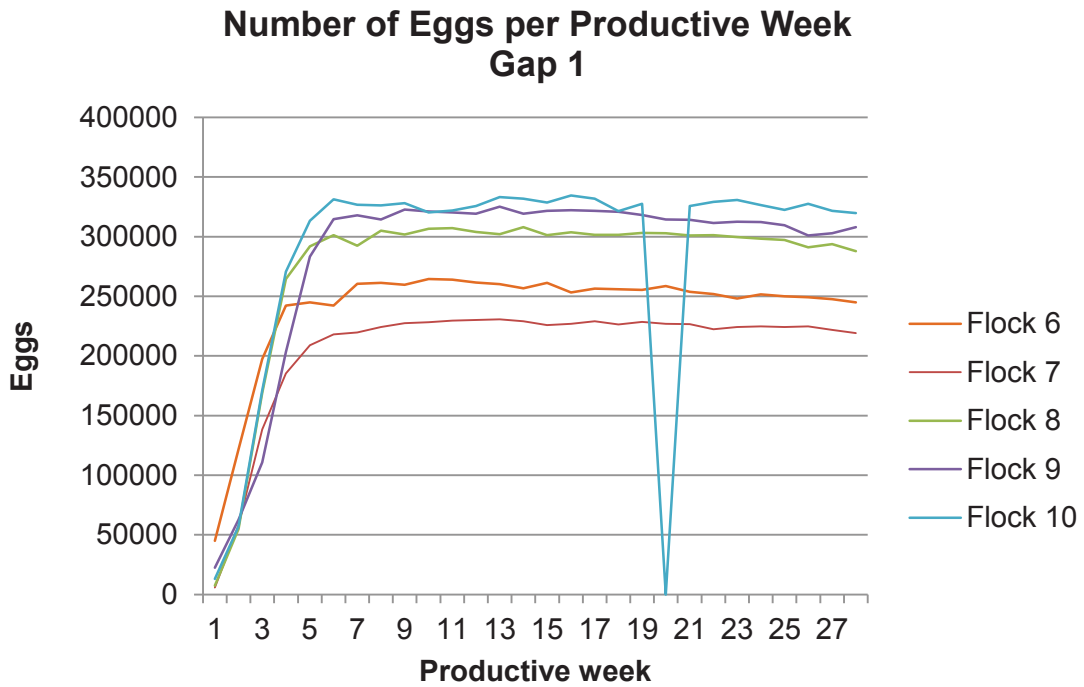
Number of Eggs per Productive Week Gap 2



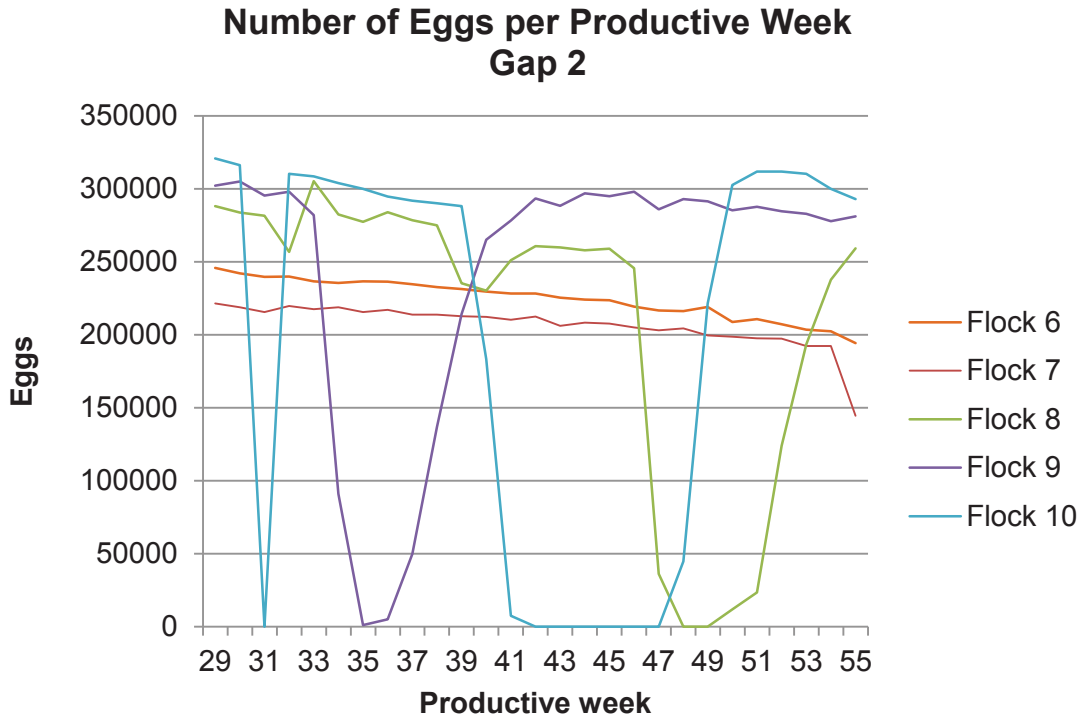
Graphic 2 - Number of eggs per productive week Gap 2



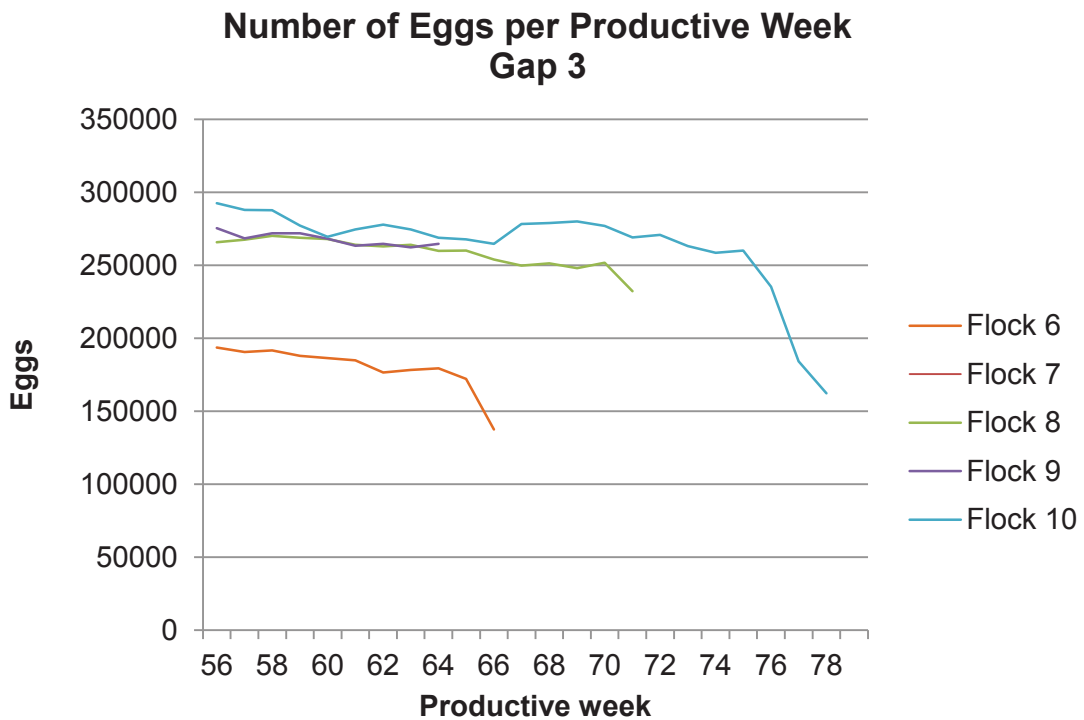
Graphic 3 - Number of eggs per productive week Gap 3



Graphic 4 – Number of eggs per productive week Gap 4



Graphic 5 - Number of eggs per productive week Gap 5



Graphic 6 - Number of per productive week Gap 6

7.1 PRODUCTION INDICATORS

Before the introduction of the descriptive statistics it is important to present all the data relative to productive indicators in general which are usually associated with the egg production activity. Table 8 shows the number of productive weeks for each of the flocks (of which the variation was explained in the data collection section) as well as the total quantity of feed provided to the animals during this period and the number of produced eggs.

Table 8 – Production indicators I

Flock n°	N° productive weeks	Total feeding(kg)	Total produced eggs
1	65	3058520	20944814
2	55	2372570	16794864
3	79	4134186	26830968
4	52	2834870	18933200
5	79	3997732	26481000
6	66	2121230	14766840
7	55	1610190	11362140
8	71	2585260	17535060
9	64	2508980	16923780
10	77	2930250	19388080

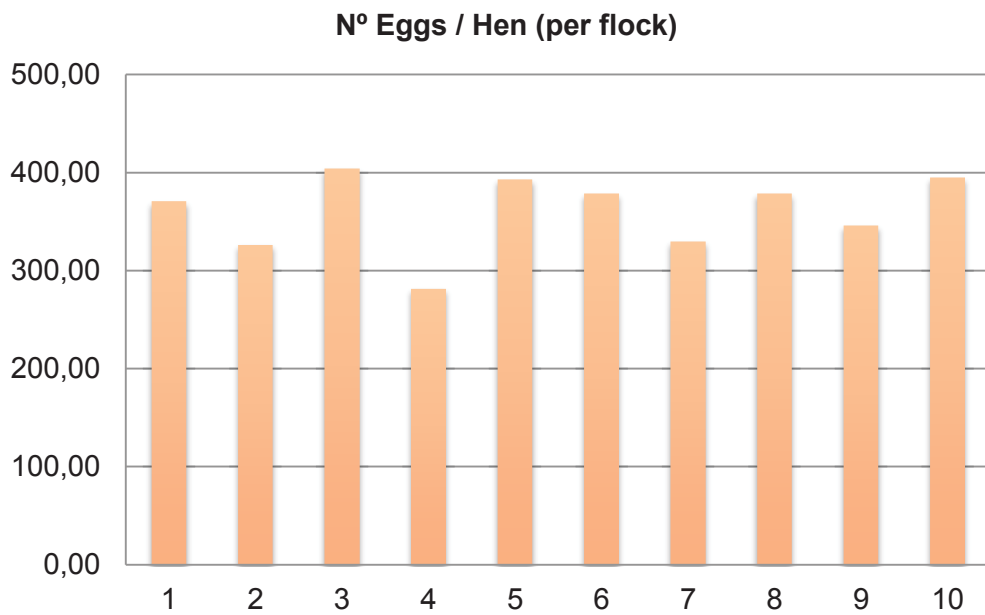
Some productive indicators were estimated for each group, available in table 9 and graphics 7 and 8:

- N° eggs / hen – average number of eggs produced by each hen;
- N° eggs / hen / productive week – average number of eggs produced by each hen per productive week
- N° eggs / Total feeding – average number of eggs produced per KG of feed.

