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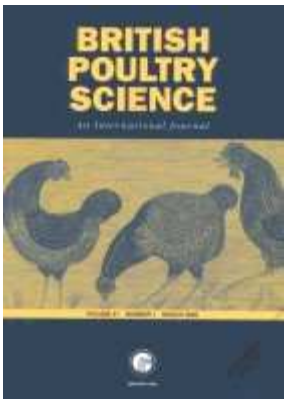

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Choice of nest types by hens of three lines of broiler breeders

A. HOLCMAN, Š. MALOVRH AND I. ŠTUHEC

Department of Animal Science, Biotechnical Faculty, University of Ljubljana, Slovenia

Running head: NEST CHOICES OF BREEDER HENS

Correspondence to Prof. Dr. Antonija Holcman, Department of Animal Science, Groblje 3, 1230 Domžale, Slovenia, Tel.: +386 1 7217 853; Fax: +386 1 7241 005; E-mail: Antonija.Holcman@bfro.uni-lj.si

Abstract 1. Choice of three different nest types by hens of broiler breeder lines was investigated: metal nests (width 26 x depth 29 x height 33-45 cm) with inclined rubber mats, metal nests of the same size with litter, and larger wooden nests (30 x 40 x 38) with litter. Three lines were studied: line B (324 females + 36 males), line P (315 + 36), and line WM (306 + 32). Each line was housed in a pen 23.3 x 3.9 m (90.7 m^2); half the area was concrete floor with litter, and the other half raised plastic slats, on which stood 84 nests, 28 of each type, in two-tier blocks.

2. Ninety five per cent of eggs were laid in nests, with significant variation between types: 63% metal littered, 30% wooden littered, and 2.3% metal with inclined rubber mats. Choice between types was similar in the three lines. Hens of line B laid 66% of nest eggs in lower nests, P laid 57% and WM laid 64%.

3. The other 5.1% of eggs were laid on the floor: 1.2% on the litter and 3.9% on the slats in front of the nests. It is suggested that some subordinate hens were excluded from nests, and therefore laid on the floor.

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INTRODUCTION

Broiler breeder lines of hens are kept to produce good hatching eggs, which require clean, unbroken eggs in clean nests: each dirty or broken egg is an economic loss. Sheppard *et al.* (2002) suggest that broiler breeder hens lay more floor eggs than commercial egg layers, and Perry *et al.* (1971) found approximately 30% floor eggs in a flock of broiler parent stock after 45 weeks of lay. The high incidence of floor eggs was not typical but could indicate the broiler breeder bird's specific preferences for a particular nest box. Factors contributing to increased floor eggs can be categorised as genetic or environmental or the interactions between these. Selection has caused differences among various strains. For example, the Ross 308 can be expected to lay 3 to 6% floor eggs, the 508 about 5 to 7% and the 708 between 1 and 2% (Cox, 2005). Hens of light and heavy lines differ in laying behaviour. For broiler breeders there are relatively few studies on nesting behaviour although the appropriate nests are important for heavy lines, because dirty or broken floor eggs in broiler breeders mean greater economic loss than in laying hens.

For the hen, the most desirable qualities for the nest site are safety (concealment, inaccessibility to predators, good separation from conspecifics), beneficial conditions for hatchability (dryness, protection from extremes of weather, cleanliness), minimum stress for the sitting hen (proximity to food and water, lack of disturbance) and beneficial conditions for the newly-hatched chicks, such as for instance ease for the chicks to follow the mother hen (Wood-Gush, 1983). For several of these reasons, an important factor in nest selection is litter (Huber *et al.,* 1985). Appleby *et al.* (1988) compared littered and unlittered wooden nests. Hens laid more than two thirds of eggs in littered nests. Freire *et al.* (1996) compared pre-laying behaviour of hens in the presence or absence of litter in

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the nest box. Hens with an unlittered nest box had longer duration of pre-laying behaviour, longer searching phase, and shorter sitting phase. They made an increased number of nest examinations during the searching and sitting phases, and made more entries of shorter duration per entry into the nest box.

