

# Herbage intake and use of outdoor area by organic broilers: effects of vegetation type and shelter addition

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## Abstract

The herbage intake and use of outdoor areas by organic broilers were investigated in an experiment laid out in two fields, i.e., a grass-clover pasture and wheat stubble with undersown clover. Each field was divided into two plots, one with and one without extra shelter consisting of camouflaging nets around huts constructed from straw bales where the broilers were housed during the night. Five hundred birds were assigned to each of the four treatment combinations. To analyse the use of outdoor areas with respect to herbage intake, plots were divided into three smaller areas surrounding the night house: P<sub>1</sub> (most intensively used area), P<sub>2</sub> (intermediate area) and P<sub>3</sub> (least intensively used area). The mean daily herbage dry matter intake per broiler between 25 and 80 days of age was 10.7 g, irrespective of vegetation type. The amount of herbage consumed represented up to 7 and 3% of the birds' daily protein and energy requirements, respectively. When extra shelter was provided, the area of P<sub>1</sub> increased, suggesting that some extra protection gave the broilers more confidence to explore further areas of the plots. However, the total frequently-used area (P<sub>1</sub>+P<sub>2</sub>) was not affected by the presence of extra shelter, indicating that there was a critical distance (about 20 m in this study) that was seldom surpassed. It is concluded that adding shelter in the field contributes only marginally to a more even distribution of the excreta.

*Additional keywords:* outdoor range, poultry, forage, grass, clover

## Introduction

Consumer demand for poultry meat has continuously increased since years. Simultaneously, public-political debates are more and more focused on the development of sustainable production systems, product quality, environmental impact, animal welfare and competitiveness of poultry meat production (Wolf-Reuter, 2004). Consequently, the market for free-ranging broilers, such as those reared on organic farms, is also growing (Anon., 2003), although the recent fear of Avian Influenza could temporarily affect this trend of outdoor ranging in the near future.

In poultry production, feed can account for up to 70% of the total variable costs (Walker & Gordon, 2003). So it is of major importance to adjust feed intake and match it with the requirements of the birds. It has been estimated that a laying hen can consume up to 30–40 g of dry matter per day from herbage, worms and insects, in addition to more than 100 g of concentrates (Hughes & Dun, 1983a). However, such information is not available for outdoor broilers. Also Walker & Gordon (2003) and Hermansen *et al.* (2004) pointed out the necessity to know the actual intake of herbage by outdoor poultry with the purpose of adjusting the amounts of concentrates to the real requirements of free-range broilers. Such data, despite being an approximation and depending on many factors, could help animal nutritionists to make adjustments in the feed formulation that are likely to reduce costs.

Another matter of interest is the use of the outdoor run by the birds, which is reflected in the spatial pattern of herbage intake. Kratz *et al.* (2004) suggested that efforts should be made to motivate broilers to uniformly use the outdoor space in order to reduce local concentrations of excreted nutrients. Some authors (Bubier & Bradshaw, 1998; Mirabito & Lubac, 2001) have pointed out that adding shelter to the free-range area helps to increase the use of the outdoor run. Most studies, however, have been conducted with free-range laying hens instead of broilers, so there is not much information on the foraging pattern of this type of birds. Considering the differences in the production system (age of the animals, length of the production period, genetic background) it is expected that the foraging pattern of broilers would differ too (Dawkins *et al.*, 2003).

In this paper we address both herbage intake and use of the outdoor run by organic broilers in order to help to optimize the production system. To our knowledge, this is the first attempt to measure accurately the herbage intake by free-ranging broilers over a prolonged period. Moreover, attention is paid to the effects of adding shelter on the use of the outdoor areas to investigate whether the broilers would feel more protected and explore further areas, thus spreading the manure droppings more uniformly.

