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Substrate preferences in laying hens

Ingrid C. de Jong*, Maaike Fillerup, Kees van Reenen

Animal Sciences Group of Wageningen UR, Division of Animal Resources Development, Research Group Animal Welfare, PO Box 65, 8200 AB Lelystad, The Netherlands

We investigated the substrate preference of laying hens with respect to dustbathing and foraging behaviour, in order to determine which resources should be provided in laying hen housing systems for the expression of these behaviours. The consumer demand approach was used to study the strength of preference. Hens had to push a weighted door to enter choice pens with either a wire floor, sand, wood shavings or peat moss as substrate. Twelve Isa-Brown hens, reared on battery cages, successfully learned to open the push door. Most of the hens worked for getting access to all choice pens. The slopes of the demand curves for the number of entries to the choice pens were steep and not significantly different. Also no differences were found in the maximum price paid and the total expenditure. These data indicate that there seems to be no preference for wire or any substrate *per se*. However, with respect to dustbathing, almost all hens worked for getting access to peat moss to take a dustbath whereas only some hens worked for sand or wood shavings. The slope of the demand curve for dustbathing in peat moss was relatively shallow and the maximum price paid and the total expenditure to take a dustbath in peat moss were significantly higher as compared to dustbathing in sand or wood shavings. With respect to foraging no clear substrate preference was found. We conclude that the value of a particular substrate varies with the behaviour performed in the substrate and that there is a strong demand for peat moss for dustbathing.

KEY WORDS: consumer demand / dustbathing / foraging /laying hen, substrate / welfare

In enriched cage systems some substrate should be provided to allow foraging behaviour and potentially dustbathing behaviour, but full expression of these behav-

*Corresponding author: ingrid.dejong@wur.nl

iours is not possible [4]. It has been shown that dustbathing behaviour in enriched cages is often disturbed and vacuum dustbathing on wire is common, indicating that the supplied litter is inappropriate [e.g. 1]. Alternative systems provide more opportunities to perform dustbathing and foraging but full expression of these behaviours is also not observed here [4]. Thus, with respect to laying hen welfare it is important to know what resources are most appropriate for full expression of dustbathing and foraging behaviour. Moreover, it would be useful to know if there should be a requirement to provide additional resources over and above the pecking and scratching area in enriched cages, e.g. a dustbathing area [4].

Using preference tests, it has been shown that laying hens prefer sand or peat moss for dustbathing [12, 14]. However, when hens are asked to perform a task or to pay a price in order to obtain access to substrate, results do not clearly show that hens are willing to pay a price to enter a substrate or to pay a price to perform dustbathing in a particular substrate. It has been shown that hens more readily work to obtain food than to obtain access to a substrate [6, 8]. Using key-pecking as operant hens did not work to get access to a particular substrate [7, 9]. In contrast, Matthews [11] found that hens would peck a key to get access to a particular substrate and their results indicated that getting access to a substrate (to perform either dustbathing or foraging) is an important commodity. Also Widowski and Duncan [15] showed that hens were willing to work to enter a dustbath containing peat moss.

Thus, previous studies do not unequivocally demonstrate that the presence of substrate is important for laying hens. In addition, it is not clear which substrate should be provided to perform particular behaviours, *i.e.* if the same substrate can be provided for both dustbathing and foraging, or if laying hens have a preference for different substrates to perform these behaviours.

Consumer demand studies are becoming more popular to study the strength of environmental preferences [e.g. 2, 4, 10, 11]. Animals can make cost-benefit trade-offs between paying the cost and using resources or trade-offs between spending time using alternative resources [4]. Consumer demand studies thus seem to be useful to determine which substrates are preferred by laying hens and should be provided in laying hen housing systems. This method was therefore used in the present experiment. Hens could make cost-benefit trade-offs between paying a cost in the form of pushing a weight and spending time in one of four different choice pens equipped with either a wire floor or three different substrates. Foraging and dustbathing behaviour were observed to determine if substrate preference varies with the behaviour performed in the substrate.

Material and methods

Sixteen laying hens, reared in battery cages, were tested in four batches of four birds at 21, 24, 27 and 30 weeks of age, respectively. Birds were housed with four in a pen (1.5 × 1.0 m) with wire floor and four laying nests. Before the start of the experiment, they were familiarized with the different substrates and with individual housing

by housing them one week individually on each substrate. Sequence of substrates was randomized per hen. Water and feed were available *ad lib.* Lights were on from 02.00 to 18.00 h. All hens were in lay during testing.

