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Disturbance of resting behaviour of broilers under different environmental conditions

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ABSTRACT

Resting behaviours make up a large part of the daily time budget of broilers. However, in intensive broiler production systems disruptions of resting behaviours occur, where resting individuals get disturbed by active individuals. Such interruptions of resting behaviour may negatively affect the welfare of the birds but also disturb important functions of sleep related for instance to restoration and growth. This study investigated if a lower stocking density or the provision of separate resting places in the form of elevated platforms would result in less disruption of resting patterns of fast-growing broilers. Three different treatments were used, one with an elevated platform, one with lowered stocking density and a control setting. A randomized block design was used, consisting of six blocks, giving six to eight replicates of each treatment. Depending on treatment, 422-497 broilers (Ross 308) were kept per pen. Data on duration of resting bouts, occurrence of disturbances and position in pen during resting were collected on days 20 and 34 of age. An overall effect of treatment x position was found on duration of resting bouts both during day ($P < 0.01$) and night ($P < 0.001$). When resting on platforms the duration of resting bouts during daytime was longer compared to when birds were resting in open areas in the control groups ($P = 0.04$). During night the duration of resting bouts on platforms was longer compared to duration of resting bouts at all other locations in all treatments. In addition, resting position also had an overall effect on proportion of disturbances during day ($P = 0.0018$) and night ($P = 0.0225$). Resting on platforms reduced the number of physical disturbances of resting chickens compared to open areas in the control group both during day (P adj < 0.001) and night (P adj $= 0.01$).

Generally, the level of disturbances was high in all treatments, suggesting that birds experience disrupted rest. As rest and sleep are vital needs, it is a welfare concern that chickens negatively affect other individuals' resting behaviour. A separate resting place appears to reduce disturbances to some extent and thus potentially increases the welfare of broiler chickens. However, provision of platforms is not enough to prevent frequent disturbances of resting and it is concluded that additional changes in housing conditions of broiler chickens are needed to improve their rest and sleep.

1. Introduction

Broiler production raises various welfare issues, e.g. health problems, impaired locomotion and behavioural restrictions (EFSA Panel on Animal Health and Welfare (AHAW), 2012). Often neglected behaviours in this context are rest and sleep. Rest may be defined as a prolonged period of inactivity that can clearly be distinguished from other maintenance behaviours (Blokhuis, 1984). Sleep is a specific state of rest with altered consciousness, reduced responsiveness to external stimuli and homeostatic regulation (Carskadon & Dement, 2005). The conservation of rest and sleep across all mammals and birds suggests that it serves a vital function. Suggested functions include: tissue restoration and growth, energy conservation, neurobehavioral and neurocognitive performance, memory processing and learning and increased waste clearance in the brain (Carskadon & Dement 2005; Siegel 2005; Assefa et al., 2015). These functions, and the notion that sleep deprivation leads to a strong need for sleeping (with associated feelings of distress in humans, likely also in animals) underline the importance of sufficient rest and sleep. Both the quantity, as in duration, and quality, as without disturbances, of rest and sleep are important. A certain duration of

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undisturbed sleep is needed to acquire both deep sleep and Rapid Eye Movement (REM) sleep, which together serve the vital function of sleep (Assefa et al., 2015). In addition to being a welfare problem, disturbance of sleep may also affect productivity in farm animals (e.g. less growth, increased sickness and possibly death) and thus profitability (Rial et al., 2007; Assefa et al., 2015).

Under natural conditions where a mother hen is present, chicks have regular rest periods throughout the day. The rest periods are induced through the periodic brooding of the hen (Shimmura et al., 2010). This behaviour results in a highly synchronised pattern of undisturbed resting behaviour (Roden & Wechsler, 1998). One of the most important factors affecting sleep and its quality in practical poultry husbandry is the duration and pattern of dark periods (Schwean-Lardner et al., 2012). This may be specifically relevant for young chicks since the light/dark schedules applied in practice differ substantially from the pattern induced by natural darkness as well as the brooding pattern of the mother hen. Modern broiler chickens are generally kept under continuous lighting with one dark period (1-6 hours). In the EU the maximum allowed light period is 18 hours a day (European Commission, 2007). For up to the first seven days of age and the last three days of life 24 hours of light a day is allowed (European Commission, 2007). These lighting conditions may result in loss of synchronisation of activity causing active and resting birds to share the same areas, leading to a high risk of birds physically disturbing resting conspecifics. A high stocking density may contribute to such disturbances as more birds share the same area. Indeed, under such circumstances frequent disturbances of resting behaviour are seen (Yngvesson et al., 2017), which, especially in young birds, may lead to sleep disturbance and sleep deprivation. Such disturbed sleeping patterns have been termed sleep fragmentation (Bonnet, 2005) and such disrupted rest has a negative effect on welfare in several ways and species (Malleau et al., 2007; Abou-Ismail et al., 2008; Opp & Krueger, 2015). In broilers, disrupted rest can negatively affect behavioural expressions (Schwean-Lardner et al., 2012) and cause welfare problems such as frustration (defined as an aversive state arising when animals are prevented from performing behaviour that they are strongly motivated to perform (Fraser, 2008)). Moreover, vital functions of sleep may be disturbed resulting in other (as yet unknown) welfare issues as in humans (Medic et al., 2017).