It is also important to consider size and number of nests. A nest should be large enough to allow a hen to rotate within it (Kilgour and Dalton, 1984). The European Union (EU) Directive 1999/74/EC (EU, 1999) requires that in alternative housing systems there should be at least one nest for every 7 hens, while Damm (1993) recommends one nest for 4 to 5 hens and Leeson and Summers (2000) suggest one nest for 4 hens.

In our experiment hens of three different broiler breeder lines could choose between three types of nests: larger littered wooden or smaller littered metal nests, and smaller unlittered metal nests with inclined rubber mats. The aim of the study was to investigate the influence of the line, type of nest, position of the nest (lower or upper tier) and periods of experiment (three experimental periods of 12 d) on nest choice. For floor eggs we also investigated the location of laying (on litter or elevated slatted floor).

MATERIAL AND METHODS

Birds and housing

The study was carried out in three windowless pens of broiler breeder lines of Slovenian provenance Prelux. In the first pen was line B (a female line, with 324 hens + 36 cocks), in the second line P (another female line; 315 + 36), and in the third line WM (a male line; 306 +32). The main goal of these lines is production of

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hatching eggs. Pens were identical. Each pen was 23.3 x 3.9 m (90.7 m^2, giving 3.7 – 4.0 animals per m^2), with 51% of the area as raised plastic slats, 45 cm higher than the remaining concrete floor that was covered with dry wood shavings as litter. Circular drinking troughs (providing 1.6 – 2.0 cm per bird) and round automatic feeders (7.1 – 8.0 cm per animal) with a complete feed mixture were hung over the slats. Each day, 2 kg oats was scattered on the litter in each pen to stimulate searching behaviour and litter manipulation. Negative pressure ventilation and artificial lighting in two lighting periods per day (3L:3D:7L:11D commencing at 07.00 h) were provided. Such a lighting programme has no influence on egg production, but can reduce costs of electrical energy.

Nest boxes stood on the edge of the slats facing the slatted area. There were 84 in each pen, giving 3.6 to 3.9 per bird, with 28 of each of three types: metal nests (width 26 x depth 29 x height 33-45 cm) with inclined rubber mats, metal nests of the same size with wood shavings as litter, and larger wooden nests (30 x 40 x 38) with litter. Wooden nests (WN) were in blocks with 8 nests each, metallic nests with litter (ML) or with inclined rubber mats (MRM) in blocks with 14 nests each. These blocks were disposed alongside the pen in the sequence 8WN-14ML-14MRM-12WN-14MRM-14ML-8WN. All types of nests were in blocks with two tiers, arranged to give easy access to each type from any part of the pen.

The hens of all three lines reached sexual maturity at 24 weeks of age. Egg records started when the birds were 26 weeks old. Data were then collected in three 12 d observation periods separated by intervals of 12 d. Eggs were collected 5 times per d (07.00, 08.00, 09.00, 13.00 and 19.00 h), noting numbers in each nest type (including tier) and in each location for floor eggs (litter or slats). In the first collection period production rate was 40.8%, 29.6%, and 47.1%, in the second

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67.9%, 60.3%, and 63.8%, and in the third 68.1%, 63.6%, and 60.7% for lines B, P, and WM.

Statistical analyses

Data on choice of nest types by hens within a pen were not fully independent. However, partial independence was achieved by the use of multiple egg collections per day, limiting the extent to which birds were influenced by eggs laid earlier, and by the fact that the experimental unit used for statistics was not individual eggs or hens but "observations." The number of observations (n) for nest type and nest position was altogether 648 (Table 1). That is a product of 36 d x 3 lines x 3 nest types x 2 nest positions. The number of observations for floor egg position is a product of 36 d x 3 lines x 2 egg positions: n = 216.