## Material and methods

### Bird management and experimental layout

Two thousand one-day old, slow-growing broilers of the ISA-957 strain selected to grow in outdoor conditions (Merial, France), were housed for 24 days in a climatized poultry

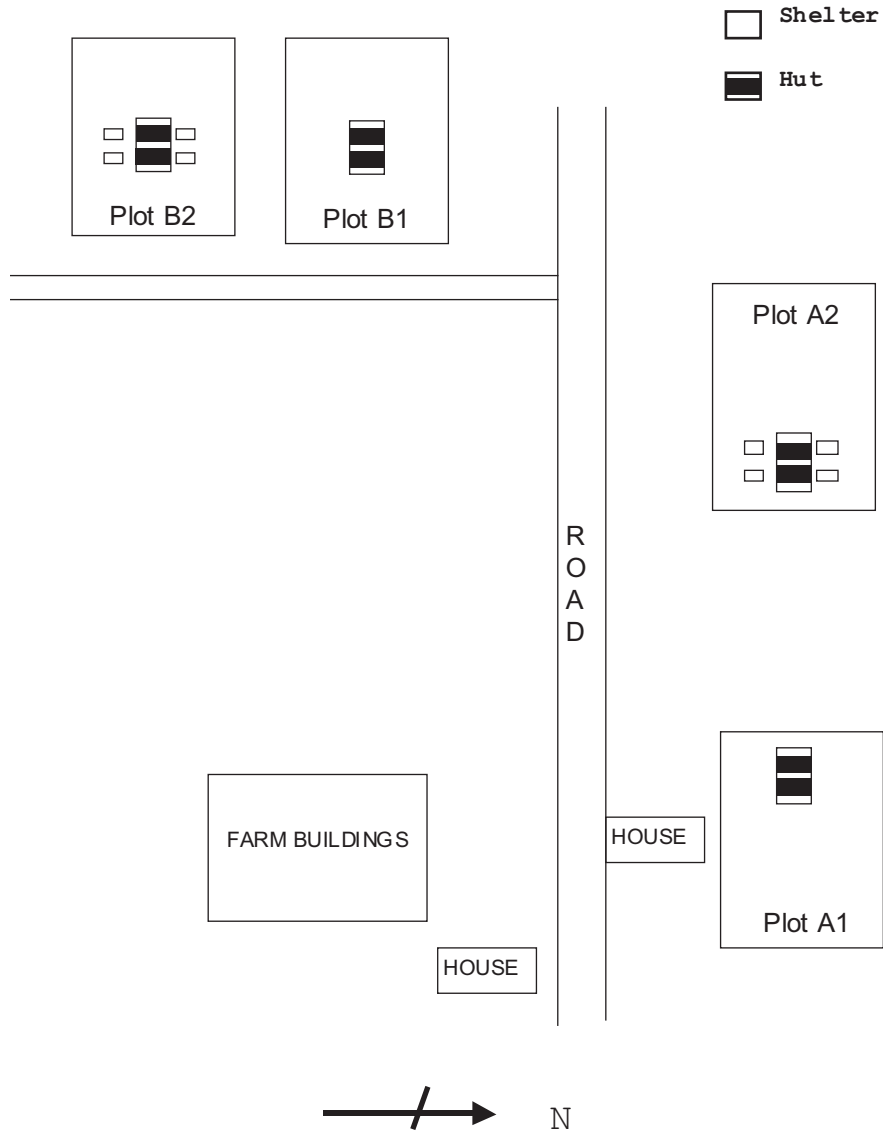


Figure 1. Map of the experimental plots at the Organic Educational and Experimental Farm 'Droevendaal'. Plots A1 and A2: undersown clover in wheat stubble; plots B1 and B2: grass-clover pasture. Plots A1 and B1: without extra shelter; plots A2 and B2: with extra shelter.

Table 1. Details of the experimental layout.

	Field: A		B	
	Plot: A1	A2	B1	B2
Vegetation type	undersown clover	undersown clover	grass-clover	grass-clover
Extra shelter	no	yes	no	yes
Field size (m <sup>2</sup> )	3006	3206	2471	2217
Number of broilers	500	500	500	500
Outdoor area per broiler (m <sup>2</sup> )	6.0	6.4	4.9	4.5
Broilers per m <sup>2</sup>	0.17	0.16	0.20	0.23
Night house area (m <sup>2</sup> )	58	58	58	58

house at the experimental facilities of 'De Haar – Zodiac' of Wageningen University during August 2004. All birds were offered both a standard organic starter diet (crude protein: 218 g per kg; crude fat: 61 g per kg; crude fibre: 40 g per kg; crude ash: 61 g per kg; metabolizable energy: 11.5 MJ per kg; lysine: 10.8 g per kg; methionine + cystine: 8.2 g per kg) and water *ad libitum*. Temperature in the poultry house was gradually decreased from 32 °C at day 1 to 18 °C at day 21, which was maintained until day 24.