Apart from stocking density and lighting schedule, resting may also be affected by the structure of the housing. Chickens have previously shown to avoid open areas and instead gather along walls to rest when kept in a barren environment (Buijs et al., 2010). The provision of functional areas for active behaviours such as eating, drinking and dustbathing that are structurally separated from areas for resting may support undisturbed resting. A possibility to achieve this is the provision of elevated resting places where the risk of active birds disturbing resting birds is thought to be reduced. For example, Yngvesson et al. (2018) showed that broilers resting on perches were less physically disturbed by other individuals. Similarly, laying hens often rest on elevated structures such as perches as they have a natural motivation to rest above ground level (Olsson & Keeling, 2000; Olsson & Keeling, 2002). However, fast-growing broilers tend to not use perches due to their heavy weight (e.g. Yngvesson et al. (2018)), and would thus instead need something sturdier, like a platform.

In the present study, the aim was to investigate how resting behaviour and disturbances of fast-growing broilers were affected by providing platforms or by reducing the stocking density. We hypothesised that broilers kept in an environment with elevated platforms will get better rest qualitatively than broilers kept in a barren environment and that reducing the stocking density will reduce disturbances. We expected that the frequency of disturbances would increase with the bird's age as they take up more space.

2. Materials and Methods

2.1. Animals and Housing

This experiment was conducted at AU Foulum, Aarhus University, Denmark. In the building, two identical rooms (10.7 m x 16.6 m) were equipped with five pens (10 pens in total) of 3.1 m x 9.6 m (29.8m^2). The pens were separated by 60 cm high dark brown panels and the floor was covered with a four-centimetre layer of wood shavings.

Mixed-sex Ross 308 broilers were delivered as day-old from a commercial hatchery (DanHatch A/S, Sønderborg, DK) to the research facilities. At delivery, the chicks were randomly divided over the pens and raised under commercial-like management practices. Commercial conditions were simulated by keeping the stocking density at an expected 40 kg/m^2 at slaughter age. Water was provided *ad libitum* by nipple drinkers (11.7 broilers/nipple) and feed was provided in round feeders (1.61 cm feeder space per bird). Birds were fed a recommended commercial diet *ad libitum* (feed company DLG, Tjele, DK). At one day of age, the light schedule was programmed for 23L: 1D. Subsequently, the dark period was gradually increased to 6 h on day 6 of age (18L: 6D) and maintained until the end of the experiment (the light was on 04:30-22:30). The light intensity was 27 lux at animal level. A standard temperature programme was followed, starting at 34 °C on day 0 and gradually decreased to reach 20 °C at 28 days and to the end of the growing period.

All flocks were slaughtered at 35 days of age. Further description of the animals and housing can be found in Tahamtani et al. (2018).

2.2. Experimental design

Three treatments were used in the present investigation, i.e. treatment EP consisting of an elevated platform (L × W×H: 5.40 m × 0.60 m × 0.30 m, stocking density at 40 kg/m^2), treatment SD consisting of one type of manipulation of the environment (low stocking density at 34 kg/m^2) and control C (no platform, stocking density at 40 kg/m^2). In the treatment EP, two access ramps at an incline of 14.5 ° were provided to ease the access. Both platforms and access ramps consisted of perforated plastic slats. The area underneath the platforms and ramps was fenced off and not accessible to the birds.