Nest choices were assumed to be independent from day to day, because in large groups of birds interactions among animals cannot be accounted for. Because number of eggs as a trait belongs to count data, Poisson error structure was assumed for number of eggs laid in different types of nests and for distribution of floor eggs. The proportion of floor eggs was treated as a binomial trait. Data were analysed by the GENMOD procedure (Generalised Linear Models) in SAS/STAT statistical software (SAS software, version 8e, 2000), which allows distributions other than a normal one. The log-linear model for nest eggs (1) included collection period (C_i), line (L_j), nest type (T_k), and nest position (P_l) as fixed effects. Interactions between collection period and line (CL_{ij}), collection period and nest position (CP_{il}), line and nest type (LT_{jk}), and between line and position (LP_{jl}) were also included. The log-linear model for floor eggs (2) contained collection period (C_i), line (L_j), egg position (P_k), and interactions between collection period and line (CL_{ij}), collection

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period and nest position (CP_{ik}), and between line and egg position (LP_{jk}). The logistic regression model for proportion of floor eggs (3) contained collection period (C_i), line (L_j), and interaction between collection period and line (CL_{ij}). Because each line was housed in a separate pen, the effects of line and pen are confounded and cannot be separated.

$$y_{ijklm} = \mu + C_i + L_j + T_k + P_l + CL_{ij} + CP_{il} + LT_{jk} + LP_{jl} + e_{ijklm} \quad (1)$$

$$y_{ijkl} = \mu + C_i + L_j + P_k + CL_{ij} + CP_{ik} + LP_{jk} + e_{ijkl} \quad (2)$$

$$y_{ijk} = \mu + C_i + L_j + CL_{ij} + e_{ijk} \quad (3)$$

The appropriate link function for the Poisson distribution is log ($g(\mu) = log(\mu)$); the associate variance function is $V(\mu) = \mu$. The link function for binomial distribution is logit ($g(\mu) = log(\mu/(1-\mu))$); the associate variance function is $V(\mu) = \mu(1-\mu)$. Selection of the model was based on goodness-of-fit test, where difference in deviance and degrees of freedom were considered. Estimated differences in results are presented on a log scale because log linear or logistic regression models were used. Thus, comparisons are not additive but multiplicative.

RESULTS

Overall 95% of eggs were laid in nests: 63% in metal littered nests, 30% in wooden littered and 2.3 % in metal nests with rubber mat. Of the 5.1% floor eggs less than one quarter was laid on floor litter (1.2%) and the remainder on the slats in front of the nests (3.9%). General descriptive statistics of egg distribution are given in Table 1.

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All factors: collection period, nest type, line and nest position had significant effects on the distribution of nest eggs (Table 2). All interactions included were also significant. The effect of line was not significant in the model for floor egg distribution ($P = 0.93$), while other effects and interactions included were significant. As mentioned above, the effects of line and pen cannot be distinguished in practice and any possible pen effects may be appreciable. The collection period and interaction between collection period and line were significant for the proportion of floor eggs, while the line showed only a trend ($P = 0.095$).

Collection period

The difference between the first and the second collection period was -0.49 (Table 3), and as exp(-0.49) = 0.61 this means that hens in the first collection period laid 0.61 as many eggs as in the second period. Conversely they laid 1.64 times as many in the second, and 1.67 times as many in the third, as in the first period. The difference between the second and the third collection period was not significant ($P = 0.317$). Similarly, the difference between lines B and WM was not significant ($P = 0.386$). However, hens of line P laid 1.24 times more eggs than line B and 1.19 times more than WM.

Nest type

Hens of all lines preferred the metal littered nests more than the wooden littered nests and both more than the metal nests with rubber mats (Table 3). When results from the lines were combined, twice as many eggs were laid in metal littered nests as in wooden littered nests. There were more than 22 times as many eggs in metal littered nests, and more than 11 times as many in wooden littered nests, as in metal nests with rubber mats. Lower nests were used more than upper nests, with 1.66 times more eggs laid there.

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Lines

Differences between lines were relatively minor (Table 4). Hens of line B laid 0.78 times as many eggs in wooden littered nests as line P and 0.83 times as many as WM, but they laid more in metal littered nests than the other two lines (1.61 and 1.12 times respectively).