When the broilers were 24 days old, they were transferred to outdoor fields at the Organic Educational and Experimental Farm 'Droevendaal' of Wageningen University, about 3 km from 'De Haar – Zodiac'. Table 1 gives a brief description of the layout of the experimental fields. The fields consisted of undersown clover in wheat stubble (Field A) or a pasture of grass and clover (Field B). The two fields were about 200 m apart, separated by a road and other fields with crops (Figure 1). Each field was divided into two plots, one without (A1 and B1), the other with extra shelter added (A2 and B2). Consequently, the experiment comprised four treatments. The facilities of each plot consisted of a straw-bale hut covered with a wooden plate roof. The total floor surface was approximately 58 m<sup>2</sup> per hut (8.6 birds per m<sup>2</sup>). The outer walls of the huts were covered with chicken wire (mesh size 3 cm) and the huts were closed at night with four fox-proof fences. Plots A2 and B2 were provided with extra shelter consisting of 4 camouflaging nets (6 m × 3 m × 0.90 m) at both sides of each hut (two per side), approximately 4 m from the house.

Five hundred birds were assigned to each plot. Animal density in the outdoor area ranged from 0.16 to 0.22 broilers per m<sup>2</sup>, equivalent to an average area of 4.5 to 6.4 m<sup>2</sup> per broiler (Table 1). The total outdoor period lasted 8 weeks in which the broilers reached an age of 80 days. For adaptation purposes, the birds remained in the huts during the first two days of the outdoor period (feed and water provided inside). From then on, doors were opened every morning at 8 a.m. to release the birds until enclosure late in the afternoon (around 5 p.m. in September and 4 p.m. in October).

Every three weeks, 10% of the broilers in each plot were randomly selected and weighed to determine growth rates. The diet was based on a 54:46 ratio of concentrates

Table 2. Composition of the concentrates offered outdoors to the organic broilers from 25 to 80 days of age.

Ingredients	Nutrient composition	
	(%)	(g kg <sup>-1</sup> )
Soya beans	21.6	Starch 265
Maize	19.8	Crude protein 250
Peas	13.2	Crude ash 86
Sunflower-seed flakes	12.4	Crude fat 81
Wheat	8.2	Crude fibre 64
Maize gluten meal	4.6	Linoleic acid 37
Sesame flakes	4.4	Calcium 16
Potato protein	3.8	Phosphorus <sup>1</sup> 7.7
Barley	2.5	Lysine <sup>2</sup> 12.5
Soya bean flakes	1.9	Threonine 9.8
Triticale	1.7	Methionine + cystine <sup>3</sup> 8.8
Limestone	2.1	Tryptophane 2.8
Dicalcium phosphate	1.6	-----
Organic acids	0.5	Metabolizable energy 10.9 MJ kg <sup>-1</sup>
Vitamin-mineral premix	1.7	

<sup>1</sup> 4.2 g kg<sup>-1</sup> digestible phosphorus.

<sup>2</sup> 10.4 g kg<sup>-1</sup> digestible lysine.

<sup>3</sup> 7.5 g kg<sup>-1</sup> digestible methionine + cystine.

and wheat, respectively. Every morning the birds were offered water and concentrates in mobile feed troughs located in the surroundings of the huts, whereas in the evening wheat was provided inside the huts (scattered over the floor) to help confining the birds. The composition of the concentrates is given in Table 2. The concentrates had a relatively high crude protein content to compensate for the relatively high proportion of wheat in the complementary diet. The supplied amounts were based on the feed conversion ratio (FCR) calculated over the first 17 days of the experiment and adjusted to both actual body weights and changes in FCR with age. To stimulate the foraging nature of the birds, diets were offered on a restricted basis (approximately 90% of *ad libitum*) and similar quantities per plot were used since average body weights differed only marginally.

## Herbage intake

To estimate the intake of 'grazed' herbage, the sward cutting technique described by Lantinga *et al.* (2004) was applied. Using a metallic frame (0.50 m × 0.50 m) with a fixed cutting height of 4 cm, herbage samples were collected before and after the outdoor period in each of the four plots and analysed separately. In all cases, four herbage samples were taken per plot. The first batch of samples was collected the day before

the broilers were transferred to the outdoor fields, the second batch shortly after the broilers had been removed for slaughtering. Samples were dried for 72 hours at 70 °C to determine dry matter (DM) content. Organic matter (OM) was determined by incinerating 1.5-g samples of dry grass. The Kjeldahl method was used to determine the nitrogen (N) content of the samples.