Depending on treatment, a flock of 422-497 broilers was housed in each pen. The number of drinking nipples and feeding space per bird was controlled to account for differences in flock size per experimental group to preclude any confounding effects due to differences in competition for resources. The treatments were arranged in a randomized block design, consisting of six blocks, where the first started up in September 2016 and the last was completed in July 2017. The treatments were balanced between the two rooms, in order to account for any confounding effects of rooms. Each block consisted of one replicate of each treatment (also including treatments not used in this study and an additional treatment replicate). For further details see Tahamtani et al. (2018). In total, the study contained six replicates of treatment EP, six replicates of treatment SD and eight replicates of treatment C. A minor flooding during block 1 resulted in the exclusion of observations in a control group and a platform group.

2.3. Data collection

Four cameras (CCTV Camera, D1325) were placed above each pen, facing directly downwards, for an overview of the whole pen. Data were collected on days 20 and 34 of age from the video recordings using focal animal sampling. Each pen was observed two times per observation day (days 20 and 34), at night from 00:30-02:30 h and at noon from 11:30-13:30 h. On the videos, each part of the pen (covered by one camera) was divided into nine imaginary squares of equal size. Two to three individuals per part of the pen was followed during each observation period, giving a total of ten individuals per pen and observation period.

Focal animals were chosen as individuals starting to rest (defined as lying with a leg to the side or sitting with the legs under the body while not engaging in any other activities), chosen in a randomised square of the pen (randomisation through a given list of numbers between one and nine). The focal animals were followed during a complete resting bout where the length of each resting bout as well as the occurrence of disturbances (defined as physical disturbances by other individuals, causing the focal animal to change position or become active) were registered. In addition, it was registered whether the focal animal was 1) "on the platform", defined as being situated on the platform or ramp (only treatment EP), 2) close to a wall, defined as being within one bird length from a wall or 3) elsewhere in the pen.

2.4. Statistical analysis

Statistical analyses were performed using R (R version 3.6.1, R Core Team, 2019). All data were analysed separately for the period of the day (day/night). The effect of disturbances on duration of resting bouts and duration of activity between resting bouts were examined using a t-test. The data were analysed separately for the age (20/34 days of age). After a logarithmic transformation of the duration data, the data adhered to normal distribution and homogeneity of variances.

The effect of treatment, position in the pen and their interaction on the proportion of disturbances was examined using a Chi-squared test. A second Chi-squared test was used to test the change of proportion of disturbances between ages (20/34 days). The explanatory factors used in this model was the treatments, position in the pen and age, and the interactions between the explanatory factors were included.

An ANOVA test was used to compare the duration of resting bouts between the treatment groups. The explanatory factors used in this model was the treatments, position in the pen and age and the random factor used was the pen. The interactions between the explanatory factors were also included. A similar model was used in another ANOVA test to compare the duration of activity between resting bouts during the day between treatment groups. After a logarithmic transformation of the duration data, the data adhered to normal distribution and homogeneity of variances. Both in the Chi-squared test and ANOVA tests, *post hoc* comparisons of significant factors were performed using Pairwise Nominal Independence or Tukey's test (Tukey's HSD test).

2.5. Ethical statement

The experiment was carried out according to the guidelines of the Danish Animal Experiments Inspectorate with respect to animal experimentation and care of animals under study.

3. Results

3.1. Duration of resting bouts and activity between resting bouts on disturbances

At 20 days of age, the duration of resting bouts during the night decreased if the resting bout ended due to disturbance (Disturbance 279.68 ± 41.02 s; No disturbance 345.10 ± 40.12 s, df = 175.28, t = 2.831, p = 0.005), but no effect was found during the day (Disturbance 80.99 ± 8.78 s; No disturbance 112.53 ± 9.69 s, df = 171.27, t = 0.051, p = 0.96). At 34 days of age, the duration of resting bouts was not affected by whether the resting bouts were ended due to disturbance during the day (Disturbance 89.01 ± 8.47 s; No disturbance 112.87 ± 12.80 s, df = 136.27, t = 0.457, p = 0.65), but it tended to decrease if the birds were disturbed during the night (Disturbance 194.60 ± 21.86 s; No disturbance 225.24 ± 20.23 s, df = 177.99, t = 1.905, p = 0.058).