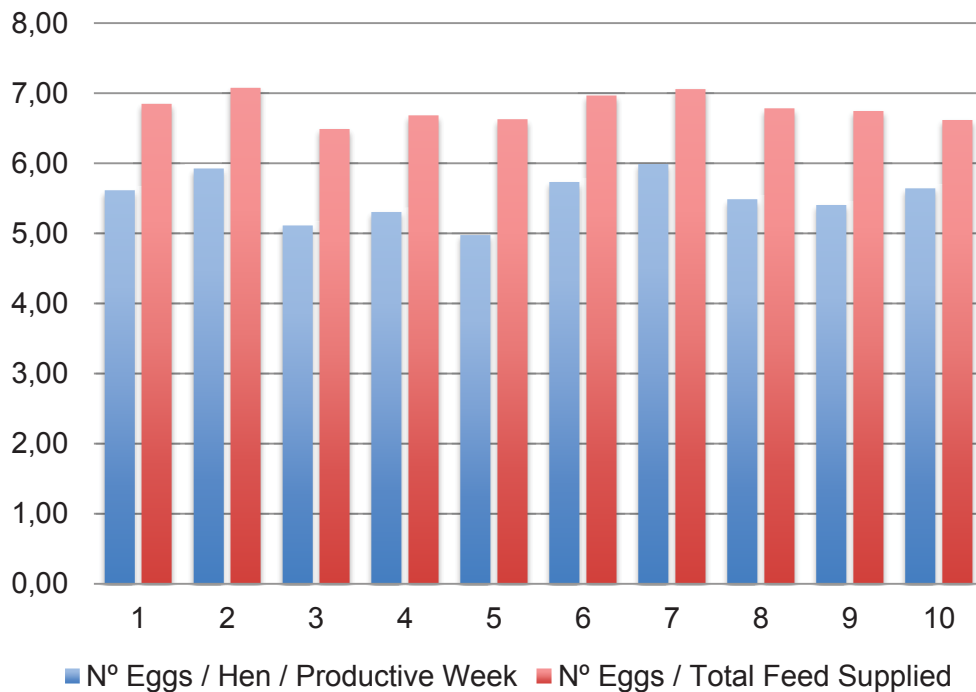
Table 9 - Production indicators II

Flock n°	N° eggs / hen	N° eggs / hen / productive week	N° eggs / Total feeding
1	370,42	5,61	6,85
2	325,99	5,93	7,08
3	403,85	5,11	6,49
4	281,25	5,31	6,68
5	393,04	4,98	6,62
6	378,20	5,73	6,96
7	329,41	5,99	7,06
8	378,25	5,48	6,78

9	345,84	5,40	6,75
10	394,95	5,64	6,62



Graphic 7 - Productive indicators - N° eggs/ Hen



Graphic 8 - Productive indicators - N° Eggs / hen / productive week and N° eggs/ total feeding grouped by flock

Mortality data (table 10) was estimated considering the number of animals remaining in each flock in the final productive week. However, if the real husbandry practice is considered, such indicator might not be very reliable, as the final week is coincident with the transportation to the slaughter house period. Therefore, flock mortality during the productive period. Therefore, flock mortality during the productive period will most likely be better assessed considering the number of animal remaining in the week before the last.

Table 10 – Productive indicators III - Mortality

Flock n°	Mortality
1	3,6%
2	2,3%
3	13,7%
4	8%
5	7%
6	3,3%
7	2,0%
8	6,1%
9	5,8%
10	6%

7.2 DESCRIPTIVE STATISTICS

The following statistical information included all the data per productive week in each flock. It will only be presented the data referring to the total of eggs and leaving the analysis referring to the different classes of eggs to another part of this paper.

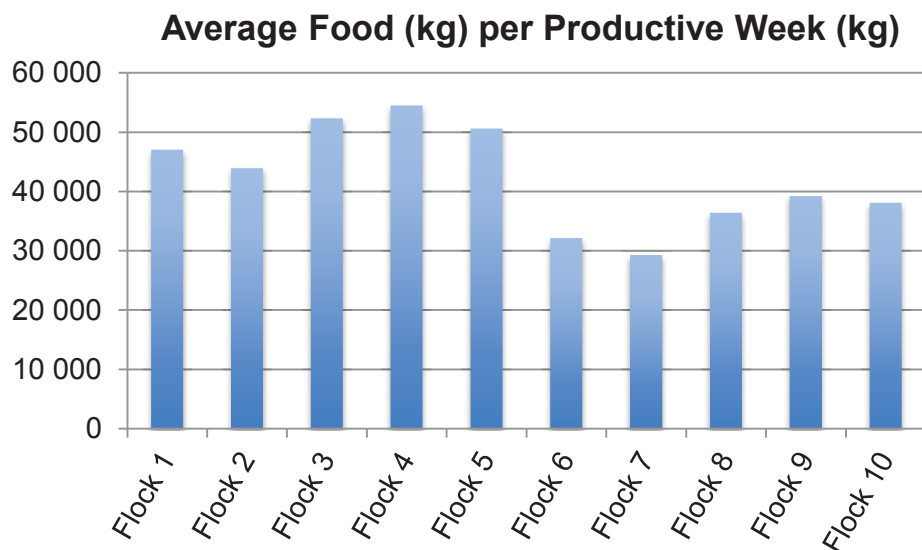
Table 11 - Descriptive statistics: feeding per group I

Feeding (kg)		Flock 1	Flock 2	Flock 3	Flock 4	Flock 5
Productive weeks		65	55	79	52	79
Average		47054,15	43906,85	52331,47	54495,38	50604,20
FCR 95% average	Inferior Limit	45201,98	41426,68	49224,67	50644,26	47265,06
	Superior limit	48906,33	46387,02	55438,27	58346,51	53943,35

Median	49790	46410	56570	59170	54760
Minimum	14960	2120	18160	0	5772
Minimum week	64	55	44	53	53
Maximum	59860	60310	82200	78690	77590
Maximum week	1	2	69	21	6

Table 12 - Descriptive statistics: feeding per group II

Feeding (kg)		Flock 6	Flock 7	Flock 8	Flock 9	Flock 10
Productive weeks		66	55	71	64	77
Average		32139,85	29276,18	36412,11	39202,81	38078,97
FCR 95% average	Inferior Limit	30227,51	27207,45	34016,21	36739,70	35500,70
	Superior limit	34052,19	31344,91	38808,01	41665,92	40657,25
Median		34055	30850	39650	41390	41155
Minimum		0	6860	0	14630	0
Minimum week		44	55	46	3	40
Maximum		47960	51240	60120	59900	69600
Maximum week		50	10	52	38	47



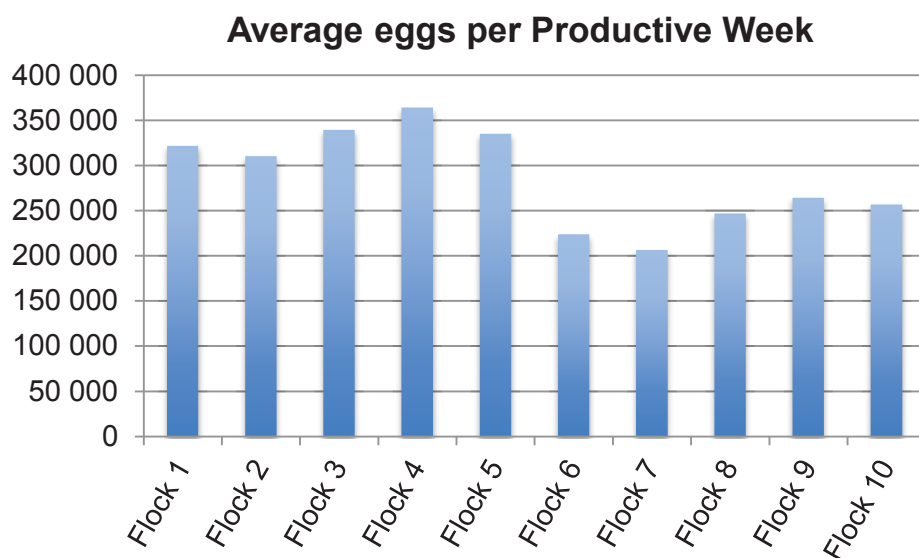
Graphic 9: Average feed per productive week per flock (kg)

Table 13 -Descriptive statistics: number of eggs per group I

NrEggs		Flock 1	Flock 2	Flock 3	Flock 4	Flock 5
Average		321898,37	310579,33	339632,51	363892,31	335202,53
FCR 95% average	Inferior Limit	305999,35	294654,95	314826,73	340708,51	306778,12
	Superior limit	337797,38	326503,71	364438,28	387076,10	363626,95
Median		339300	323712	375480	383040	391500
Minimum		14960	11880	0	59580	0
Minimum week		66	1	45	53	41
Maximum		59860	352800	440460	445320	453780
Maximum week		12	7	13	6	8

Table 14 - Descriptive statistics: number of eggs per group II

NrEggs		Flock 6	Flock 7	Flock 8	Flock 9	Flock 10
Average		223740,00	206584,36	246972,68	264434,06	256821,03
FCR 95% average	Inferior Limit	214303,54	196053,95	227437,49	243682,52	233912,91
	Superior limit	233176,46	217114,78	266507,86	285185,60	279729,14
Median		235170	217620	268020	292230	292280
Minimum		45000	5760	0	1260	0
Minimum week		1	1	1	35	41
Maximum		264420	230580	307800	325080	334440
Maximum week		10	13	14	13	16



Graphic 10: Average number of eggs per productive week per flock

Once the raw data referring to the number of eggs, feed and number of animals has been analysed, many ratios concerning the productive performance were calculated.

Ratios of eggs produced per animal, kg of feed per animal and number of eggs produced per kg of feed were estimated for every group during every week.

The following tables show the descriptive statistics relative to these three indicators, being the productive week the statistical unit. For instance, the average of eggs per animal reports to the average egg production per animal per productive week

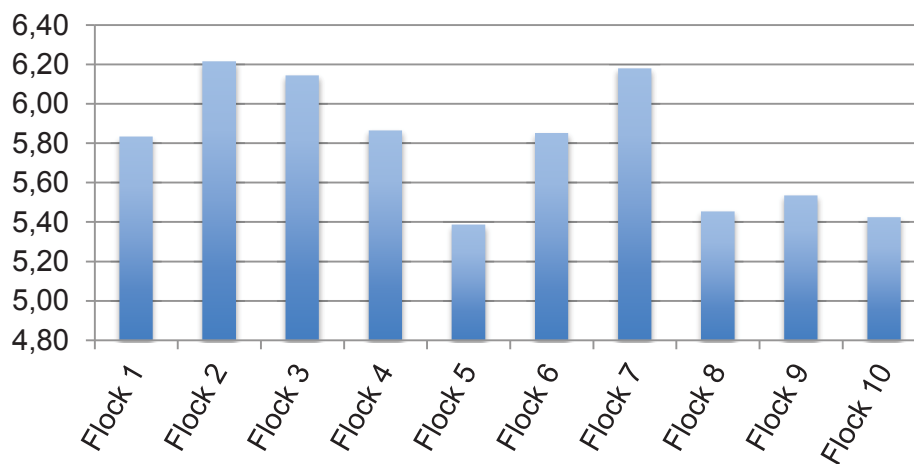
Table 15 - Descriptive statistics: Ratio eggs per animal I

Eggs/Animal		Flock 1	Flock 2	Flock 3	Flock 4	Flock 5
Average		5,83	6,22	6,14	5,86	5,39
FCR	Inferior Limit	5,57	5,88	4,73	5,60	4,94
	Superior limit	6,10	6,56	7,56	6,13	5,83
95% average						
Median		6,09	6,36	6,11	5,94	5,99
Minimum		0,49	0,23	0,00	1,65	0,00
Minimum week		1	1	45	1	41
Maximum		7,18	10,50	9,61	9,44	10,65
Maximum week		65	54	60	52	79