Hens of line P laid less in metal littered nests (0.70 times as many eggs) than line WM. In metal nests with rubber mats only two differences were significant. Hens of the line B laid only 0.42 times as many eggs in these nests as line P, while those of line P laid 2.26 times more eggs in them than line WM.

Nest position

Hens of all lines preferred lower nests (Table 5). Lines B, P and WM laid 1.92, 1.34 and 1.79 times more eggs in lower than in upper nests, respectively (they laid 66, 57 and 64% of nest eggs in lower nests, respectively). Slightly more eggs were laid in lower nests in the second collection period (1.81 times as many as in upper nests) than in first and third periods (1.60 times).

Floor eggs

The number of eggs laid on the floor decreased over time. Hens laid 0.68 as many eggs on the floor in the second and 0.41 as many in the third collection period as in the first one (Table 6). In the third collection period there were 0.60 as many floor eggs as in the second. In each line the differences between the first and the third collection period were greater than differences between the first and the second (Table 7). The only difference between periods within lines that was not statistically significant was that between the second and the third collection period in line WM.

Floor eggs were found on the slats 3.21 times more often than on the litter. In lines B, P and WM this difference was 5.21, 2.62 and 2.42 times more respectively

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(Table 8), while the ratio was higher in the second (4.08) and third (3.66) collection periods than in the first (2.21). As with the number of floor eggs, the proportion of floor eggs decreased over time (Table 9), being in the second period 0.46 times that in the first, and in the third 0.53 times that in the second. In the first collection period the proportion of floor eggs was similar in lines B and WM, while line P had a proportion 1.69 and 1.52 times greater than WM and B respectively. In the second period differences between lines were similar to those in the first. Differences between lines changed in the third collection period, when line P had a lower proportion of floor eggs than lines B and WM (0.67 and 0.65 times respectively).

DISCUSSION

For both hens and producers, the most appropriate place for laying is the nest, and the broiler breeders in our experiment laid 95% of eggs in nests. Of these, 98% were in littered nests, showing a preference for littered nests even greater than found for laying hens (Appleby *et al.,* 1988). The other distinct preference shown was for lower nests, which was found in all three collection periods. This trend has also been observed in laying hens: Appleby and McRae (1986) offered birds two tiers of nests and both light and medium hybrids generally preferred the lower tier.

The preference for litter was such that 93% of all eggs were found in littered nests. Amongst those littered nests, though, hens choose smaller metal nests nearly twice as often as larger wooden nests. This is rather difficult to explain, as the few recommendations that have been made on nest size tend to favour larger nests. Kilgour and Dalton (1984), for example, recommend nests large enough to enable birds to rotate within them. However, one possible explanation is offered by the

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estimation of Sherwin and Nicol (1993) that half of the laying hens they studied were gregarious and half solitary in their nesting behaviour. We can presume that in our broiler breeder lines more hens had solitary nesting behaviour. In a large nest it is more likely that the hen would get a companion than in a smaller one. According to Lewis *et al.* (2004), the broiler breeder hens have mean oviposition time 4:16 relative to start of the photoperiod, if it lasts 13 h. Only dominant hens had really a choice of nests, because there were not enough nests of each type for all hens. Perry *et al.* (1971) observed a defence of nest at dominant hens. We can assume that submissive hens had fewer possibilities of laying in desired nests; therefore they sometimes laid on the slatted floor in front of the nests.

In the nest, litter is always a very important material (Huber *et al.,* 1985; Appleby *et al.,* 1988; Freire *et al.,* 1996). Our findings support this statement. However, the majority of floor eggs in the experiment were laid on the slats and not on the litter. It seems likely that hens laid eggs on the slats in front of the nests while waiting for a preferred nest to be available. Strong motivation to reach the nest in the last 30 min prior to oviposition has been demonstrated by Cooper and Appleby (1996) and Freire *et al.* (1997). Freire *et al.* (1997) also observed more frequent movement in the hour prior to oviposition in subordinate hens. The larger number of floor eggs on the slats in front of the nests suggested that subordinate hens waited for a longer period of time prior to oviposition. Dominant hens could achieve entry to a preferred nest and then defend it as a territory – as shown by Perry *et al.* (1971) in broiler parent stock. If subordinate hens could not reach a nest, they laid on the slatted floor.