At both 20 and 34 days of age, the duration of activity between resting bouts during the day decreased if the preceding resting bout had been ended due to disturbance (20 days of age, Disturbance 12.26 ± 2.10 s; No disturbance 27.45 ± 6.21 s, df = 167.98, t = 2.014, p = 0.046; 34 days of age, Disturbance 12.97 ± 2.56 s; No disturbance 21.12 ± 3.52 s, df = 152.98, t = 2.664, p = 0.009) but no effect was found during the night (20 days of age, Disturbance 5.83 ± 0.69 s; No disturbance 7.29 ± 1.19 s, df = 172.92, t = 0.358, p = 0.72; 34 days of age Disturbance 5.02 ± 0.75 s; No disturbance 7.38 ± 0.97 s, df = 177.98, t = 0.813, p = 0.42).

3.2. Proportion of resting bouts disturbed

The percentage of broilers being physically disturbed during resting by other birds during the day and night, respectively, was ranging from about 30% to about 77%, depending on treatment and the position in the pen (Table 1). The proportion of disturbances was lower on platforms in treatment EP than in open areas in treatment C both during day (p adj < 0.001) and night (p adj = 0.010). During night, resting on platforms in treatment EP showed lower proportions of disturbances than resting near walls in treatment LD (p adj = 0.016). None of the other positions in the pen differed in any treatments.

Age affected the proportion of disturbances; in some positions in the pen it increased with age whereas in others it decreased (Table 2). Comparing the proportion of disturbances during the day between ages, there is a difference between age 20 and 34 (Table 2), where the increase with age in disturbances on platforms in treatment EP differ from the decrease with age in open areas in treatment EP (p adj = 0.03) and along walls in treatment LD (p adj = 0.03). Also, the increase with age in open areas in treatment LD differ from the decrease with age in open areas in treatment EP (p adj = 0.02) and along walls in treatment C (p adj = 0.04) and treatment LD (p adj = 0.02). Comparing the proportion of disturbances during the night between ages, there is a difference between age 20 and 34 (Table 2), where the decrease with age in disturbances in open areas in treatment EP differ from the increase with age on the platform in treatment EP (p = 0.002) and open areas in treatment C (p = 0.002) and treatment LD (p = 0.001).

3.3. Duration of resting bouts

During the day, there were differences in the duration of resting bouts between positions within and between treatments (Table 3). Specifically, the resting bouts were longer on platforms in the treatment EP than in open areas in treatment C (Tukey's test p = 0.04) and longer near walls in treatment LD than in open areas in treatment C (Tukey's test p < 0.001) (Table 3). No differences between the other treatments and resting positions were found during the day. There was no effect of age on the duration of resting bouts during the day (df = 1, F = 0.071, p = 0.789).

During the night, there were differences in the duration of resting bouts between positions within and between treatments (Table 3). Specifically, the resting bouts were longer on platforms in the treatment EP than in the other resting positions in all treatments. No differences were found between the other resting positions in any of the treatments. In the analysis of duration of resting bouts, none of the other interactions were significant. There was an effect of age on the duration of resting bouts during the night (df = 1, F = 5.472, p = 0.0199) where the resting bouts were on average longer for younger birds (20 vs. 34 days: 314.57 ± 28.74 s vs. 211.11 ± 14.85 s).

3.4. Duration of activity between resting bouts

No effect of treatment was found in the duration of activity between resting bouts during the day (Table 3), nor in any other factors or interactions of factors.

4. Discussion

This study as well as earlier research (e.g. Yngvesson et al., 2018)

Table 1
Proportion of resting bouts where the resting bird is disturbed by companions shown separately for day and night and divided into occurrences in different treatments and positions in the pen. The statistical values indicated are for the interactions 'treatment × position in the pens'.

	Treatment							Df	X-square	p-value
	Elevated platforms			Control		Low density				
	Platform	Open	Wall	Open	Wall	Open	Wall			
Proportion disturbed by other birds during day	0.40a	0.46ab	0.64ab	0.77b	0.58ab	0.54ab	0.56ab	6	21.0	0.0018
Proportion disturbed by other birds during night	0.30a	0.43ab	0.48ab	0.55b	0.52ab	0.32ab	0.56b	6	14.7	0.0225

Different letters within period of the day indicate significant differences

showed that resting in broiler chickens is regularly disturbed by active conspecifics resulting in a fragmentation of this behaviour. As described earlier, this may affect the quality of sleep and can cause sleep deprivation (Bonnet, 2005), which may deteriorate important functions of sleep related to for instance neurobehavioral and neurocognitive performance, memory processing and learning and increased waste clearance in the brain tissue. This in turn can negatively affect behavioural expressions and cause stress and welfare problems (Schwean-Lardner et al. 2012). Moreover, a disturbed quality of sleep may affect tissue restoration and growth and energy conservation with impact on production efficiency and thereby on profitability. To be able to draw conclusions on sleep quality, further physiological characterisation of rest and sleep under optimal conditions would be needed but observation of disturbances of resting behaviour like in the present study allows the identification of causal factors and remediate measures.

