

ECONOMIC IMPACT OF DECREASING STOCKING DENSITIES IN BROILER RABBIT PRODUCTION BASED ON BELGIAN FARM DATA

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ABSTRACT: Stocking density is a prominent issue in public debates on farm animal welfare. Public perceptions and economic impact of reduced stocking density should be considered, along with effects on animal performances and welfare. In this paper, experimental data and accountancy data based on 15 Belgian farms were combined to calculate the financial impact of different stocking densities on broiler rabbit farm profitability. Using the partial budget technique, only those elements that change with stocking density were taken into account. From the experiment, feed conversion and feed intake were found to increase slightly though significantly with decreasing stocking density, although only 5% and 6% of the variation, respectively, were explained by stocking density. However, reducing stocking density implies a recalculation of all costs in a reduced number of broiler rabbits, which has a negative impact on farm profitability. Reducing stocking density from the standard situation of 15 rabbits per m² to 10 rabbits per m² reduced added value by €22 per doe. In general, farm income was low and amounted to only €28.10 per doe during 2006–2008 for the reference situation of 15 rabbits per m². Below a density of 9 rabbits/m², a negative farm income was calculated. Sensitivity analysis showed that rabbit meat price has a stronger influence on the added value at a given density than rabbit feed price.

Key Words: Stocking density, fattening rabbit performance, economic analysis.

INTRODUCTION

Animal welfare has become a hotly debated and increasingly relevant issue in today's industrialised societies. Citizens ask for more animal friendly livestock production practices (María, 2006; Vanhonacker *et al.*, 2010) and the market segment that takes animal welfare into account during their food purchasing process is steadily growing. Intensive animal production, adopted many decades ago to ensure food security and reduce production costs, is now increasingly criticised for its compromise on the farm animals' welfare. The urbanised and lay public strongly perceives animal welfare from a human-centred perspective, in which attention to "natural living" occupies a primary role (Lassen *et al.*, 2006; Vanhonacker *et al.*, 2008). From this viewpoint, high stocking densities applied to maximise profit per unit area result in negative general welfare perceptions and adverse reactions to animal production systems among the public (Vanhonacker *et al.*, 2009).

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Although the number of rabbits in a cage or pen is amongst the most important factors for the well being and production aspects (Szendrő *et al.*, 2009), from a scientific point of view no consensus has yet been reached on the range within which stocking density affects rabbit welfare. The European Food Safety Authority has issued an extended overview of different aspects of animal welfare in rabbit production (EFSA, 2005). Based on production parameters, 40 kg/m² (or 16 fatteners of 2.5 kg per m²) has long been considered as maximum load in small cages (Maertens and De Groote, 1984) and is still commonly used in commercial fattening rabbit units (EFSA, 2005). However, to date (May 2011) there is no European regulation that stipulates requirements on stocking densities, group sizes or other housing conditions for broiler rabbits. Some European countries such as the Netherlands (Productschap Pluimvee en Eieren, 2006), Austria (Austrian Federal Chancellery, 2004) and Switzerland (Swiss Federal Council, 1981) have a national legislation on animal welfare specifically for rabbits related to enrichment, cage height, platforms for does or dimensions and material of cages or pens. The Swiss Animal Protection Ordinance specifies standards on stocking densities. This Swiss Ordinance allows three rabbits with body weight under 3.5 kg in a cage of 4000 cm², which equals a stocking density of 7.5 animals per m². Other countries such as the UK have set codes for livestock welfare recommendations in general and for rabbits in particular. These welfare codes do not lay down statutory requirements.

There is an inherent conflict between animal welfare (as perceived by humans) and livestock productivity (as pursued by increasingly ‘intensive’ methods of production). Higher welfare production methods generally require a reduction in ‘intensity’ (McInerney, 2004) and hence are an economic cost. In this perspective, it is relevant to investigate the balance between farm return and an acceptable level of animal welfare, e.g. in terms of stocking density.

To the authors’ knowledge, empirical data about the implications of different stocking densities on the profitability of broiler rabbit farms have not been reported previously. The present study applies 2 unique datasets to investigate the trade-off between stocking density and rabbit farm economic profitability in the region of Flanders, the northern Dutch-speaking part of Belgium. This study combines performance data from an experiment on the impact of varying stocking density, together with accountancy data from 15 commercial rabbit farms from the Flemish Association of Poultry and Rabbit Breeders, in an economic partial budget analysis. A partial budget analysis contains only those elements or parameters of a complete budget (or farm budget) which will change if a proposed modification (in this case stocking density) is implemented (Dijkhuizen and Morris, 1997). The aim is to estimate the change that will occur in terms of farm profit or farm loss from a change in the farm management system (Boehlje and Eidman, 1984). This approach allows a more precise calculation of the economic impact of reduced stocking densities. Results are relevant to support debates related to legislation and policy implementations with impact on farm animal welfare and the economic viability of broiler rabbit production.