The suggestion from Perry *et al.* (1971) that dominance can contribute to the shortage of nests and cause floor egg laying, combined with the present results, raises

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an important issue. The EU Directive 1999/74/EC (EU, 1999) requires at least one nest for every 7 laying hens in alternative housing systems. We provided more than one nest for each 4 hens, but one third of the nests (metal nests with inclined rubber mats) were practically unused. Efforts to improve hen welfare should therefore take into consideration the type of nests that hens prefer.

Floor laying declined with time. One factor that may have contributed to this was the frequent collection of eggs (5 times per day). Leeson and Summers (2000) recommended picking up floor eggs as many as 6 or even 8 times each day at the start of egg production. The decrease in number of floor eggs was similar in lines B and WM, but strongest in line P. This led to a shift in the differences in the proportion of floor eggs between lines from the first and second collection period to the opposite trend in the third period.

In conclusion, a preference for littered nests by hens of broiler breeder lines was apparent. In addition, they preferred lower positioned nests. The number of eggs laid on the floor decreased over the course of the experiment. However, 1.2% of all eggs were laid on the litter floor and 3.9% on the slats. The number of floor eggs could be even lower, if subordinate hens could use preferred nests at the time of oviposition. Among our three lines there were minor differences in contrast with greater differences among various strains of Ross (Cox, 2005).

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TABLE 1. *Descriptive statistics for eggs laid in nests by nest type and nest position and for floor eggs by egg position.*

Item		n	Median	Minimum	Maximum
		Eggs laid in nests			
Nest type	WL	216	21.5	1	118
	ML	216	48.5	14	108
	MR	216	2.0	0	10
Nest position	Lower	324	34.0	0	118
	Upper	324	16.5	0	72
		Floor eggs			
Egg position	Slatted floor	108	6	0	15
	Littered floor	108	1	0	8

n – number of observations, WL – wooden littered nests, ML – metal littered nests, MR – metal nests with rubber mat

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TABLE 2. *Deviance, source of variability, and Wald statistics for distribution of eggs laid in nests and floor eggs, and proportion of floor eggs.*

	Eggs laid in nests		Floor eggs		% floor eggs	
Deviance	df	Value	Df	Value	df	Value
	628	1102.03	202	191.48	99	148.79
Effect	df	*P*	Df	*P*	df	*P*
Collection period (C)	2	<0.0001	2	<0.0001	2	<0.0001
Line (L)	2	<0.0001	2	0.935	2	0.0949
Nest type (T)	2	<0.0001	-	-	-	-
Position (P)[a]	1	<0.0001	1	<0.0001	-	-
C*L	4	<0.0001	4	0.0311	4	0.0020
C*P	2	0.0006	2	0.0004	-	-
L*T	4	<0.0001	-	-	-	-
L*P	2	<0.0001	2	<0.0001	-	-

[a] nest position for eggs laid in nests, egg position for floor eggs

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TABLE 3. *Estimated differences between subclasses with standard errors (SEE) for collection period, line, nest type, and nest position in eggs laid in nests.*

Effect	Difference	Estimate	SEE	*P*	Exp(estimate)
Collection period	1 – 2	-0.49	0.021	<0.0001	0.61
	1 – 3	-0.51	0.020	<0.0001	0.60
	2 – 3	-0.02	0.018	0.317	0.98
Line	B – WM	-0.04	0.044	0.386	0.96
	P – B	0.21	0.038	<0.0001	1.24
	P – WM	0.17	0.016	<0.0001	1.19
Nest type	WL – ML	-0.71	0.048	<0.0001	0.49
	WL – MR	2.41	0.047	<0.0001	11.11
	ML – MR	3.11	0.016	<0.0001	22.50
Nest position	L – U	0.51	0.052	<0.0001	1.66

WL – wooden littered nests, ML – metal littered nests, MR – metal nests with rubber mat
L – lower position, U – upper position

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TABLE 4. *Estimated differences with standard errors (SEE) between lines within types of nests in eggs laid in nests.*