In the present study there were in general a lot of physical disturbances causing individual birds to end resting bouts. Disturbances were common in all treatments and situations. Thus, both during day and night, at least 30% of the observed birds resting on top of a platform were disturbed by other birds, while up to 77% in an open area in the control group were disturbed. Similarly, in a study by Yngvesson et al. (2018), 53% of the focal birds were disturbed during resting at day 45, during daytime, again suggesting that physical disturbances are common. Platforms were suggested to be a separate resting place where birds could go to rest, away from active birds. Platforms have been shown to be a better solution than perches to the heavy body weight of broilers (Norring et al., 2016) and broiler breeders (Gebhardt-Henrich et al., 2017, 2018). As platforms at least partially can be used to satisfy the perching motivation and as the number of disturbances was lower on the platforms, they seem to some extent to fulfil the intended purpose of a separate resting place.

In this study, the duration of resting bouts was also used to indicate the quality of rest. From other species it is known that a certain period of undisturbed sleep is necessary to reach specific sleep stages like Rapid Eye Movement (REM) sleep (e.g. rats, Trachsel et al., 1991; Frank & Heller 1997; humans, Carskadon & Dement 2005; zebra finches, Low et al., 2008). Poultry also shows REM-like sleeping patterns (Van Luijtelaar et al., 1987) and a longer period of undisturbed sleep is therefore likely to be important for chickens as well. We observed resting bouts of up to ten minutes, but most bouts only lasted a couple of minutes. The bouts ended when the bird became active, changed position or were disturbed by another individual. The duration of the resting bouts showed the longest duration in the EP treatment, specifically resting performed on a platform. However, the duration of resting bouts did not depend on whether they were ended by a disturbance or not, except during the night at 20 days of age. We had expected to find that disturbances cause shorter resting bouts but the reasons for our results are unclear. Further studies on duration of resting bouts combined with physiological measures of sleep quality are needed to determine the duration necessary to achieve a good quality of sleep.

In this study, a lower stocking density (34 kg/m^2) was applied to examine if available space as such would affect disturbances. The expectation was that with additional space birds can move about with less physical contact resulting in less disturbances. However, no effect on the number of disturbances was found although during daytime the resting bouts were longer near walls compared to the open area in the control treatment. Dawkins et al. (2004) showed that the disturbances increased with stocking densities where differences were found between a stocking density of 30 kg/m^2 and 42 kg/m^2 or higher. Also, earlier studies have shown an increase in disturbances with an increase in stocking density (Hall 2001; Cornetto et al., 2002; Ventura et al., 2012). Possibly, the difference in stocking density in this study was insufficient for an effect to be found.

If restricted space is a main factor in causing disturbances, one would also expect disturbances to increase with age as the birds take up more space. However, we did not find such an effect of age. The proportion of disturbances increased with age in some resting positions (e.g. on the platform in EP, in open areas in C and LD) within treatments but decreased in others (e.g. open areas in EP, near walls in C and LD). As the walls are a preferred resting place for broilers (Arnould et al., 2001; Buijs et al., 2010) but are a limited resource, the number of birds that fit near walls decrease with size and thus age. In our study, the first observations were made at 20 days of age and the birds might have reached such a high level of disturbances that it will not increase further with age. On the other hand, open areas are less preferred, probably due to lack of cover (Newberry & Shackleton, 1997), but with the increase in size of the birds they fill up more of the open space and therefore there is an increase in disturbances with age. The platforms seemed to be a preferred resting place due to the motivation to rest at an elevated area and with an increase in the size of the birds the competition for this space increases, which might explain why we see an increase in disturbances with age.

We also found an effect of age in the duration of resting bouts, specifically during the night, where younger birds had longer resting bouts than older birds. This has not yet been studied in broilers, but in general, younger individuals tend to have a need for more sleep than older individuals (e.g. domesticated species, Arnold 1985; Nicolau et al., 2000; rats, Mendelson & Bergmann 1999; humans, Feinberg 1974; Kurth et al., 2010).