Table 16 - Descriptive statistics: Ratio eggs per animal II

Eggs/Animal		Flock 6	Flock 7	Flock 8	Flock 9	Flock 10
Average		5,85	6,18	5,45	5,54	5,42
FCR 95% average	Inferior Limit	5,62	5,81	5,03	5,10	4,95
	Superior limit	6,08	6,55	5,88	5,97	5,90
Median		6,12	6,37	6,05	6,18	6,19
Minimum		1,15	0,17	0,00	0,03	0,00
Minimum week		1	1	48	35	42
Maximum		6,81	11,97	6,67	6,66	7,1
Maximum week		10	55	33	13	20

Average number of eggs per hen per productive week



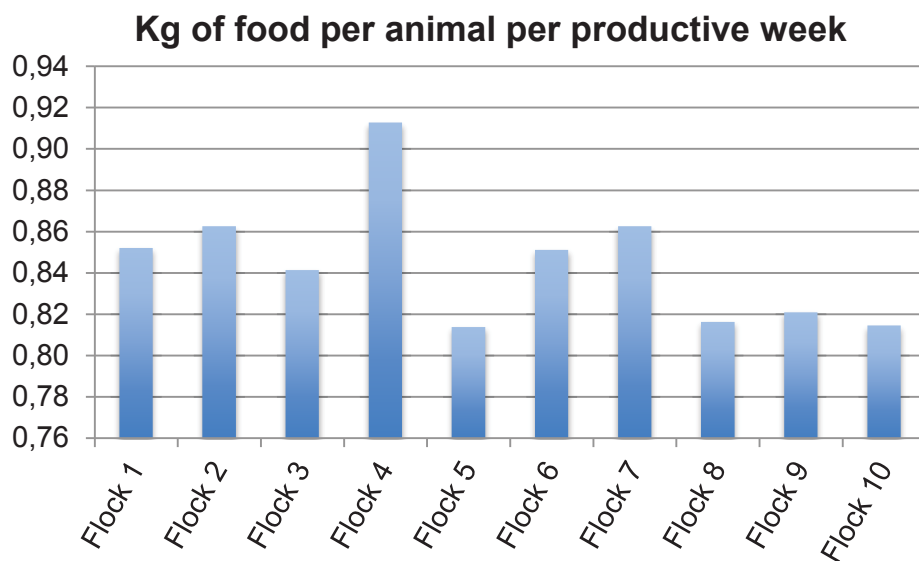
Graphic 11 : Average number of eggs per animal per productive week per flock

Table 17 - Descriptive statistics: ratio kg of feed per animal I

Feed/Animal		Flock 1	Flock 2	Flock 3	Flock 4	Flock 5
Average		0,85	0,86	0,84	0,91	0,81
FCR 95% average	Inferior Limit	0,82	0,82	0,79	0,84	0,76
	Superior limit	0,88	0,91	0,89	0,99	0,87
Median		0,89	0,91	0,91	0,91	0,86
Minimum		0,27	0,12	0,29	0,36	0,09
Minimum week		64	54	4	20	53
Maximum		1,07	1,17	1,40	2,56	1,49
Maximum week		34	2	69	51	79

Table 18 - Descriptive statistics: Ratio kg of feed per animal II

Feed/Animal		Flock 6	Flock 7	Flock 8	Flock 9	Flock 10
Average		0,85	0,86	0,82	0,82	0,81
FCR 95% average	Inferior Limit	0,81	0,81	0,77	0,77	0,77
	Superior limit	0,89	0,92	0,86	0,87	0,86
Median		0,89	0,90	0,86	0,88	0,86
Minimum		0,38	0,40	0,14	0,30	0,31
Minimum week		67	11	53	3	41
Maximum		1,36	1,49	1,35	1,26	1,47
Maximum week		51	10	52	38	47



Graphic 12 - Average number of kg of feed per animal per productive week

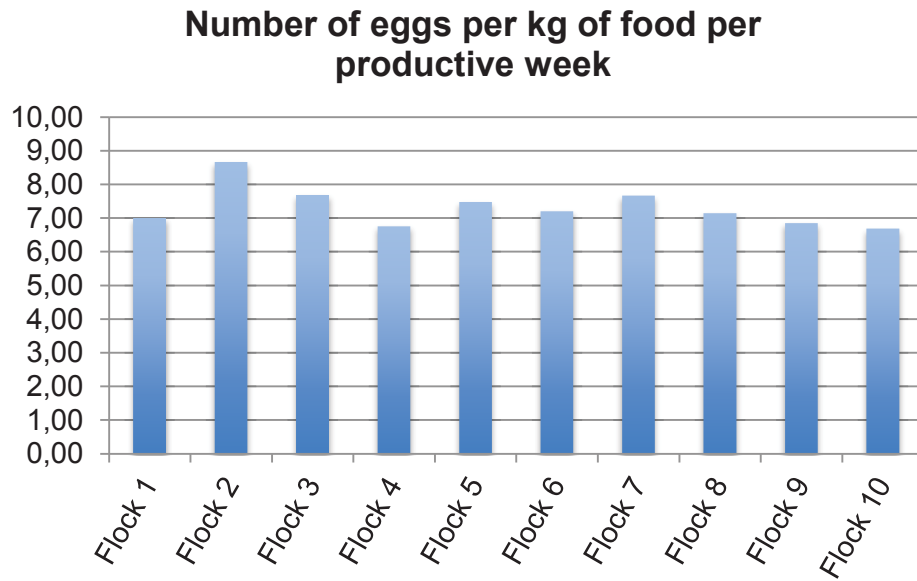
Table 19 - Descriptive statistics: ratio eggs per kg of feed I

Eggs/Feed		Flock 1	Flock 2	Flock 3	Flock 4	Flock 5
Average		7,00	8,66	7,69	6,75	7,48
FCR	Inferior Limit	6,57	5,53	5,78	6,22	5,67
	Superior limit	7,44	11,79	9,60	7,29	9,29
95% average						
Median		7,13	7,09	6,85	6,48	6,83
Minimum		0,46	0,60	0,00	2,35	0,00
Minimum week		1	1	45	51	41
Maximum		16,41	90,42	78,09	16,59	70,48
Maximum week		64	54	60	20	53

Table 20 - Descriptive statistics ratio of eggs per kg of feed II

Eggs/Feed		Flock 6	Flock 7	Flock 8	Flock 9	Flock 10
Average		7,21	7,67	7,15	6,85	6,69
FCR	Inferior Limit	6,65	6,80	6,20	6,21	5,95
	Superior limit	7,76	8,53	8,09	7,49	7,42
95% average						

Median	6,79	7,15	6,90	6,92	7,05
Minimum	1,80	0,40	0,00	0,08	0,00
Minimum week	1	1	48	35	42
Maximum	15,35	21,07	30,67	15,16	19,83
Maximum week	66	55	53	33	35



Graphic 13 - Number of eggs per kg of feed per productive week per flock

7.3 INFERENCE STATISTICS

Having in mind that, due to the size of the sample, the normality of the data distribution has been assumed, some ANOVA tests have been run for the inferential statistical analysis. For simplification of the reading process, table 7 is included here once again, as it will help remind the data organization.

Table 7- Flock number of initial animals and legislative period

Flock n°	Flock of origin	Pavilion	N° initial animals	Legislative period
1	CM3B8	TS	56564	AL
2	CM3B7	TS	51522	AL
3	CM3B5	TS	66460	BL
4	CM3B4	TS	67340	BL
5	CM3B3	TS	67452	BL
6	RM2B7	RM	39062	AL
7	RM2B6	RM	34500	AL
8	RM2B4	RM	46366	BL
9	RM2B3	RM	48936	BL
10	RM2B2	RM	49100	BL

7.3.1 COMPARISON BETWEEN TWO PAVILLONS

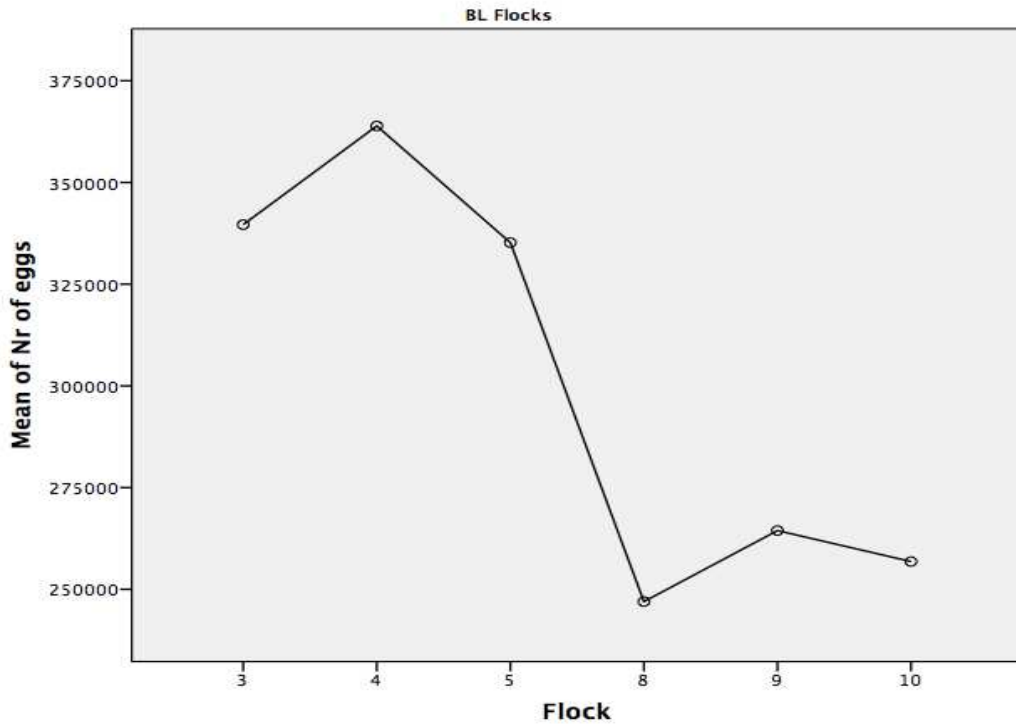
The first analysis intended to detect the significant differences between the TS and RM pavilion's flocks.

Then flocks were grouped as BL flocks (3 to 5 (TS Flocks) and 8 to 10 (RM flocks) and AL flocks (1,2 TS flocks, 6 and 7 (RM flocks), in order to detect differences between the two pavilions. ANOVA tests were made for the following variables: number of eggs, number of eggs per hen and number of eggs per feed.

Some significant differences were found in the BL groups concerning the number of eggs produced ($F(5,417)=16,790$, $p \leq 0,001$). However, there were no significant differences found relating the number of eggs per animal or number of eggs per feed.

Considering only the data concerning the number of eggs produced, the Tukey HSD and Bonferroni post-hoc tests indicate that there are two homogeneous groups: one considering the group 3, 4 and 5 and another considering the groups 8, 9 and 10. This two groups show different averages values of the number of eggs produced. The average value of eggs produced between the flocks in the same group are similar.

Graphic 14 shows the average of the number of eggs produced per group and shows the statistic similarity between flocks 3, 4 and 5 (TS flocks) and between groups 8, 9 and 10 (RM Flocks).