The test arena (Fig. 1) consisted of a home pen with wire floor and four choice pens. From the home pen hens could reach one of the choice pens trough a one-way vertically swinging door ('push door') [e.g. 3]. The choice pens had either a wire floor or a 5 cm layer of peat moss, sand or wood shavings. Water and a nest box were available in the home pen, feed was available in the home pen and in all choice pens. Each hen started with the push doors open for 48 h to facilitate exploration of the choice pens. Thereafter doors were closed and the following weights were attached to the doors (via a pulley) for 48 h: 0, 50, 100, 150, 250, 500, 750, 1000 and 1250 g. Entrance doors to the choice compartments were weighted whereas exit doors were always unloaded. Because previous experiments showed that testing hens in isolation attenuated performance (*i.e.* learning the push door was more difficult), additional companion hens were housed in the rooms in such a way that at each corner of the test pen a test hen could have visual contact with companion hens. Companion hens were obtained from the same breeding group. Location of the different substrates in the test pen was changed after a complete test session of one hen was finished.

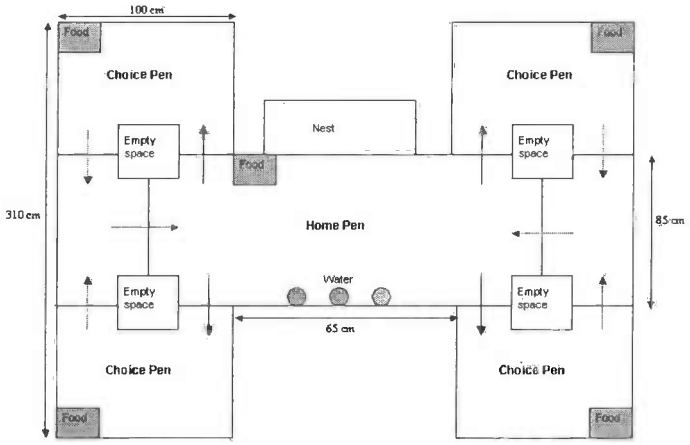

Fig. 1. Schematic drawing of the test arena. Arrows within the pens indicate push doors; a dotted arrow means that the doors are unloaded whereas a full arrow indicates that weights were attached to the doors.

Cameras were mounted above the test arena. The behaviour of the hens during the light period (02.00-18.00 h) on two subsequent days with each of the following weights was analysed: 150, 250, 500, 750, 1000 and 1250 g. The location of the hens during the light period was continuously recorded. Duration of dustbathing was scored in three selected periods: 2-4 h, 9-13 h and 16-18 h. Foraging behaviour was scored

using 0/1 sampling every 5 min during the same three observation periods. All calculations were performed for the total number of entries and the number of entries with dustbathing or foraging only. Analysis was performed on 12 hens because four hens failed to learn to operate the push door.

For maximum weight pushed (reservation price, [10]) and total expenditure for a compartment (*i.e.* number of times an animal enters a compartment and expresses a particular type of behaviour multiplied by weight pushed [10]) a mixed analysis of variance model was used. This model comprized fixed effects for compartments and random animal effects. Compartments were jointly compared with the Wald test and subsequently compared pairwise with Fisher's LSD method.

Additionally, separate regression analyses were performed per compartment per chicken for frequency of visits, visits with dustbathing and visits with foraging. Transformed counts $\log(c+1)$ were regressed on log transformed weights. The estimated slope per chicken was saved. This rough-and-ready measure for overall trend (price elasticity [e.g. 10] was subsequently analysed as a new response variable with a mixed analysis of variance model, comprising fixed effects for compartments and random animal effects. Hens not working for a particular choice pen were excluded from this analysis.

Finally, separate analyses were performed per weight applied, and compartments were compared with respect to the aforementioned response variables with a mixed analysis of variance model, comprising fixed effects for compartments and random animal effects. For frequencies and fractions, these models were instances of generalized linear mixed models (GLMMs) and analysed. All calculations were performed with the statistical software package GenStat.

Results and discussion

Almost all hens worked for getting access to all resources, *i.e.* 11 hens worked for peat moss and wire, and 10 hens for sand and wood shavings. The number of visits per choice pen decreased with increasing door weight. No differences were found in the number of visits to the choice pens per weight category. The slopes of the demand functions for the number of entries to the choice pens were steep and not significantly different (Tab. 1; mean slope -1.27). Also no difference was found in the maximum weight pushed to enter a choice pen (Tab. 2) and for the total expenditure per resource (Tab. 3).