Nest type/Difference	Estimate	SEE	*P*	Exp(estimate)
WL				
B – P	-0.25	0.033	<0.0001	0.78
B – WM	-0.19	0.034	<0.0001	0.83
P – WM	0.06	0.033	0.0608	1.06
ML				
B – P	0.48	0.025	<0.0001	1.61
B – WM	0.12	0.022	<0.0001	1.12
P – WM	-0.36	0.025	<0.0001	0.70
MR				
B – P	-0.86	1.106	<0.0001	0.42
B – WM	-0.04	0.027	0.741	0.96
P – WM	0.82	0.107	<0.0001	2.26

WL – wooden littered nests, ML – metal littered nests, MR – metal nests with rubber mat

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TABLE 5. *Estimated differences with standard errors (SEE) between nest positions (L – U) within line and within collection period in eggs laid in nests.*

Effect	Estimate	SEE	*P*	Exp(estimate)
Line				
B	0.65	0.026	<0.0001	1.92
P	0.30	0.028	<0.0001	1.34
WM	0.58	0.027	<0.0001	1.79
Collection period				
1	0.47	0.032	<0.0001	1.60
2	0.59	0.025	<0.0001	1.81
3	0.47	0.025	<0.0001	1.60

L – lower position, U – upper position

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TABLE 6. *Estimated differences between subclasses with standard errors (SEE) for collection period and egg position (S – L) in floor eggs.*

Effect	Difference	Estimate	SEE	*P*	Exp(estimate)
Collection p.	1 – 2	0.38	0.082	<0.0001	1.47
	1 – 3	0.90	0.098	<0.0001	2.45
	2 – 3	0.51	0.107	<0.0001	1.67
Egg position	S – L	1.17	0.079	<0.0001	3.21

S – slatted floor, L – littered floor

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TABLE 7. *Estimated differences with standard errors (SEE) between collection periods within line in floor eggs.*

Line/Difference	Estimate	SEE	*P*	Exp(estimate)
B				
1 – 2	0.34	0.130	0.0082	1.41
1 – 3	0.79	0.150	<0.0001	2.20
2 – 3	0.45	1.158	0.0049	1.56
P				
1 – 2	0.26	0.124	0.0320	1.30
1 – 3	1.17	0.164	<0.0001	3.21
2 – 3	0.90	0.170	<0.0001	2.47
WM				
1 – 2	0.54	0.138	<0.0001	1.72
1 – 3	0.74	0.148	<0.0001	2.09
2 – 3	0.20	0.163	0.226	1.22

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TABLE 8. *Estimated differences with standard errors (SEE) between eggs position (S – L) within line and within collection period in floor eggs.*

Effect	Estimate	SEE	*P*	Exp(estimate)
Line				
B	1.65	0.140	<0.0001	5.21
P	0.96	0.125	<0.0001	2.62
WM	0.88	0.126	<0.0001	2.42
Collection period				
1	0.79	0.102	<0.0001	2.21
2	1.41	0.133	<0.0001	4.08
3	1.30	0.168	<0.0001	3.66

S – slatted floor, L – littered floor

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TABLE 9. *Estimated differences with standard errors (SEE) between collection periods and between lines within collection periods for proportion of floor eggs.*

Difference	Estimate	SEE	*P*	Exp(estimate)
1 – 2	0.77	0.077	<0.0001	2.17
1 – 3	1.41	0.093	<0.0001	4.09
2 – 3	0.63	0.096	<0.0001	1.89
Collection period				
1				
B – P	-0.41	0.124	0.0010	0.66
B – WM	0.11	0.125	0.360	1.12
P – WM	0.52	0.127	<0.0001	1.69
2				
B – P	-0.22	0.130	0.0834	0.80
B – WM	0.28	0.144	0.0491	1.33
P – WM	0.51	0.145	0.0004	1.66
3				
B – P	0.40	0.196	0.0413	1.49
B – WM	-0.04	0.174	0.836	0.96
P – WM	-0.44	0.201	0.0301	0.65

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