MATERIALS AND METHODS

Data sources

Data from stocking density experiment: The experiment on housing conditions was designed to investigate the impact of stocking density and cage size on spatial preferences (Buijs, 2011), fearfulness (Buijs *et al.*, 2009), bone strength (Van Poucke *et al.*, 2009) and performance of broiler rabbits (Maertens *et al.*, 2009).

A total of 672 broiler rabbits, weaned at 30 d of age, were housed in open-topped wire cages of 7 different sizes (surface area ranging from 0.4 m² to 1.6 m²). Group size was fixed at 8 rabbits and in consequence seven corresponding stocking densities of 20, 17.5, 15, 12.5, 10, 7.5 and 5 rabbits/m² were compared. Siblings were placed in different pens and sex ratio was 1:1. Dead animals were only replaced during the first 2 wk of the experiment. Rabbits had *ad libitum* access to feed and water and were slaughtered at 72 d of age. Three experimental rounds were conducted and within each round each stocking density was repeated 4 times. With the exception of the 2 smallest cage sizes, half of the cages were enriched with a U-shaped wooden structure placed in the centre of the cage. This structure was constructed of 3 wooden boards and could be used as a shelter, resting area and as gnawing material (Van Poucke *et al.*, 2009). Technical performance data such as weight gain, feed intake and feed conversion were collected.

Accounting Data: Economic information on commercial rabbit farms came from the bookkeeping records from all 15 rabbit farms from the Flemish Association of Poultry and Rabbit Breeders. However, on rabbit farms most technical details are available only for the whole production period. Therefore, variables that describe the post-weaning growing period only are not readily available. This is, e.g., the case for water consumption, heating or electricity costs. Total variable costs (electricity, heating, water, disinfection, insurance, taxes and administration, but excluding fodder costs) are derived from accounting data, although they do not exclusively cover the fattening phase but the whole growing period. From these figures, those costs that are constant per doe are subtracted, such as veterinary costs or costs for nest material.

Investment, depreciation and maintenance costs are based on data obtained from the Netherlands, where similar housing conditions are used (Vermeij *et al.*, 2007). However, it is known that there has been little investment recently in the Flemish rabbit farms, which is confirmed by sector representatives and can be seen in replacement values from accountancies: €353 per doe (mean 2006–2008) compared to €505 per doe in the Netherlands (Vermeij *et al.*, 2007). It is assumed more realistic to take the higher replacement value into account, because rabbit growers will have to invest to stay competitive. Depreciation is calculated using a straight line depreciation method with a lifetime of 30 y for buildings and 15 y for equipment. Maintenance rates are 1% for buildings and 2% for equipment. Interest rates are fixed at 4%.

The mortality rate from the experimental study (1%) was very low to avoid interference with stocking density due to the continuous treatment with Zn-bacitracin during the first weeks of the trial. This mortality rate is however not representative for commercial on-farm conditions during the fattening phase in Belgium. In contrast with some other European countries, it is strictly prohibited by national law to use Zn-bacitracin in commercial rabbit farming in Belgium. Moreover, hygienic conditions of production units are generally lower as few farms use an all in-all out management system. Thus, a mortality rate after weaning of 6-8%, as is commonly reported in literature (EFSA, 2005; Rosell *et al.*, 2009), does not represent the Belgian situation. The mortality rate used will therefore be the mean as known from the accounting data of the rabbit producers kept by the Flemish Association of Poultry and Rabbit Breeders and is assumed not be dependent on stocking density.

Final weight is used to express stocking density in kg/m². For the effect of stocking density on the farm result however, it is only the weight gain during the growing phase that needs to be taken into account. It is assumed that weight gain during the weaning period is independent of stocking density during the growing phase.

Table 1: Basic data for calculation of technical indicators and costs.