With respect to dustbathing behaviour, nine hens worked for getting access to peat to take a dustbath whereas only three hens worked for wood shavings and two hens worked for sand to take a dustbath. We were not able to calculate demand functions for dustbathing in wood shavings or sand because insufficient entries were obtained. The slope of the demand curve for dustbathing in peat moss was relatively shallow (Tab. 1). The maximum weight the hens pushed to enter peat moss to take a dustbath was significantly higher as compared to sand or wood shavings (χ^2=7.66, P<0.05, Tab. 2). In addition, the total expenditure was significantly higher for peat moss as compared to sand and wood shavings (χ^2=9.83, P<0.01, Tab. 3).

Table 1. Means of the slopes of the demand functions for each resource. For each resource separate functions were calculated, *i.e.* for the total numbers of reinforcers obtained, for reinforcers involving dustbathing and for reinforcers involving foraging behaviour

Item	Total number of reinforcers	Dustbathing	Foraging
Peat moss	-0.95	-0.42	-0.69
Wood shavings	-1.53	*	-1.10
Sand	-1.35	*	-1.19
Wire	-1.27	**	**
Standard error of differences	0.28	0.02	0.33

*The slope could not be calculated because insufficient reinforcers were obtained for these resources.
**On wire, no dustbathing or foraging behaviour was observed.

Table 2. Maximum price paid (g) to enter a particular resource, or to enter a particular resource to perform dustbathing or foraging behaviour

Item	All entries	Dustbathing	Foraging
Peat moss	658	604[a]	637
Wood shavings	608	229[b]	583
Sand	638	104[b]	617
Wire	542	*	*
Standard error of differences	176	188	180

[a,b]Different letters within a column indicate significant differences ($P<0.05$).
*Behaviours not observed on wire.

Table 3. Total expenditure (kg) calculated for all entries to the resources, or for dustbathing only or foraging only

Item	All entries	Dustbathing	Foraging
Peat moss	26.89	3.88[a]	12.31
Wood shavings	28.53	0.86[b]	15.22
Sand	43.78	0.321[b]	29.39
Wire	11.70	*	*
Standard error of differences	14.07	1.22	9.65

[a,b]Different letters within a column indicate significant differences ($P<0.05$).
*Behaviours not observed on wire.

The frequency of dustbathing was significantly higher in peat moss as compared to sand and wood shavings at 150, 250, 500 and 750 g ($\chi^2=14.55$, $P=0.001$; $\chi^2=12.53$, $P<0.01$; $\chi^2=6.18$, $P<0.05$; $\chi^2=12.38$, $P=0.002$, respectively, Fig. 2). The consumption,

i.e. the time spent dustbathing as percentage of the total time spent in a particular resource, was significantly higher in peat moss as compared to sand and wood shavings at 150, 250 and 750 gr (χ^2=14.17, P=0.001; χ^2=13.84, P=0.001; χ^2=10.98, P<0.01, respectively).

Most of the hens worked for getting access to each substrate to perform foraging behaviour (*i.e.* 11 hens worked for peat and nine hens for sand and wood shavings),

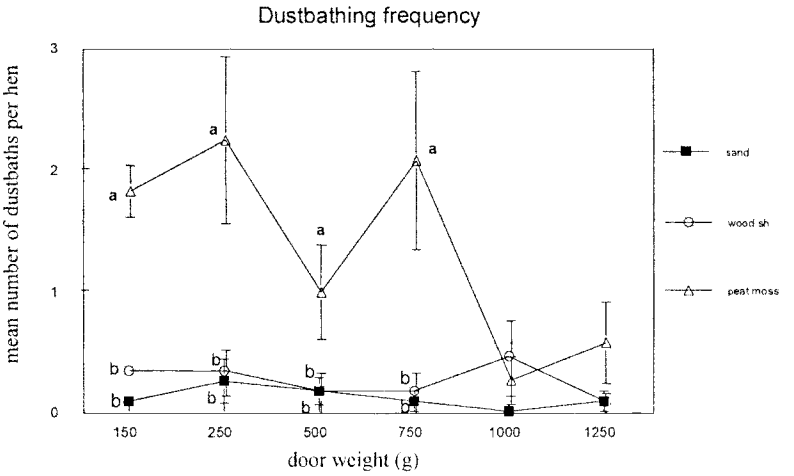

Fig. 2. Effect of door weight on the mean frequency of dustbathing per hen per day for each substrate. Different letters indicate significant differences per weight category (P<0.05 at least).