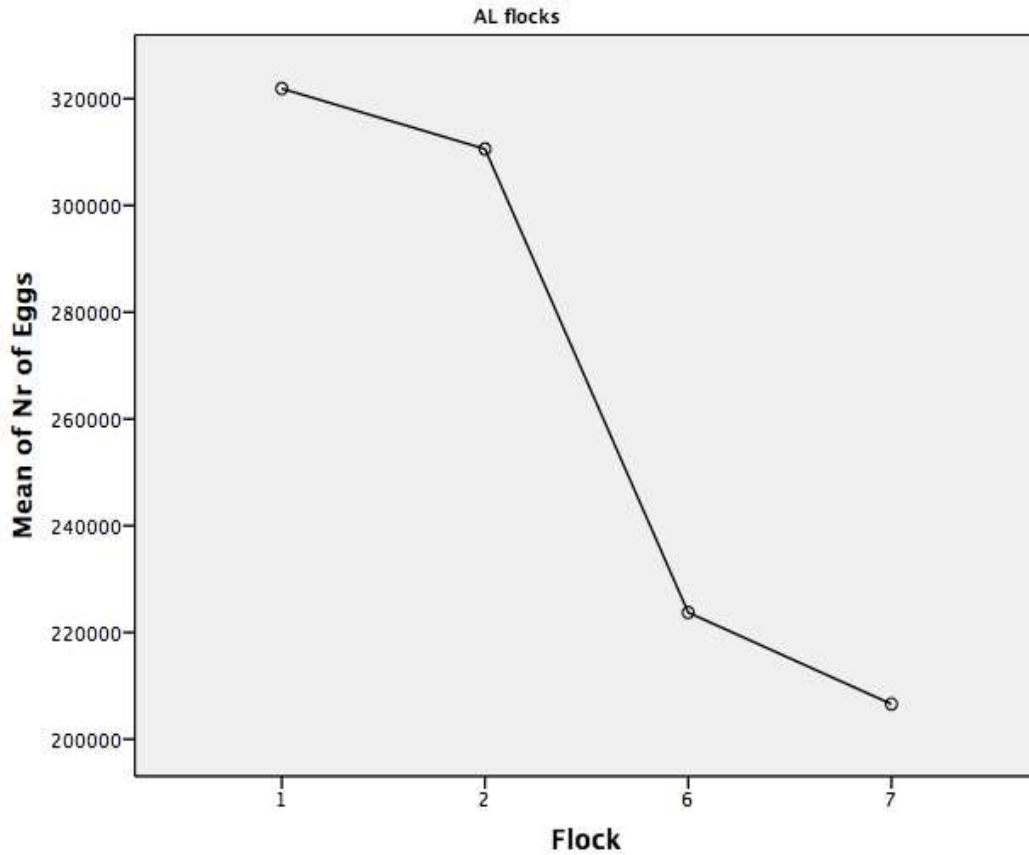


Graphic 14 - Average number of eggs produced per flock, for the BL flocks

For BL groups the results are very similar. Significant differences were found between the flocks for the number of eggs produced ($F(3,236)=78,774$, $p \leq 0,001$), however there were not significant differences between the number of eggs per animal and the number of eggs per feed.

Considering only the results for the number of eggs produced, the tests post-hoc of Bonferroni and the Tukey HSD indicate once again that there are two homogeneous groups: one group is constituted by the flocks 1 and 2 (TS flocks) and the other group is constituted by the flocks 6 and 7 (RM Flocks). These two groups have different averages for the number of eggs produced between each other. The average for the numbers of eggs produced between flocks of the same group aren't statistically different.

Graphic 15 represents the average number of eggs produced per flock, and shows the statistical similarity between the flocks 1 and 2 and between the flocks 6 and 7, as well as the statistical difference between the two groups.



Graphic 15 - Average number of eggs produced per flock, for the flocks AL

These results will be the object of further analysis in the context of the discussion and conclusions of this dissertation. Nevertheless, it is important to point out that from the productive point of view these results are expected, since the total number of eggs produced is conditioned by the conditions of each pavilion. The initial number of animals should therefore be remembered, as indicated in the tables 21 and 22.

Table 21 - Number of initial animals per flock BL

Flock n°	Pavilion	Initial nr of animals
3	TS	66460
4	TS	67340
5	TS	67452
8	RM	46366
9	RM	48936
10	RM	49100

It is clear that flocks 8, 9 and 10 had a similar initial number of animals (from 46000 animals to 49000), while flocks 3 to 5 had similar numbers to each other (from 66500 to 67500) but quite different from the remaining flocks.

Table 22 - Number of initial animals per flocks AL

Flock n°	Pavilion	Inicial nr of animals
1	TS	56564
2	TS	51522
6	RM	39062
7	RM	34500

The same type of reasoning can be applied to the flocks 1 and 2, which are very different in the number of animals from the flocks 6 and 7.

These data justify the statistical differences found. The TS Pavilion flocks always had more animals than the RM Pavilion flocks. Therefore, it is linear that the TS pavilion flocks produce more eggs than the RM pavilion flocks.

The lack of statistical difference between flocks for the variables number of eggs per animal and number of eggs per feed is also expected, since the groups in this case were grouped in BL and AL, so they would be exposed to basically the same productive conditions.

In this context, productivity indicators per bird (such as the number of eggs per bird) may not be expected to change, nor indicators such as the conversion rate (egg per feed), independently of the pavilion of origin.

7.3.1 COMPARISON BETWEEN FLOCKS BL AND FLOCKS AL

The previous analysis of the results per flock based on the legislative period would have involved the number of animals and consequently the total number of eggs produced as a confuse factor, impossible to isolate.

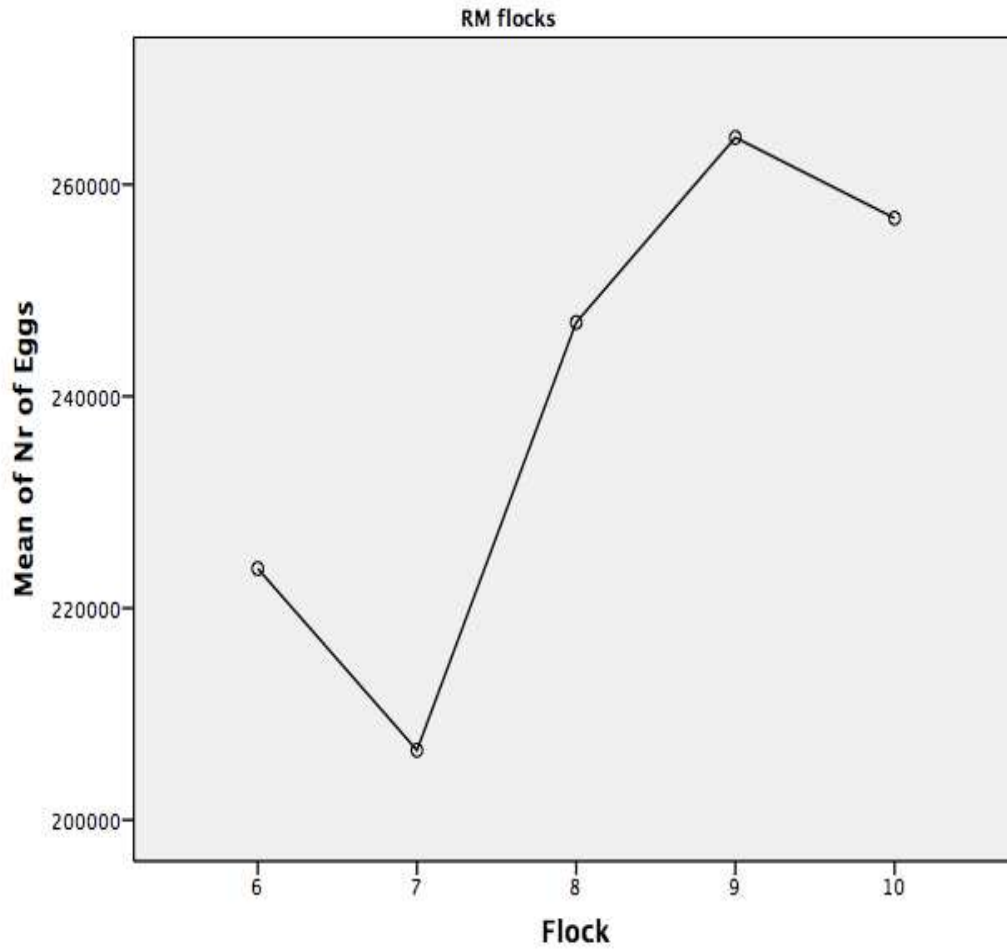
A comparison was made between flocks from the same pavilion, considering the legislative period. For both pavilions the performance was compared between the BL flocks (3 to 5 for the TS pavilion and 8 to 10 for the RM pavilion) and the AL flocks (1 and 2 for the TS pavilion and 6 and 7 for the RM pavilion). Once again, ANOVA tests were performed for

the following variables: number of eggs, number of eggs per bird and number of eggs per feed.

7.3.2 RM PAVILLON

For the RM flocks, significant differences were found between flocks for the number of eggs produced ($F(4,329) = 6,197$, $p = 0,000$). Considering only the data on the number of eggs produced, Bonferroni and Tukey HSD post-hoc tests indicate that there are significant differences between flock 7 and flocks 8 to 10, as well as between flock 6 and flocks 9 and 10. Flocks 6 and 8 do not present significant differences between them for this parameter. This means that there are differences between groups BL and AL, with one exception in the possible comparisons (between groups 6 and 8) for which a justification should be pointed out, namely deviations from normality.

Graphic 16 represents the average number of eggs produced per flock and shows the statistical similarity between flocks 6 and 7 and between flocks 8, 9 and 10, as well as the difference between the two groups. Graphically, groups 6 and 8 look different.



Graphic 16 - Average number of eggs produced per flock, for the RM Flocks

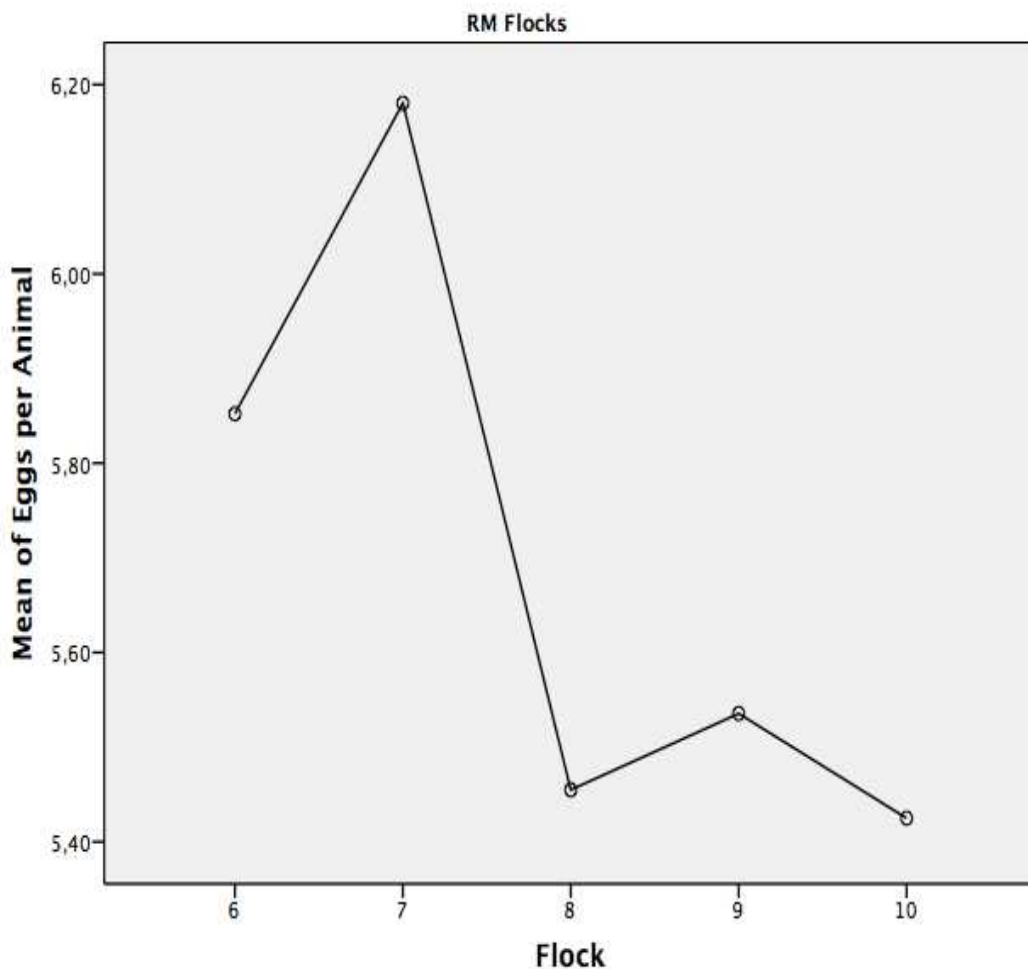
It is clear that the lower total productivity between the flocks 6 and 7 and the flocks 8 to 10 is different, suggesting a smaller production in the legislative period AL. It is important, however, to remember the initial number of birds (table 12) before establish conclusions.