Variable or cost component	Data source	Period	Mean
No. litter/y	Accounting (mean 2006-2008)	Total period	7.1
Mean litter size	Accounting (mean 2006-2008)	Total period	9.13
Weight gain	Experiment	Growing period	1.98 kg
Final weight	Accounting (mean 2006-2008)	Total period	2.65 kg
% mortality	Accounting (mean 2006-2008)	Nursing period	13.9%
% mortality after weaning	Accounting (mean 2006-2008)	Growing period	14.4%
Feed intake	Experiment	Growing period	Formula (see Table 3)
Feed cost/kg	Accounting (mean 2006-2008)	Total period	€26.1/kg
Replacement value building	KWIN 2007-2008 (Vermeij <i>et al.</i> , 2007)	Total period	€310/doe/y
Other costs (doe-independent)	Accounting (mean 2006-2008)	Total period	€38/doe/y
Other costs (doe-dependent)	Accounting (mean 2006-2008)	Total period	€10.5/doe/y
Farm income	Accounting (mean 2006-2008)	Total period	€28.1/doe/y

Overview of the technical data and cost components: Table 1 provides an overview of the variables used, their mean values, their source and if they cover total production period, nursing or growing period.

Partial budget analysis

Partial budgeting is based on the principle that a small change in the organisation of a farm business will have one or more of the following effects: eliminate or reduce some costs; eliminate or reduce some returns, cause additional costs to be incurred, cause additional returns to be received (Dalsted and Gutierrez, 1992). The net effect will be the sum of positive economic effects minus the sum of negative economic effects. The final outcome of this technique is a net effect, i.e. it gives a measure for the possible change in farm profit. The result is therefore always compared to a reference situation.

In the literature, the partial budget method is often used to calculate the effect of changes in farm management, change of crops or the introduction of a new technology (Ehui and Rey, 1992; Engle and Brown, 1999; Overton, 2005; Allen, 2006; Nahamya *et al.*, 2006; Cox *et al.*, 2009). The unit of analysis in these studies is the farm or a housing unit (e.g. stable). To analyse the effect of stocking densities, however, it is important to include investment costs. The investment costs are equal per stable but are different per animal, i.e. investment costs per animal increase with lower stocking densities. Therefore, the partial budget analysis will be performed in this study per unit of doe. Although for some equipment, such as ventilation or watering systems, less capacity is needed for lower stocking densities, this is assumed not to play an important role. From similar research for the poultry sector, a survey amongst building companies revealed that the most basic elements of the construction and equipment, including labour costs, are independent of the stocking density (Verspecht *et al.*, 2011).

As a result, all other variables will be calculated per unit of doe. This allows a detailed investigation of the effect of stocking density on production performance and on farm technical data. In the final stage of analysis, the profit per doe will be reconverted to profit per square

metre. This will result in a more comprehensive, realistic and detailed description of the impact of varying stocking densities on farm profit.

A commercial rabbit farm is assumed to hold 15 animals per m² in cages of 0.4 m² and has about 700 does. The stocking density of 15 animals per m² is therefore seen as the reference situation.

Assumptions

The experimental design, as described above, is based on weaned rabbits and looks at different stocking densities within the fattening period. In order to give a good representation of an on-farm process, some assumptions need to be made.

First, we assume that the zootechnical performance during the nursing period is constant for different stocking densities (feed intake, feed conversion, mortality rate, weight gain) and comparable to real farming practices, based on accounting data for the Flemish rabbit sector. As in commercial rabbit farms, we assume that does are rebred every 6 wk and that the normal weaning time is 4 or 5 wk. During this time, weanlings are housed in breeding cages. Afterwards, rabbits are fattened in a different compartment (grower cages) till the age of 10 or 11 wk.

Second, we assume that a farmer, in practice, will more easily change the number of animals in existing cages and then adapt the cage sizes¹. So, instead of looking at changes in stocking densities caused by different cage sizes, as was done in the experiment, the findings are transformed into changing densities caused by a different number of rabbits in a fixed number of cages.

Third, although the partial budget technique only assumes different stocking densities in the fattening period, directly affecting the situation in the grower cages, there will be an indirect effect on the rabbits in the breeding cages. Having more or fewer fattening rabbits means that more or fewer does are needed, and because the breeding cage density remains constant, the number of breeding cages needed will change. Therefore, we assume that dual purpose cages are used which can be filled either with weanlings and does or with fattening rabbits. The dual purpose cages are assumed to be 0.4 m², which is an average size in intensive rabbit breeding (EFSA, 2005).

Fourth, further based on the accounting data, 6% non-lactating females are assumed (due to non-successful reproduction). These females are housed individually in cages with a dimension of 0.2 m². For the calculations it is assumed that 2 individual cages can easily be consolidated to become one grower or dual purpose cage.