DM herbage intake (C) was estimated using the following equation (Lantinga *et al.*, 2004):

$$C = (HMs - HMe) + [(1 - (HMe/HMs)) / -\ln(HMe/HMs)] \times (HMu - HMs) \quad (1)$$

where *HMs* is the herbage mass present at the start of the outdoor period; *HMe* is the herbage mass that remained at the end of the experiment, and *HMu* is the undisturbed herbage mass from a nearby ungrazed area.

As the broilers did not forage uniformly over the plot, Equation 1 had to be adapted to the actual herbage situation at the end of the experiment. For this reason, the total area of the plot was divided into three separate concentric sub-areas around the hut. These sub-areas were defined after a visual screening of the remaining herbage, and for simplification purposes were taken as rectangles. Nearest to the hut, including its inside, an intensively used sub-area was distinguished with no herbage left (*P1*). The sub-area furthest away from the hut was least used and abundant herbage remained (*P3*). At the end of the experiment, herbage samples were taken in this sub-area (*HMe*) and in the more remote unaffected area (*HMu*). In the intermediate sub-area (*P2*) the herbage was scarce and short, its height being of about the same level (4 cm) as that of the sampling method. The size of these sub-areas was measured and for each of them, the herbage intake was independently estimated, making specific assumptions in Equation 1. For *P1* it was assumed that herbage intake equalled the herbage present on that particular area at the start of the experiment. Since the sward cutting technique was originally developed for ruminants, it does not include herbage shorter than 4 cm. For this reason, the stubble remaining aboveground after cutting the samples was also measured (*HMa*) and included in the estimate:  $C(P1) = HMs + HMa$ . In case of *P2*, considering that the residual herbage height was approximately that of the cutting level, the intake was calculated assuming that *HMe* was very close to 0. Thus, Equation 1 was transformed into:

$$C(P2) = (HMs) + [(1 - (0.001/HMs)) / -\ln(0.001/HMs)] \times (HMu - HMs) \quad (2)$$

For *P3*, the herbage intake ( $C(P3)$ ) was calculated using Equation 1. Finally, the total herbage intake was the sum of the intakes in each of the sub-areas:  $C = C(P1) + C(P2) + C(P3)$ .

### Use of outdoor areas

The exploratory pattern of the broilers was inferred from herbage intake observations, assuming that the birds spent longer periods of time and excreted more manure in those areas that were more intensively used. Accordingly, the size of each of the

Table 3. Available aboveground herbage at the start of the experiment and mean herbage [dry matter (DM), organic matter (OM) and nitrogen (N)] intake, final body weight and body weight gain of outdoor broilers between 25 and 80 days of age for undersown clover in wheat stubble and permanent grass-clover pasture, with or without extra shelter.

Experimental treatment	Available herbage	Intake			Final body weight	Body weight gain <sup>1</sup>
		DM	OM	N		
	(g DM m <sup>-2</sup> )	(g per broiler per day)			(kg)	(g day <sup>-1</sup> )
<i>Undersown clover</i>						
- without extra shelter	101	9.6	7.6	0.34	2.66	36.9
- with extra shelter	130	11.7	9.4	0.39	2.68	36.6
<i>Grass-clover pasture</i>						
- without extra shelter	183	11.0	9.2	0.36	2.70	37.6
- with extra shelter	156	10.5	8.9	0.32	2.79	39.1

<sup>1</sup> Average values for the period 25 to 80 days of age; calculated from Coobs (2005).

foraged sub-areas (P1, P2, P3) reflects the spatial use of the specific outdoor area.

The inherent characteristics of this method, which provides an average intake per plot and no individual data per bird, together with the absence of replicates, made statistical analysis impossible.

## Results

No health problems or predation losses were experienced. The overall mortality rate was 3.4%, with only about one quarter of it in the outdoor period. Mortality was already 2.6% in the indoor period, mainly due to dehydration in the first week and some cannibalism as a result of feather pecking behaviour in the two weeks thereafter. During the outdoor period the average intake per bird of concentrates and wheat was 62.2 g per day (range 41.8–84.9) and 52.9 g per day (range 34.2–66.4), respectively (data not shown). Thus, mean total intake of supplied feed was 115.1 g per day per bird (equal to about 100 g DM per day based on 0.9 g DM per g for both feedstuffs).