Table 23 - Number of initial animals per legislative period in the RM pavilion

Flock n°	Pavillion	Initial nr of animals
6	RM	39062
7	RM	34500
8	RM	46366
9	RM	48936
10	RM	49100

Significant differences were found for the number of eggs per animal, at 90% confidence level ($F(4,329) = 2,324$ $p = 0,056$). The Bonferroni and Tukey HSD post-hoc tests show similar results to the total number of eggs, showing that there are significant differences between flock 7 and flocks 8 to 10, as well as between flock 6 and flocks 9 and 10. The flocks 6 and 8 do not present significant differences between them for this parameter, which is consistent with the previous analysis.

Graphic 17 represents the average number of eggs produced per flock, and shows the statistical similarity between flocks 6 and 7 and between flocks 8, 9 and 10, as well as the difference between the two groups. Graphically, flocks 6 and 8 appear, once again, to be distinct.



Graphic 17 - Average number of eggs produced per animal per flocks RM

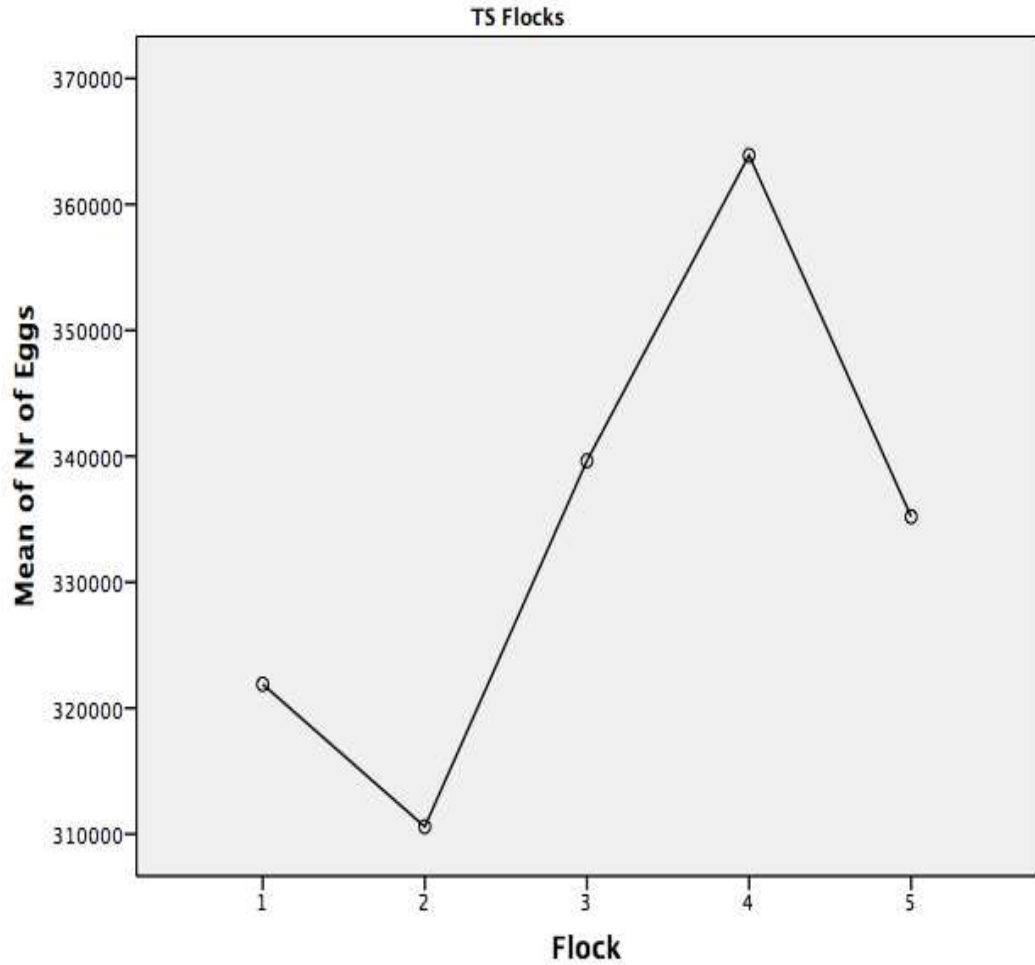
Considering that the number of eggs per animal is an indicator of productivity, the best productivity per animal is evident for groups 6 and 7 during the AL period.

No statistically significant relationship was found between the groups for the egg / feed variable, showing that there are no significant differences between the medium of feed consumed per egg produced during the two distinct legislative periods.

7.3.3. TS PAVILLION

For TS flocks, significant differences were found between flocks for the number of eggs produced ($F(4,324) = 2,374$, $p = 0.052$). Considering only data on the number of eggs produced, post-hoc Bonferroni and Tukey HSD tests show that flocks 1 and 2 are similar, and that flocks 3 to 5 are similar as well. However, the post-hoc tests do not show the formation of two clear groups for this parameter.

Graphic 18 represents the average number of eggs produced per group and shows the statistical similarity between flocks 1 and 2 and between groups 3, 4 and 5. Graphically, there is a suggestion of a difference between groups 1 and 2 and Groups 3, 4 and 5, which makes it possible to point out the existence of outliers or deviations from normality as the cause of this absence of differences.



Graphic 18 - Average of number of eggs produced per group, for the TS Flocks

No statistically significant relationship was found between the flocks for the variable eggs/animal and eggs/feed, showing that there are no significant differences between the average of eggs produced per animal and the average of feed consumed per egg produced during the two distinct legislative periods.

There seems to be an indication that the conversion rate does not improve with the introduction of the new legislation. However, a correlation analysis suggests a more concrete reality, as shown in tables 24 and 25

Table 24 - Pearson correlations fo BL Period

		NrEggs	Feed	NrAnimals
NrEggs	Person's correlation		0,583**	0,475**
	Sig.		,000	,000

** Significant correlation $p < 0,01$

Table 25 - Pearson Correlations for AL period

		NrEggs	Feed	NrAnimals
NrEggs	Person's correlation	1	,637**	,732**
	Sig.		,000	,000

** Significant correlation $p < 0,01$

The correlation between the number of eggs produced and the number of animals gained strength with the introduction of the new legislative period, increasing the value of r by almost 55%. Therefore, we can suggest a gain in productive efficiency.

It is also relevant the correlation between the number of eggs and the feed, which although gained strength, did not happened in the same scale as the number of animals. Although it is expected the increase in feed consumption with the increase of the numbers of eggs (stronger correlation), the increase on a smaller scale suggests a gain in productive efficiency and an improvement in the conversion rate.

Finally, regression analysis is in line with the correlation analysis of these variables. Equation 1 shows the regression equation for the period BL and equation 2 shows the regression equation for the period AL. for all variables.

$$NrEggs = 2,574NrAnimals + 3,536Food \quad (1)$$

$$(F(2,421)=2588,586, p<0,000; R^2= 0,925)$$

$$NrEggs = 4,930NrAnimals + 1,191Food \quad (2)$$

$$(F(2,238)=3731,226, p<0,000; R^2= 0,969)$$

The regression analysis suggests the egg production in the BL Period is much more influenced by the number of animals present, than by amount of feed, implying a gain in productive efficiency, and a better conversion rate.

Finally, it must be noted that, although BL and AL hens were from different species, they do not have different productive behavior, as indicated by hen suppliers. As such, we can speculate that these results do not have their origin in the hens species.

7.3.4 ECONOMIC ANALYSIS

Considering the better results in egg production efficiency following the introduction of the new legislation, an economic analysis of the productive results will be introduced.

It is noted that groups after the introduction of the new legislation, had smaller number of animals (decreasing animal density). We also know that the total number of eggs produced per group after the introduction of the new legislation has decreased, which is not surprising due to the lower number of animals. However, we have data that clearly indicates a gain in productive efficiency per animal and improvements in the conversion rate.

An adequate economic analysis (even if only focusing on these factors of production - animals and feed - and the egg product) would imply knowledge of the market values of current and past animals. Such information is not available, mainly because of the considerable variability of both the cost of the animals and (mainly) the feed and the value of the eggs.

For this we will consider that, *caeteris paribus*, are only variable factors the number of animals introduced in the pavilion at the beginning of the productive cycle and the number of eggs produced. This analysis is therefore based on a very simple production function in which the number of eggs produced depends on the number of animals and all other production factors are non-variable for the purposes of this analysis.

Although biologically debatable, this analysis allows a first (superficial) approach to the economic impact of the introduction of new animal welfare regulations. Therefore, it was chosen an analysis based on current average values of cost per bird and sale of eggs (regardless of class). We used the following values in this analysis:

- Cost per bird – €0,5;
- Average value per egg – €0,0625.

The liquid benefit values obtained are represented in tables 26 and 27.

Table 26 - Analysis of costs and profits for TS Pavilon flocks

Flock 1	Flock 2	Flock 3	Flock 4	Flock 5
Number of animals				
56544	51519	66438	67317	67375
Animal costs				
28272,00	25759,50	33219,00	33658,50	33687,50
Number of eggs				
20944814	16794864	26830968	18933200	26481000
Eggs selling value				
1309050,88	1049679,00	1676935,50	1183325,00	1655062,50
Liquid income				
1280778,88	1023919,50	1643716,50	1149666,50	1621375,00
4630%	4075%	5048%	3516%	4913%

Table 27 - Analysis of costs and profits for RM Pavillon group

Flock 6	Flock 7	Flock 8	Flock 9	Flock 10
Number of animals				
39045	34492	46359	48935	49090
Animal costs				
19522,50	17246,00	23179,50	24467,50	24545,00
Number of eggs				
14766840	11362140	17535060	16923780	19388080
Eggs selling value				
922927,50	710133,75	1095941,25	1057736,25	1211755,00
Liquid income				
903405,00	692887,75	1072761,75	1033268,75	1187210,00
4728%	4118%	4728%	4323%	4937%

An ANOVA analysis was performed to verify the existence of differences in the overall benefit values (income subtracted of costs) between groups, between flocks BL and

AL and between flocks of TS and RM pavilions. No significant differences were found in either case.