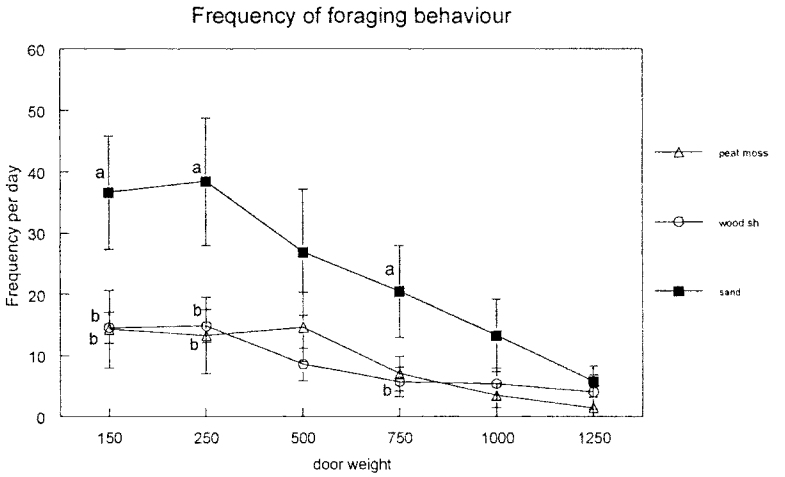

Fig. 3. Effect of doorweight on the frequency of foraging behaviour in the particular substrates. Different letters indicate significant differences between the substrates (P<0.05 at least).

but the frequency of foraging per weight category significantly differed between sand and the other substrates. For 150, 250 and 750 gr, foraging was significantly more frequently observed in sand as compared to the other substrate types (χ^2=6.00, P=0.05; χ^2=6.06, P<0.05; χ^2=5.11, P=0.08, respectively, Fig. 3). However, the slopes of the demand curves were steep and did not differ significantly (Tab.1; mean slope – 0.99). Also the maximum weight pushed to enter a substrate to forage (Tab. 2) and the total expenditure did not differ between the substrates (Tab. 3). The consumption of foraging in the different substrates was only significantly higher for sand as compared to wood shavings at 150 g (χ^2=5.91, P=0.05).

The results of the present experiment show that irrespective of the behaviour performed in a particular substrate or on wire, hens do not show a strong preference for a certain type of substrate or a preference for substrate over wire. However, the value of a particular substrate varies with the behaviour performed in the substrate. Hens have a strong demand for peat moss to take a dustbath. In contrast, with respect to foraging no clear substrate preference was found although in comparison with other substrates hens exhibited a higher consumption and a higher frequency of foraging behaviour in sand, particularly when the lowest two weights were applied.

It has been shown that the experience with a particular substrate or wire may affect the preference for a floor type [6]. In contrast to earlier studies, reporting that hens show a clear preference for substrate over wire floor [5], we did not find such a preference here. Although the hens were familiarized with all the substrate types before the start of the experiment we found that, irrespective of their behaviour, hens had a similar preference for wire as for wood shavings, peat moss and sand. This may have been caused by the rearing on wire. Another explanation may be that in the present study we did not control for the value of the operant task itself or that of occupying additional space or moving around *per se*, as had been suggested earlier [2]. We therefore can not exclude, especially at lower work rates, that hens entered the choice pens because they wanted to have more space, or wanted to explore their environment. This may explain why the elasticity of demand and reservation price were equal for the substrates and the wire floor. However, this does not play a role when we determine the elasticity of demand and maximum prices with respect to the behaviours performed in a particular substrate.

The relative inelasticity of demand for dustbathing in peat moss indicates, in comparison with other substrates, that hens have a strong preference for peat moss to perform this behaviour. This finding confirms earlier preference tests [13]. It has previously been suggested that the maximum price paid is a more robust measure of resource value than the slope of the demand curve [2, 4]. With respect to dustbathing in peat moss, the maximum price paid is in conformity with the inelasticity of demand. However, when comparing the maximum price paid for dustbathing in peat with that paid for foraging in either substrate, we found that maximum prices paid were similar. Thus, hens were not willing to work harder to take a dustbath than to forage (Tab. 2). This suggests that the performance of both behaviours are of equal importance for hens.

It has been recommended to use the demand for food as a yardstick for assessing the value of other resources because the demand for food is very inelastic [3]. It would indeed be useful to compare the demand for dustbathing in peat moss and foraging in either substrate with the demand for food in a future experiment, although it has already been shown that hens are more willing to pay a price for food than for entering a substrate [6, 8].

The results presented here lead to the conclusion that generally in terms of all entries, hens do not show a clear preference for substrate over wire. However, the value of a particular substrate varies with the behaviour performed. With respect to dustbathing, hens have a high demand for peat moss, whereas there is no clear substrate preference with respect to foraging behaviour. Laying hens were willing to work equally hard for dustbathing as for foraging. With respect to laying hen housing systems, our results imply that dustbathing requires a particular substrate (*i.e.* peat moss), and that the same substrate can be provided for foraging.

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