### Herbage intake

Table 3 presents the herbage available at the beginning of the experiment, the herbage intake and the body weight data. Less herbage was available in field A than in field B (116 vs. 169 g DM m<sup>-2</sup>). From these data, the herbage DM available per broiler per day was calculated as 36.7, 47.3, 66.5 and 56.6 g for plots A1, A2, B1 and B2, respectively. The N content of the herbage (% N in the DM) at the beginning of the experiment was 2.82, 3.30, 2.92 and 2.66% for plots A1, A2, B1 and B2, respectively. At the end of the experiment the N content was 3.55, 3.13, 3.37 and 3.09% in plots A1, A2, B1 and B2, respectively.

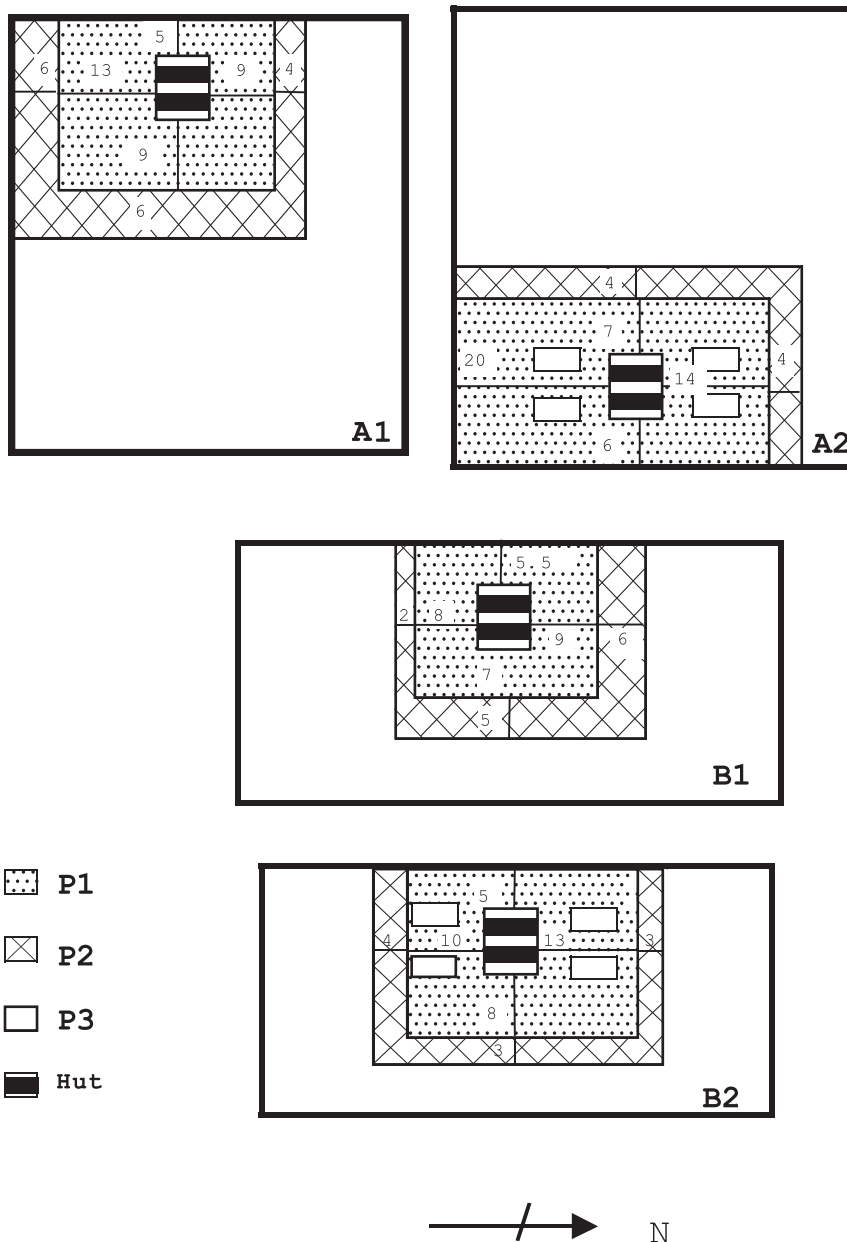


Figure 2. Layout of the four experimental plots. Plots A1 and A2: undersown clover in wheat stubble; plots B1 and B2: grass-clover pasture. Plots A1 and B1: without extra shelter; plots A2 and B2: with extra shelter. P1 = most intensively used area; P2 = moderately used area; P3 = least intensively used area. Thick lines around the plots represent fencing. Figures in hatched areas indicate distances in metres. For the position of the four plots at the farm see Figure 1.