The lack of significant differences points out that egg producers did not lose profitability due to the introduction of the legislation, although they have not increased it either. It should be remembered that profitability is not synonym of total income, and that it is therefore possible that a given producer experienced a lower total income with a similar or even bigger profitability.

Moreover, it must be dully noted that this analysis does not include the investment costs determined by the introduction of the legislation. Such costs must always be included in a proper cost bebenefit analysis.

Finally, it must also be remembered that this basic analysis did not included the animals feeding costs. Considering the feed is usually the single most relevant variable production costs, and that it was possible to detect efficiency gains related with the feed conversion after the new legislation we can speculate that at this level there may haver been considerable increases in economic performance.

It is therefore recommended a more detailed analysis of the production function including more production factor and their prices.

7.4 EVALUATION OF PRODUCTION ACCORDING TO EGG CLASSIFICATION

During this study, it was possible to obtain some empirical information regarding the evolution of egg production before and after the new legislation. One of the observations obtained refers to the existence of a bigger proportion of B class eggs comparing to A, independently of the total production.

This bigger proportion is due to the introduction of a scratching area required by the new legislation which results in a bigger number of eggs contacting animal disposal, getting dirty and being classified as B. This results in a lower value received by the producers for the same number of eggs and thus being relevant to check if this proportion has been negatively affected or not. It is important to notice that flocks 5 and 10(the older flocks in this study) were taken from this analysis due to the absence of data about egg classification.

Only in groups 2, 6 and 7 the number of eggs corresponds to the sum of A and B class eggs. With this information the data considering egg classification (as well as their weight which is not considered in the analysis) is not very consistent and so the interpretation

must be cautious. To minimize the impact of lack of data consistency, the option was to use as variable (BA) the proportion of B and A egg class – the ratio.

$$BA = \frac{\text{Number of class B eggs}}{\text{Number of class A eggs}}$$

Table 28 -Shows the descriptive analysis of the new variable

Feed (kg)		Flock 1	Flock 2	Flock 3	Flock 4
Average		11,425	10,7108	5,9511	8,4749
IC 95% average	Inferior Limit	10,9968	9,9027	4,8989	7,8845
	Superior limit	11,8532	11,5189	7,0033	9,0653
Minimum		4,76	0	0	6,23
Maximum		16,48	20,34	34,17	11,69

Table 29 – Descriptive statistics: Ratio BA per group

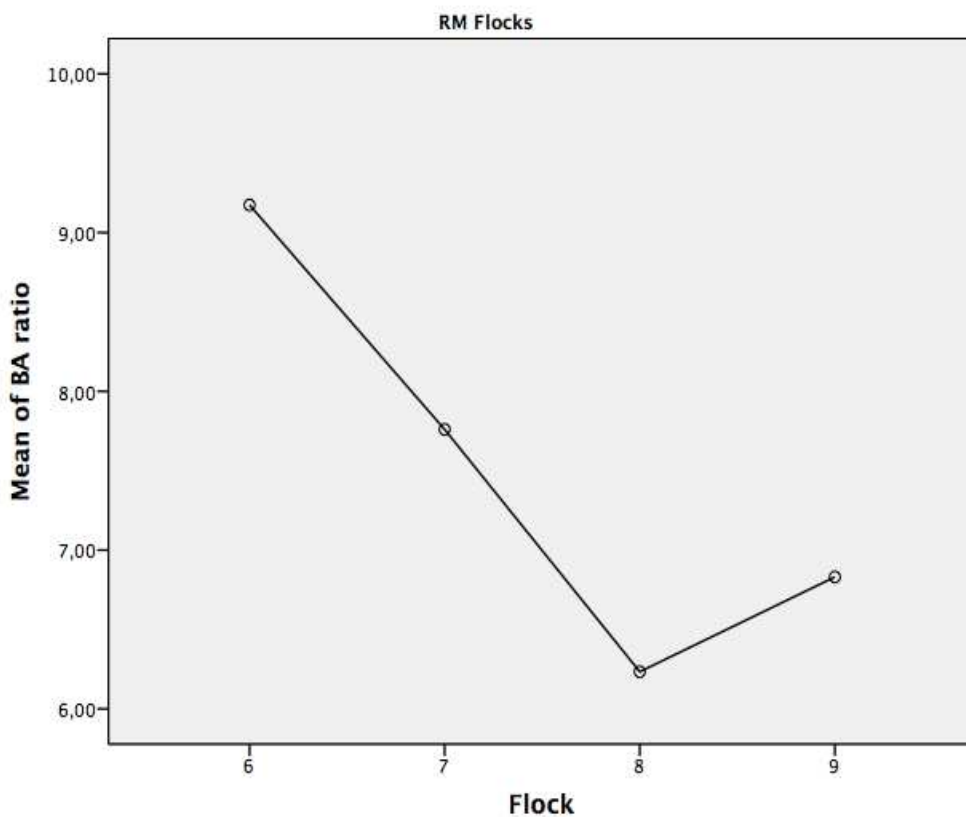
Feed (kg)		Flock 6	Flock 7	Flock 8	Flock 9
Average		9,1743	7,7597	6,2334	6,8306
IC 95% average	Inferior Limit	8,7952	7,1323	5,6153	6,2478
	Superior limit	9,5533	8,3871	6,8515	7,4133
Minimum		3,73	0	3,27	4,11
Maximum		12,62	12,62	18,93	16,82

A superior ratio shows that the egg proportion in B comparing to the eggs in A is superior. Empirically, the results in the table suggest that the flocks 1 and 2 have a bigger proportion of B eggs when compared to flocks 3 and 4. The same appears to happen in flocks 6 and 7 comparing to flocks 8 and 9. This empirical perception is in line with the observed data during this study and the comments from the farmer.

In this context, a ANOVA analysis was made with the intention of verifying if there is a significant difference between the average BA ratio of the different flocks. It was decided to analyse this data with separate pavilions because the previous analysis had already shown a substantial difference between them.

For the RM flocks significant differences were found between flocks for BA ratio ($F(3,236)=22,977$, $p=0,000$), the Tukey HSD and Bonferroni post-hoc tests indicate that flock 6 presents a BA ratio average superior the BA ratio average of flocks 7, 8 and 9. This difference is statically significant in the three cases. Flock 7 (as also 6, after the new legislation) is also statically different from flocks 8 and 9.

Graphic 19 represents the BA ratio average per flock and shows the difference between flocks 6 and 7 and flocks 8 and 9.

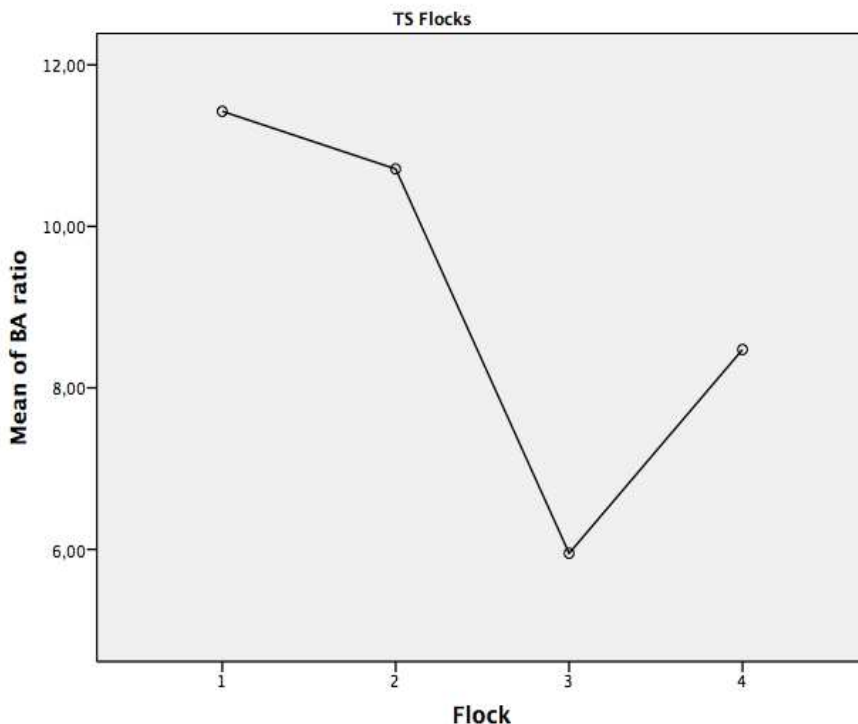


Graphic 19 - BA ratio average per flock

In the TS flocks it was found a significant difference for the BA ratio values between flocks ($F(3,210)=38,937$, $p=0,000$), the post-hoc Bonferroni and Tukey HSD tests indicate that flocks 1 and 2 (after the new legislation) show a similar BA ratio average between

themselves and slightly different value from flocks 3 and 4 BA ratio average (which are also similar between themselves).

Graphic 20 represents each flock BA ratio average, and shows the statistic difference between flocks 1 and 2 and flocks 3 and 4.



Graphic 20 - BA ratio average flocks 1 and 2 flocks 3 and 4

Even though the discussion of these results have been placed in the conclusion of this dissertation, it is important to notice that the differences found in BA ratio for the two legislative periods are the same as the empiric perception of the producers. It is also important that, even though the economic analysis does not show a loss for the egg producers due to decreased productivity, an average value has been used between A and B class egg. As the B class eggs proportion, has raised, it is possible that, seen by their lower selling value, in fact, the producers are experiencing lower incomes.

8. DISCUSSION

The intent of this study was to evaluate the egg production of laying hens before and after the implementation of the current legislation. Flocks were selected from two pavilions. Although their population densities were different, both pavilions complied with the law, as they had cages with different sizes. Moreover, even though flocks were divided in groups according to the legislation applied during their production, all of them were, in fact, compliant with the most recent law in what concerns cages requirements. For this reason, only three elements introduced by the new legislation could be eligible for this analysis: the existence of nests, scratching area and perches. This can be a limiting factor for the present study.

To evaluate productivity, several indicators were analysed (number of eggs / bird; number of eggs / bird / productive week; number of eggs / total feed supplied). When only the number of eggs / bird is considered, the difference between flocks productive period is not considered. Therefore, the number of eggs / bird / productive week and number of eggs / total feed supplied are more relevant to the influence that the conditions pre or post-new legislation might have on the productivity. As shown in Table 9, flocks 1, 2, 6 and 7 are the ones with the highest number of eggs / bird / productive week and number of eggs / total feed supplied, the latter being important to analyse the conversion rate. The same flocks (1, 2, 6 and 7) also have better results regarding the mortality rate, which is another relevant indicator of productivity. We can conclude that the new legislation led to an increase in the productivity rates.

Hence, considering both pavilions separately and, in each one, dividing flocks in groups BL and AL, we can see the number of eggs produced per flock is similar in each group (Graph 14 and 15). In other words, in pavilion TS, all flocks in group BL produced similar rates of eggs (flocks 3, 4 and 5), and all flocks in group AL produced similar rates of eggs as well (flock 1 and 2). The same applies to group BL (flock 8, 9 and 10) and group AL (flock 6 and 7) of pavilion RM. We can conclude that, under similar conditions, productivity is identical and mainly influenced by the initial number of animals in the flock (Table 21 and 22).

The next step of this study was to analyse each pavilion separately, and to determine if there were differences in the egg production of laying hens before and after the new legislation. Starting with pavilion RM, significant differences were found between the number of eggs produced in flock 7 (AL) and flocks 8 to 10 (BL), as well as between flock 6 (AL) and flocks 9 and 10 (BL), both cases showing a larger amount of eggs produced in flocks AL.