To get an impression of the motivation to rest, and thereby of the impact of disturbances, the duration of activity between two resting bouts was observed. It was expected that when a resting bout was followed by a short phase of activity, the bird had high motivation to continue resting. In human infants the resting cycles seem to be mostly regulated by hunger and disrupted rest often results in a continuation of resting (Goodlin-Jones et al., 2000). In the current study, the average time the birds spent active was a few seconds, in all treatments. However, during the day the activity following a resting bout was shorter if the bird was disturbed. This might show a motivation to continue resting and that the resting is indeed disrupted. We could not find this link between disturbances and activity during night which might depend on the general low level of activity of broilers in darkness (Norring et al., 2016).

A main reason for the high frequency of disturbances in all treatments is likely the lack of behavioural synchronisation. When resting, chickens seek each other's company and since they are not synchronised birds are continuously entering and leaving resting groups and areas, disturbing birds still resting. During dark periods chicks tend to rest

Table 2
Proportion of resting bouts where the resting bird is disturbed by companions shown separately for age 20 and age 34 and divided into occurrences in different treatments and positions in the pen. The statistical values indicated are for the interactions 'treatment × position in the pens × age'.

	Treatment												df	X-square	p-value
	Elevated platforms						Control				Low density						
	Platform		Open		Wall		Open		Wall		Open		Wall				
	Age 20	Age 34	Age 20	Age 34	Age 20	Age 34	Age 20	Age 34	Age 20	Age 34	Age 20	Age 34	Age 20	Age 34			
Day	0.29	0.50	0.50	0.42	0.57	0.71	0.75	0.79	0.60	0.56	0.40	0.68	0.60	0.52	6	13.1	0.041
Change during day		+0.21ae		−0.08bcd		+0.14ace		+0.04ade		−0.04ac		+0.28e		−0.08bd			
Night	0.23	0.36	0.60	0.23	0.54	0.42	0.50	0.60	0.55	0.49	0.24	0.40	0.60	0.52	6	25.8	<0.001
Change during night		+0.13a		−0.37b		−0.12ab		+0.10a		−0.06ab		+0.16a		−0.08ab			

Different letters within the change during period of the day indicate significant differences

Table 3
Duration (s) of resting bouts during day and night, respectively, and duration of activity between resting bouts during the day (mean ± SE). The statistical values listed are for the interaction treatment x positions in pen.

	Treatment							df	F	p-value
	Elevated platforms			Control		Low density				
	Platform	Open	Wall	Open	Wall	Open	Wall			
Resting bout during day	116.13 ± 17.30a	66.29 ± 11.15ab	99.29 ± 17.30ab	60.85 ± 5.95b	107.63 ± 10.83ab	98.10 ± 11.15ab	127.88 ± 15.88a	4	4.144	<0.01
Resting bout during night	500.64 ± 66.96a	207.04 ± 44.24b	240.36 ± 63.58b	247.90 ± 34.91b	167.77 ± 23.54b	261.58 ± 38.84b	257.48 ± 32.43b	4	7.443	<0.001
Activity between resting bouts during day	11.07 ± 1.92a	18.54 ± 6.25a	15.34 ± 4.44a	12.38 ± 2.25a	11.03 ± 1.93a	13.99 ± 3.15a	10.11 ± 1.47a	4	0.959	0.429

Different letters within parameter indicate significant differences together as a group (Malleau et al., 2007). Also, commercial rearing of chicks does not include broody hens. Without a broody hen, layer chicks are less synchronised in activity (Riber et al., 2007). Improved synchronisation of behavioural patterns may further reduce disturbances, possibly in combination with platforms and lower stocking densities.

4.1. Conclusion

The results of this study showed that broiler chickens experience difficulties in achieving undisturbed rest. The introduction of elevated platforms provided an opportunity for somewhat better rest, if the rest took place on a platform. Lowering the stocking density to 34 kg/m^2 did not affect the frequency of disturbances, but it did increase the duration of resting bouts during daytime. Disrupted rest was common in all situations suggesting that more measures than adding an elevated platform or a reduction in density from 40 to 34 kg/m^2 are needed to further reduce disturbances and thus increase welfare of the birds. Increased synchronisation of behavioural patterns could possibly be such a measure that further reduces disturbance, but more research is needed to determine how to induce it in broiler flocks and to evaluate its potential effects on quality of sleep.

Declarations of interest: none.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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