Table 4. Use of outdoor area by organic broilers. Total plot size and areas most intensively used, moderately used and most frequently used for undersown clover in wheat stubble and permanent grass-clover pasture, with or without extra shelter.

Experimental treatment	Area (m <sup>2</sup> )			
	Total	Most intensively used (P <sub>1</sub> )	Moderately used (P <sub>2</sub> )	Most frequently used (P <sub>1</sub> + P <sub>2</sub> )
<i>Undersown clover</i>				
- without extra shelter	3006	687	475	1162
- with extra shelter	3206	934	274	1208
<i>Grass-clover pasture</i>				
- without extra shelter	2471	529	340	869
- with extra shelter	2217	686	273	959

Herbage intake did not appear to be affected by vegetation type or through the addition of extra shelter. The average intake per bird per day over the four plots was 10.7 g DM, 8.8 g OM and 0.35 g N.

### Use of outdoor areas

The linear distances from the hut of the different sub-areas used by the broilers are shown in Figure 2. The most intensively used sub-area (P<sub>1</sub>) was larger in the plots where extra shelter was provided (A<sub>2</sub> and B<sub>2</sub>), although the sum of the two most frequently foraged sub-areas (P<sub>1</sub> + P<sub>2</sub>) seemed to be little affected. When expressed in m<sup>2</sup>, the addition of extra shelter increased the size of P<sub>1</sub> by 26% for field A and 23% for field B (Table 4). However, the size of the moderately used sub-area, P<sub>2</sub>, tended to decrease when shelter was provided, especially in field A.

## Discussion

### Herbage intake

According to the best of our knowledge, this is the first attempt to estimate the amount of ingested herbage by free-ranging broilers in a grass-clover pasture or wheat stubble undersown with clover. Previously it has been estimated that a layer can consume up to 30–40 g DM per day from herbage, worms and insects, apart from the more than 100 g of additionally fed concentrates (Hughes & Dun, 1983a). The results of Bassler (1997) are in line with this, since he found that reducing the quantity of concentrates fed to layers by 15% had no detrimental effect on egg production, while individual herbage consumption was up to 30 g DM per day. However, if we consider that laying hens are adult animals whereas the birds in the current experiment were only 25 to

80 days old, the measured average herbage intake of 10.7 g DM per broiler per day, irrespective of vegetation type, seems to be reasonable. Following Mirabito & Lubac (2001) and Christensen *et al.* (2003), chickens tend to increase the use of the outdoor area with increasing familiarity, i.e., age, whereas Bassler (2005) suggests that broilers show less 'grazing' capabilities than layers, probably due to differences in age.

Given the estimated N intake from herbage and assuming that the energy provided is 5.38 kJ metabolizable energy (ME) per g herbage DM (Anon., 2004), the daily contribution of herbage to the requirements of the birds can be calculated. We estimated that broilers could obtain up to 0.39 g N per day (2.41 g of protein) and 62.9 kJ ME per day from the herbage. Assuming an average daily requirement per broiler throughout the experiment of 33.3 g of crude protein (CP) and 2268 kJ ME, broilers in this experiment were getting up to respectively 7% and 3% of their daily protein and energy requirements, and up to respectively 14% and 5% of the nitrogen and energy provided by the offered concentrates. Eyles (1963) estimated that fresh herbage could provide 5% of the daily DM intake of chickens and 10% of growing and laying poultry. Walker & Gordon (2003) suggest that even if the contribution of grass to the energy, fibre and protein demand were only 5%, it nevertheless is an important source since feed can account for about 70% of the variable costs of poultry production. Moreover, Fanatico (1998) stated that keeping broilers at pasture and thus allowing the birds to forage on plants, seeds, insects and worms, can reduce the costs of concentrates by 30%. Additionally, it must be noted that the possible intake of insects and worms, which was not quantified here, can provide even more protein and energy to the diet. Savory *et al.* (1978) found that half of the diet of domestic fowls reared in the wild consisted of invertebrates, and remained a major component in the diet for at least two months. Lomu *et al.* (2004) noted that free-ranging poultry that foraged paddocks caused a reduction in insect numbers in the paddocks. Nutritional values of worms and insects, relative to standard concentrates rations, are four times higher for digestible protein and somewhat similar for metabolizable energy (Bassler, 2005). The extent to which broilers' nutritional requirement can be covered by the outdoor range differs widely and mainly depends on time of the year, stocking rate, quality and utilization of the range and level of production (Bassler *et al.*, 2000). Also the diet composition should be taken into account. Nielsen *et al.* (2003) found that broilers that were offered a moderate-energy diet made less use of the outdoor area than broilers fed a low-energy diet. They indicated that this could be due to some shortage of nutrients or trace elements in the moderate-energy diet.