However, the absolute number of eggs production is obviously influenced by the number of animals in each flock (table 23). Therefore, the number of eggs produced per animal is more accurate. And in this case, the same group comparisons (flock 7 vs flock 8 to 10 and flock 6 vs flock 9 and 10) also showed better results in group AL. Therefore, the conditions created by the new legislation brought benefits to the individual productivity of each animal. It is important to mention that, in contrast to the previous comparisons, there was no difference between flock 8 (BL) and flock 6 (AL) regarding the number of eggs and the number of eggs produced per animal. This could be explained by the fact that flock 8 was submitted to a “physiological shock” where hens were deprived of feed for an amount of time and then came back to the same regime extending their productive lifetime with acceptable egg production results.

In pavilion TS, although group AL (flock 1 and 3) produced larger amounts of eggs than group BL (flock 3, 4 and 5), post-hoc tests did not show a clear difference between these groups. The number of eggs produced per animal was also not statistically different, nor the number of eggs per feed. So, in this pavilion, a productivity difference was not established between both legislative periods.

However, the Pearson’s correlation tests show that the new law might bring more favourable results in terms of number of eggs produced and conversion rate. Moreover, regression analysis also suggests that the increase of animals in the AL period has more influence on the number of eggs produced than the feed provided, which is also in favour of a higher conversion rate for the AL period.

Two limiting factors must be taken into consideration before performing this analysis. On one hand, there is not a current market study or sufficient data available that allows a more accurate analysis. To overcome this limitation, this study tries to make an estimate of the profitability based on simple variables (number of animals introduced in the pavilion and number of eggs produced) and their average values. On the other hand, because the structural changes required by the new legislation were not the focus of the present study, costs related to the structural adaptations were not taken into consideration.

To make this economic analysis, first, we must consider that the new legislation requires a lower population density and, subsequently, the absolute production for the same space will probably be smaller. On the other hand, a better conversion rate also leads to a reduction in feed costs for a similar result.

Comparing costs and profits, no significant differences were found between flocks themselves, between group BL vs group AL and between pavilion RM vs pavilion TS.

Despite this absence of significant difference, further analysis must be made to evaluate profitability. From a profitability point of view, a relationship can be established between the sales value of the eggs, the number of animals and the productive weeks. As shown in Table 27, the most profitable flocks correspond to the AL period. This analysis eliminates the influence of longer productive periods. There is a difference of 0.02 € between the least profitable AL and the most profitable BL flocks. Thus, on a scale of tens of thousands of individuals, it has a large influence on the total value. In addition to that, as previously mentioned, the conversion rate is higher and, therefore, the cost with feed will be lower, further increasing the profitability.

The profitability analysis is not complete without verifying the quality of the eggs produced. In this case, during the period under review, there was a higher ratio of class B eggs produced compared to class A eggs, in groups AL (flock 1, 2, 6 and 7) - Table 27. This can be explained by the introduction of a scratching area in the new legislation, which leads to a greater number of eggs coming in contact with animal waste, becoming dirty and changing from class A to class B.

An analysis was performed individually in each pavilion to verify if there were differences between the flocks. In the pavilion RM, both flock 6 and 7 (AL) had a statistically higher proportion of class B eggs/class A eggs. In the pavilion TS, higher proportion of class B eggs were also found in flocks of the group AL (1 and 2) than group BL (3 and 4).

Thus, despite the previous analysis based on average values, an accurate economic study should take into consideration this difference between class A and class B eggs production. Although this was not the primary endpoint of the present study, the author still finds that the results shown are useful to this analysis.

The use of two different breeds of laying hens can also be a limitation for this study, literature support that the development of these distinct breeds is very similar, in growing and productive level as well as average weight.

9. CONCLUSION

This research aimed at understanding how the introduction of the new legislation (the Council Directive 1999/74/EC) helped to improve the welfare of the laying hens; we can conclude that the measures implemented due to this Directive definitely have enhanced the laying hens' welfare conditions, allowing them the chance to experience most of their natural behaviours, such as dust bathing, nesting, perching and foraging. Our research indicates that the new legislation has benefits for producers too, because it enhances the individual productivity of laying hens, in terms of egg production and conversion rate.

Another key goal was to estimate the egg production of laying hens before and after the implementation of the new legislation, in order to assess its impact upon production. The empirical part of this research was based on the study of flocks from two pavilions, located in a caged hens' facility in Ferreira do Zêzere, in the locality of Santarém; both of them applied the new regulations associated with the cages requirements in terms of their dimensions. This reason limited the analysis to the existence of nests, scratching areas and perches, because these were the only differences detected after the Directive's implementation. An important conclusion reached is that the flocks longevity does differ between before and after the new legislation was introduced; this difference probably results from the previously allowed induction of metabolic stress.

We reached the conclusion that the egg production efficiency has improved since the introduction of the new legislation, even though there was a decreased animal density in the groups, along with a decrease in the total number of eggs produced per group. However, a comparison made to assess the overall benefit values (income subtracted of costs) of flocks from the two pavilions didn't find major differences in any of them, indicating that the profits of egg producers weren't affected by the implementation of the new legislation, remaining stable.

A conclusion reached that may be not so positive is the increase in the production of B class eggs, resulting from the introduction of the new legislation. Although a more accurate and thorough economic study is necessary to assess the financial impact for the producer of the higher proportion of B class eggs compared to A, it seems clear that the reason for this proportion lies in the introduction of the scratching area, which leads to a higher number of eggs contacting animal disposal and getting dirty. We can also conclude that this results in a lower value received by producers regarding the same amount of eggs.

In conclusion, the introduction of the new legislation resulted in the creation of better welfare conditions for the laying hens, principally when compared to the old caging systems that severely limited the performance of their natural behaviours. The benefits brought by the implementation of the mentioned Directive also include an increased individual productivity of each animal and of the egg production. However, it seems clear that the impacts of the changes introduced are actually mixed (both positive and negative); further investment on investigation is required in order to operate the necessary changes on the laying chain without impacting the animals quality of life and wellbeing.

10. BIBLIOGRAPHY

- (EFSA), E. F. S. A. (2005). Welfare Aspects of Various Systems for Keeping Laying Hens. *The EFSA Journal*, 197, 143.
- Adams, A. W., & Craig, J. V. (1985). Effect of Crowding and Cage Shape on Productivity and Profitability of Caged Layers: A Survey. *Poultry Science*, 64(2), 238-242.
- Appleby, M. C., Duncan, I. J. H., & McRae, H. E. (1988). Perching and floor laying by domestic hens: Experimental results and their commercial application. *British Poultry Science*, 29(2), 351-357.
- Appleby, M. C., J. A. Mench, and B. O. Hughes. (2004). *Poultry Behaviour and Welfare*.
- Appleby, M. C., & McRae, H. E. (1986). The individual nest box as a super-stimulus for domestic hens. *Applied Animal Behaviour Science*, 15(2), 169-176.
- Appleby, M. C., Mench, J. A., Olsson, I. A. S., & Hughes, B. O. (2011). *Animal Welfare, 2nd Edition*: Cabi.
- Appleby, M. C., Smith, S. F., & Hughes, B. O. (1993). Nesting, dust bathing and perching by laying hens in cages: Effects of design on behaviour and welfare. *British Poultry Science*, 34(5), 835-847.
- Appleby, M. C., Walker, A. W., Nicol, C. J., Lindberg, A. C., Freire, R., Hughes, B. O., et al. (2002). Development of furnished cages for laying hens. *British Poultry Science*, 43(4), 489-500.
- Berkhout, N. (2010). Poland calls on delaying cage ban to 2017. *WorldPoultry*.
- Bestman, M. (2011). *Poultry Signals: A Practical Guide for Bird Focused Poultry Farming*: Roodbont Pub. B.V.
- Blokhuis, H. J. (1989). The effect of a sudden change in floor type on pecking behaviour in chicks. *Applied Animal Behaviour Science*, 22(1), 65-73.
- Blokhuis, H. J. (2009). *Welfare Quality - Assessment protocol for poultry*.
- Brake, J. (1987). Influence of Presence of Perches During Rearing on Incidence of Floor Laying in Broiler Breeders. *Poultry Science*, 66(10), 1587-1589.
- Broom, D. M. (1986). Indicators of poor welfare. *British Veterinary Journal*, 142(6), 524-526.
- Bubier, N. E. (1996). The behavioural priorities of laying hens: the effect of cost/no cost multi-choice tests on time budgets. *Behavioural Processes*, 37(2-3), 225-238.
- Castoria, E. (2011). EU Battery Cage Ban. *VegNews*.

- Cooper, J. J., & Albentosa, M. J. (2003). Behavioural Priorities of Laying Hens. *Avian and Poultry Biology Reviews*, 14(3), 127-149.
- Cooper, J. J., & Appleby, M. C. (1995). Nesting behaviour of hens: Effects of experience on motivation. *Applied Animal Behaviour Science*, 42(4), 283-295.
- Cooper, J. J., & Appleby, M. C. (1996a). Demand for nest boxes in laying hens. *Behavioural Processes*, 36(2), 171-182.
- Cooper, J. J., & Appleby, M. C. (1996b). Individual variation in prelaying behaviour and the incidence of floor eggs. *British Poultry Science*, 37(2), 245-253.
- Cooper, J. J., & Appleby, M. C. (2003). The value of environmental resources to domestic hens: a comparison of the work-rate for feed and for nests as a function of time. *Animal Welfare*, 12(1), 39-52.
- Dawkins, M. (1977). Do hens suffer in battery cages? environmental preferences and welfare. *Animal Behaviour*, 25, 1034-1046.
- Dawkins, M. (1981). Priorities in the cage size and flooring preferences of domestic hens. *British Poultry Science*, 22(3), 255-263.
- Dawkins, M. S. (1983). Cage size and flooring preferences in litter - reared and cage - reared hens. *British Poultry Science*, 24(2), 177-182.
- Dawkins, M. S. (1989). Time budgets in Red Junglefowl as a baseline for the assessment of welfare in domestic fowl. *Applied Animal Behaviour Science*, 24(1), 77-80.
- Director of Policy report - 24th January 2012. (2012). *The Ranger*.
- Duncan, I. J. H., & Hughes, B. O. (1972). Free and operant feeding in domestic fowls. *Animal Behaviour*, 20(4), 775-777.
- Duncan, I. J. H., & Kite, V. G. (1989). Nest site selection and nest-building behaviour in domestic fowl. *Animal Behaviour*, 37, Part 2, 215-231.
- Freire, R., Appleby, M. C., & Hughes, B. O. (1996). Effects of nest quality and other cues for exploration on pre-laying behaviour. *Applied Animal Behaviour Science*, 48(1-2), 37-46.
- Gregory, N. G., & Wilkins, L. J. (1989). Broken bones in domestic fowl: Handling and processing damage in end - of - lay battery hens. *British Poultry Science*, 30(3), 555-562.
- Gunnarsson, S. (1999). Effect of rearing factors on the prevalence of floor eggs, cloacal cannibalism and feather pecking in commercial flocks of loose housed laying hens. *British Poultry Science*, 40(1), 12-18.