Technical performance indicators

To express the production parameters found in the experimental design in terms of stocking density, regression analysis was used. Linear regression using ordinary least squares (OLS) for growing traits yielded the best fit as compared to various tested non-linear regression models. Significance level was 0.05. Data were analysed using SPSS 17.0. The resulting equations are the basis for estimating the impact of the technical performance indicators at different stocking densities in the partial budget analysis. The boundaries with respect to stocking density are defined by the experiment and set at 5 rabbits per m² (about 13 kg/m²) and 20 rabbits per m² (about 53 kg/m²). The resulting relations will be compared to the literature reviews of Trocino and Xiccato (2006) based on 84 scientific articles and the review of Szendrő and Dalle Zotte (2011) based on 50 scientific papers.

¹ Except for those farmers that need to invest in new stables and cages anyway.

Sensitivity analysis

In a sensitivity analysis, price variations for rabbit food and rabbit meat are taken into account. A sensitivity analysis is a technique for systematically changing parameters in a model to determine the effects of such changes and thus exploring the impact of varying input assumptions and scenarios. As such, a sensitivity analysis checks the robustness of the results and illustrates the impact of possible market price variations and related assumptions.

RESULTS AND DISCUSSION*Equations on performance indicators*

Table 2 gives an overview of the descriptive statistics of the independent variables used in the regression analysis.

In the experiment, weight gain did not vary significantly ($P > 0.05$) with stocking density (Table 3). Although most often in literature a relation between weight gain and stocking density is confirmed (see reviews of Trocino and Xiccato, 2006; Szendro and Zotte, 2011), there are examples where this relationship could not be proven (Rommers and Meijerhof, 1998; Xiccato *et al.*, 1999). Therefore, in the partial budgeting, weight gain is independent of stocking density and is the mean of all rounds and densities. In contrast, feed intake decreased with higher stocking densities. Stocking density explained 7% of the variation. In the literature, feed intake is changing in general, with different stocking densities especially for stocking densities above 15-17 rabbits/m² (see reviews of Trocino and Xiccato, 2006; Szendro and Zotte, 2011). In the economic calculations, feed intake is converted into feed cost. In our experiment, feed conversion was also found to be dependent on stocking density.

In the literature, mortality has been observed to be most often independent of group size due to the common practice of providing medication through the feed (Szendro and Zotte, 2011). Since no mortality data can be used from the experiment, mortality rate will be the mean from the accounting data and will be considered constant for all stocking densities.

Partial budget analysis results

Table 4 presents the results of the partial budget analysis. The change in costs, returns and value added because of differences in stocking density as compared with the reference situation is expressed per doe and per m². In the partial budget technique, costs that are equal per doe are not included, for example veterinary costs and nest material. For the return, only the weight gain during growing phase is used in the calculations. As weight gain did not differ significantly with stocking density, the partial return is equal per doe but different per m². The farm income is based on the mean farm income from accountancies during 2006-2008: this is €28.10 per doe for the reference situation of 15 animals per m². This income was much smaller than those reported for

Table 2: Descriptive statistics of the dataset from the stocking density experiment.

	No. of rounds	Minimum	Maximum	Mean	Std. Deviation
Weight gain (kg)	84	1.831	2.146	1.978	0.073
Feed intake per grower (kg)	84	5.389	6.787	5.906	0.270
Feed conversion (kg/kg)	84	2.790	3.360	2.989	0.115

Table 3: Performance data (30-72 d) as a function of stocking density (StD).

Production parameter	Equation	Sign. (F-stat)	R ² _{adjusted}
Weight gain (g)	1988.99 – 0.865 * StD (**) (n.s.)	0.595	-0.009
Feed intake per grower (g)	6096.17 – 15.46 * StD (**) (**)	0.009	0.070
Feed conversion	3.069 – 0.006 * StD (**) (**)	0.010	0.067

StD is expressed as number of growers per m².

P-values are indicated under the estimates: (**)<0.01 and n.s.: not significant.

French farms, being on average €109.9 per doe per y in 2009 (Lebas, 2010). However, only the feed costs are taken into consideration in this French overview.

When taking into account the costs and revenues that change with stocking density, the change in value added and in costs is within the range of €–66 to €33 per doe. The return per doe is constant as no relation was taken into account for growth rate and stocking density in the growing phase. For the highest stocking density, the value added will be €12 per doe higher as compared to the reference situation of 15 rabbits/m². Decreasing the stocking density to 10 rabbits/m² will reduce the value added by €22 per doe.

The feed cost is almost constant due to the low relation between feed intake and stocking density. All other costs double from the standard situation of 15 growers per m² to the lowest stocking density, because they can only be distributed on half the number of does. This constitutes the main negative economic impact of reducing stocking density and not the effect of stocking density on growth performance parameters.