It cannot be excluded that the early daily enclosing of the broilers in this experiment (4–5 p.m.) might have been preventing them from eating more herbage. Studies by Dawkins *et al.* (2003) and Nielsen *et al.* (2003) have shown that broilers and laying hens increase their outdoor activity in the evening. On the other hand, we may have over-estimated herbage intake, since we assumed that the herbage we could not account for was consumed, although part of this herbage may have been destroyed and/or trampled into the soil due to the animals' long presence outside. Yet, a more precise estimate of the herbage intake by the broilers would have required the use of markers to determine the individual intake, a methodology that has been successfully applied to outdoor pregnant sows (Rivera-Ferre *et al.*, 2001). However, the use of this technique

with outdoor broilers still has technical difficulties that make it unfeasible, such as the individual daily collection of the excreta.

### Use of outdoor areas

Survival instinct prevents poultry from going far away from the shelter-providing housing. Hughes & Dun (1983b) showed that laying hens in outside pens were rarely seen in the more peripheral areas, although the vegetation near the hut was heavily degraded. Grigor & Hughes (1993) reported that fowls display less anti-depredatory vigilance in habitats with a vegetation cover, although cover had only a limited effect on the attractiveness of an outdoor area. Bubier & Bradshaw (1998) suggest that a combination of vegetation of shrubs and trees would increase the use of the outdoor area by laying hens. On the other hand, Zeltner & Hirt (2003) did not find an increase in the use of the outdoor run when adding new structures to the paddock, but did observe an effect on the animals' distribution, with more hens in the farthest areas. Mirabito & Lubac (2001) observed an increase in the number of broilers outside when tree cover was provided, and Dawkins *et al.* (2003) found that within their paddocks, chickens either stayed close to the house or sought tree cover. Our results support that some extra protection increases broilers confidence, allowing them to stay longer in further outdoor areas than if the plots were unsheltered. As a result, the addition of shelter contributes to a more uniform spread of the excreta over the plot. However, this effect is limited and in our case the excreta were spread to a maximum linear distance of only 20 m from the hut. The increase in size and distance of the heavily used sub-area (P1) in the sheltered plots was more or less compensated by a similar decrease in the size and distance of the medium used sub-area (P2). So the total frequently used sub-area (P1 + P2) remained unaltered. Similar behaviour has been observed with laying hens. Hegelund *et al.* (2005) reported that when artificial cover was present, there were more hens outside and that most of them stayed in what they called 'close' and 'medium' sections, but artificial cover did not affect the use of the 'remote' section. Bassler *et al.* (2000) pointed out that although the ranging distance from the house can be 200 m, the flock's major activity would be in a radius of 10 to 20 m. For this reason, it is expected that in static production systems, the nutrients in the huts and immediate surrounding areas are likely to accumulate and exceed the desired levels. This suggests that dynamic systems using mobile houses may be better tools to uniformly distribute the excreted nutrients over a larger area, resulting in a lower negative impact on the environment.

Finally, comparing the herbage consumption data with the use of the outdoor area by the animals, it can be concluded that the herbage intake was at the upper limit. Indeed, the increased exploration of distant areas in the sheltered plots was not reflected in higher herbage intake values or in the total body weight gains. This conclusion is also supported by the fact that herbage availability did not affect herbage intake.

### Conclusions

The results can have significant consequences for the development of organic broiler

production systems, as it is a first step towards actually measuring the additional herbage that broilers can consume in outdoor conditions. Furthermore, the results indicate that in static systems the use of extra shelter in the field is not enough to obtain a more uniform distribution of the broilers' excreta over the outdoor area. There appears to be a particular distance that young birds do not surpass with enough frequency so as to spread the manure droppings more uniformly, and that can hardly be extended by providing extra shelter.

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