- Hickman, M. (2011). The end of battery farms in Britain – but not Europe. *Independent*.
- Hughes, B. O., Duncan, I. J. H., & Brown, M. F. (1989). The performance of nest building by domestic hens: is it more important than the construction of a nest? *Animal Behaviour*, *37*, Part 2, 210-214.
- John McGlone, S. F., Frank Mitloehner, Temple Grandin, Pamela Ruegg, Carolyn Stull, Gregory Lewis. (2010). Guide for the Care and Use of Agricultural Animals in Research and Teaching.
- Kent, J. P., McElligott, A. G., & Budgey, H. V. (1997). Ground-roosting in domestic fowl (*Gallus gallus domesticus*) in The Gambia: the anticipation of night. *Behavioural Processes*, *39*(3), 271-278.
- Kerswell, J. (2011). Battery egg hens still face hell as 'enriched' cages phased in. *The Ecologist*.
- Knowles, T. G., & Broom, D. M. (1990). Limb bone strength and movement in laying hens from different housing systems. *The Veterinary record*, *126*(15), 354-356.
- Le marché de l'oeuf bat provisoirement de l'aile. (2012). *20 minutes*.
- Lewis, J. (2012). French farmers ignore battery hen ban. *Telegraph*.
- Lindqvist, C., Janczak, A. M., Natt, D., Baranowska, I., Lindqvist, N., Wichman, A., et al. (2007). Transmission of stress-induced learning impairment and associated brain gene expression from parents to offspring in chickens. *PLoS One*, *2*(4), e364.
- Lindqvist, C. E. S., Schütz, K. E., & Jensen, P. (2002). Red Jungle Fowl Have More Contrafreeloading than White Leghorn Layers: Effect of Feed Deprivation and Consequences for Information Gain. *Behaviour*, *139*(9), 1195-1209.
- Meyer, W. A., & Sunde, M. L. (1974). Bone Breakage as Affected by Type Housing or an Exercise Machine for Layers. *Poultry Science*, *53*(3), 878-885.
- Newberry, R. C., Estevez, I., & Keeling, L. J. (2001). Group size and perching behaviour in young domestic fowl. *Applied Animal Behaviour Science*, *73*(2), 117-129.
- Nicol, C. J. (1986). Non-exclusive spatial preference in the laying hen. *Applied Animal Behaviour Science*, *15*(4), 337-350.
- Norgaard - Nielsen, G. (1990). Bone strength of laying hens kept in an alternative system, compared with hens in cages and on deep - litter. *British Poultry Science*, *31*(1), 81-89.
- Odén, K., Vestergaard, K. S., & Algers, B. (2000). Space use and agonistic behaviour in relation to sex composition in large flocks of laying hens. *Applied Animal Behaviour Science*, *67*(4), 307-320.

- Olsson, I. A. S., & Keeling, L. J. (2002). The Push-Door for Measuring Motivation in Hens: Laying Hens are Motivated to Perch at Night. *Animal Welfare*, 11(1), 11-19.
- Olsson, I. A. S., & Keeling, L. J. (2005). Why in earth? Dustbathing behaviour in jungle and domestic fowl reviewed from a Tinbergian and animal welfare perspective. *Applied Animal Behaviour Science*, 93(3-4), 259-282.
- Perry, G. C. (2004). *Poultry Science Symposium Series. Vol. 27, Welfare of the Laying Hen*: CABI Pub.
- Rowland, L. O., & Harms, R. H. (1970). The Effect of Wire Pens, Floor Pens and Cages on Bone Characteristics of Laying Hens. *Poultry Science*, 49(5), 1223-1225.
- Savory, C. J., Wood-Gush, D. G. M., & Duncan, I. J. H. (1978). Feeding behaviour in a population of domestic fowls in the wild. *Applied Animal Ethology*, 4(1), 13-27.
- Scientific Committee on Animal Health and Animal Welfare, (2000). *EU comission-welfare of chickens kept for meat production*
- Scott, G. B., Connell, B. J., & Lambe, N. R. (1998). The fear levels after transport of hens from cages and a free-range system. *Poultry Science*, 77(1), 62-66.
- Shepherdson, D. J., Mellen, J. D., & Hutchins, M. (1998). *Second Nature: Environmental Enrichment for Captive Animals*: Smithsonian Institution Press.
- Sherwin, C. M., & Nicol, C. J. (1993). A descriptive account of the pre-laying behaviour of hens housed individually in modified cages with nests. *Applied Animal Behaviour Science*, 38(1), 49-60.
- Shimmura, T., Eguchi, Y., Uetake, K., & Tanaka, T. (2008). Effects of separation of resources on behaviour of high-, medium- and low-ranked hens in furnished cages. *Applied Animal Behaviour Science*, 113(1-3), 74-86.
- Tauson, R., & Abrahamsson, P. (1996). Foot and Keel Bone Disorders in Laying Hens: Effects of Artificial Perch Material and Hybrid. *Acta Agriculturae Scandinavica, Section A — Animal Science*, 46(4), 239-246.
- The Humane Society of the United States. (2008). An HSUS Report: The Welfare of Animals in the Egg Industry. *HSUS Reports: Farm Industry Impacts on Animals*, Paper 16.
- Vestergaard, K. (1982). Dust-bathing in the domestic fowl — diurnal rhythm and dust deprivation. *Applied Animal Ethology*, 8(5), 487-495.
- Wabeck, C. J., & Littlefield, L. H. (1972). Bone Strength of Broilers Reared in Floor Pens and in Cages Having Different Bottoms. *Poultry Science*, 51(3), 897-899.

- Wood-Gush, D. G. M., & Vestergaard, K. (1989). Exploratory behavior and the welfare of intensively kept animals. *Journal of agricultural ethics*, 2(2), 161-169.
- Zimmerman, P. H., Koene, P., & van Hooff, J. A. R. A. M. (2000). Thwarting of behaviour in different contexts and the gakel-call in the laying hen. *Applied Animal Behaviour Science*, 69(4), 255-264.

ANNEX I

Ribeira da Mata II						
CAPACITY OF A POULTRY PAVILION:						
DATA:						
	CAGE LENGTH:	240	CM			
	CAGE WIDTH:	60	CM			
	AREA OF EACH CAGE:	14400	CM2			
	Nº CAGES/ROW:	396				
	Nº OF FLOORS:	6				
	Nº OF ROWS:	5				
	Nº OF CAGES IN THE PAVILION:	1980				
	NEST AREA:	1680	CM			
	USABLE CAGE AREA:	12720	CM2			
	LENGTH POLE / CAGE:	310	CM			
	LENGTH FEEDER / CAGE:	240	CM			
	CAGE LENGTH:	180	CM			
	CAGE WIDTH:	60	CM			
	AREA OF EACH CAGE:	10800	CM2			
	Nº CAGES/ROW:	12				
	Nº OF FLOORS:	6				
	Nº OF ROWS:	5				
	Nº OF CAGES IN THE PAVILION:	60				
	NEST AREA:	1680	CM			
	USABLE CAGE AREA:	9120	CM2			
	LENGTH POLE / CAGE:	188	CM			
	LENGTH FEEDER / CAGE:	180	CM			
LEGAL RESTRICTIONS - DECREE LAW No. 72-F / 2003						
	HEN/AREA (CM ²)	USABLE AREA/HEN (CM ²)	FEEDER/HEN (CM)	POLE/HEN (CM)	MAX HENS/CAGE	MAXIMUM PAVILION CAPACITY
	750	600	12	15		
HENS/CAGE	19,2	21,2	20,0	20,7	19	37620
	14,4	15,2	15,0		14	840
						38460

ANNEX II

Casal Mourão II - Pavilion 3						
CAPACITY OF A POULTRY PAVILION:						
DATA:				FEEDER		
	CAGE LENGTH:	244	CM	NEST	WIDTH	
	CAGE WIDTH:	63	CM			
	AREA OF EACH CAGE:	15372	CM2			
	Nº CAGES/ROW:	444				
	Nº OF FLOORS:	6		NEST		
	Nº OF ROWS:	6				
	Nº OF CAGES IN THE PAVILION:	2664				
	NEST AREA:	1680	CM			
	USABLE CAGE AREA:	13692	CM2	LENGTH		
	LENGTH POLE / CAGE:	310	CM			
	LENGTH FEEDER / CAGE:	240	CM			
	CAGE LENGTH:	122	CM			
	CAGE WIDTH:	63	CM			
	AREA OF EACH CAGE:	7686	CM2			
	Nº CAGES/ROW:	12				
	Nº OF FLOORS:	6				
	Nº OF ROWS:	6				
	Nº OF CAGES IN THE PAVILION:	72				
	NEST AREA:	1680	CM			
	USABLE CAGE AREA:	6006	CM2			
	LENGTH POLE / CAGE:	188	CM			
	LENGTH FEEDER / CAGE:	122	CM			
LEGAL RESTRICTIONS - DECREE LAW No. 72-F / 2003						
	HEN/AREA (CM ²)	USABLE AREA/HEN (CM ²)	FEEDER/HEN (CM)	POLE/HEN (CM)	MAX HENS/CAGE	MAXIMUM PAVILION CAPACITY
	750	600	12	15		
HENS/CAGE	20,496	22,82	20,0	20,7	20	53280
	10,248	10,01	10,2	9,1	9	648
						53928

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BROWN

Performance Summary

GROWING PERIOD (TO 17 WEEKS):

Livability	98%
Feed Consumed	5.75–6.13 kg
Body Weight at 17 Weeks	1.40–1.48 kg

LAYING PERIOD (TO 110 WEEKS):

Percent Peak	95–96%
Hen-Day Eggs to 60 Weeks	257–266
Hen-Day Eggs to 90 Weeks	419–432
Hen-Housed Eggs to 60 Weeks	253–262
Hen-Housed Eggs to 90 Weeks	408–421
Hen-Housed Eggs to 110 Weeks	491–508
Livability to 60 Weeks	97%
Livability to 90 Weeks	93%
Days to 50% Production (from hatch)	140 days
Egg Weight at 26 Weeks	57.3–59.7 g/egg
Egg Weight at 32 Weeks	60.1–62.5 g/egg
Egg Weight at 70 Weeks	62.9–65.5 g/egg
Total Egg Mass per Hen-Housed (18–90 weeks)	25.5 kg
Body Weight at 32 Weeks	1.85–1.97 kg
Body Weight at 70 Weeks	1.91–2.03 kg
Freedom From Egg Inclusions	Excellent
Shell Strength	Excellent
Shell Color at 38 Weeks	87
Shell Color at 56 Weeks	85
Shell Color at 70 Weeks	81
Haugh Units at 38 Weeks	90.0
Haugh Units at 56 Weeks	84.0
Haugh Units at 70 Weeks	81.1
Average Daily Feed Consumption (18–90 weeks)	105–112 g/day per bird
Feed Conversion Rate, kg Feed/kg Eggs (20–60 weeks)	1.87–1.99
Feed Conversion Rate, kg Feed/kg Eggs (20–90 weeks)	1.95–2.07
Feed Utilization, kg/Egg/kg Feed (20–60 weeks)	0.50–0.54
Feed Utilization, kg/Egg/kg Feed (20–90 weeks)	0.48–0.51
Feed per Dozen Eggs (20–60 weeks)	1.42–1.46 kg
Feed per Dozen Eggs (20–90 weeks)	1.51–1.55 kg
Skin Color	Yellow
Condition of Droppings	Dry



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Isa Brown

Cage Production Systems

Laying Period (18-90 weeks)

Liveability	93.9 %
Age at 50% production	144 days
Peak percentage	96 %
Average egg weight	62.9 g
Egg number hen housed	409
Egg mass hen housed	25.7 kg
Average feed intake	109 g/day
Feed conversion	2.14 kg/kg
Body weight	1975 g
Shell strength	4000 g
Shell color	32.0
Haugh units	82