Farm income per doe is negative for the 2 smallest densities and is break-even or positive at a density of more than 9 growers per m². In this analysis, it is assumed that the total cage size on a

Table 4: Effects of stocking density on partial budget (€ per doe per y).

Growers/m ²	5.0	7.5	10.0	12.5	15.0	17.5	20.0
Return (A) ¹	170.5	170.5	170.5	170.5	170.5	170.5	170.5
Change in total costs (B)	237.0	194.0	171.9	158.6	149.6	143.3	137.9
Feed cost (grower)	75.2	74.7	74.2	73.7	73.2	72.8	72.3
Other variable costs	80.7	59.5	48.7	42.3	38.1	35.1	32.7
Depreciation and maintenance buildings	25.5	18.8	15.4	13.4	12.0	11.1	10.4
Depreciation and maintenance equipment	32.1	23.7	19.4	16.8	15.1	14.0	13.0
Rent (buildings and equipment)	23.5	17.4	14.2	12.4	11.1	10.3	9.6
Change in value added (A) – (B)	-66.5	-23.5	-1.4	11.9	20.9	27.2	32.5
Farm income	-59.3	-16.3	5.8	19.1	28.1	34.4	39.7
Number of does	330	448	547	630	700	758	814

¹ Return per doe is constant.

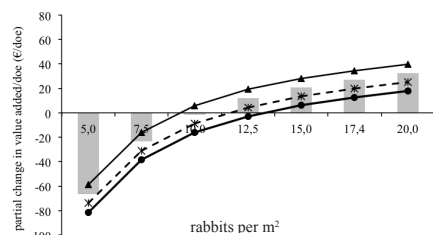


Figure 1: The effect of rabbit feed price variations on partial change in value added with changing stocking densities. (■) Basis, (—▲—) feed -10%, (- * -) feed +10%, (—●—) feed +20%.

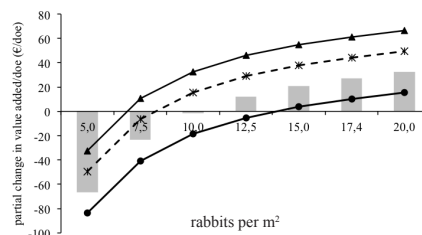


Figure 2: The effect of rabbit meat price variations on partial change in value added with changing stocking densities. (■) Basis, (—●—) meat -10%, (- * -) meat +10%, (—▲—) meat +20% .

farm is not expanded. This results in fewer does at lower stocking densities. The reference farm with 15 rabbits per m² has 700 does. Such a farm would have to diminish the number of does to 330 when the stocking density is lowered to 5 rabbits per m².

These results suggest partial budgeting as a good method to reveal changes in costs and benefits when changing stocking densities. However, the above calculations prove the importance of scale: partial budgeting on the scale of the farm would not have revealed the high importance of fixed costs (e.g. depreciation and maintenance costs when decreasing stocking density).

Sensitivity analysis

Figures 1 and 2 present the effect of changing market prices on the partial change in value added. The effects of variation in prices for feed as well as variations in the market price for rabbit meat are taken into account. Variations are calculated from 10% decrease to 20% increase in market prices.

Variations in rabbit meat price have a stronger influence on the partial change in added value than changing feed prices. An increase of 10% of the feed price requires a shift of the stocking density to almost 12 rabbits per m² before partial change in value added becomes positive. A decrease of 10% in meat price however, will shift stocking density to almost 14 growers per m² to make the partial change become positive.

CONCLUSIONS

Reducing stocking density involves a recalculation of all costs on a reduced number of rabbits. In this paper, experimental data and farm accountancy data were combined to calculate the financial impact of different stocking densities in broiler rabbit production. Using the partial budget technique, only those elements that change with stocking density were taken into account. From the experiment, feed conversion and feed intake were found to increase slightly though significantly with decreasing stocking density.

It was estimated that a reduction in stocking density to 7.5 rabbits per m² compared to the standard situation of 15 rabbits per m² will reduce added value by €44 per doe and generate a negative farm income. Next to the loss in added value per doe, the number of does per farm will also decrease from 700 to 450 does, under the assumption that farms cannot easily and readily

expand their business. The redistribution of fixed costs over a smaller number of does has the strongest impact on the financial situation of a rabbit farm. In conclusion, a stocking density requirement of 7.5 rabbits per m² like the one currently applied in Switzerland means operating below the economic break-even point of farms using Belgian conditions during 2006-2008.

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