Short Communication

An automated nest box system for individual performance testing and parentage control in laying hens maintained in groups

Ein automatisches Nestsystem zur individuellen Lege- und Abstammungskontrolle bei Legehennen in Gruppenhaltung

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Introduction

Individual performance testing and parentage control have always been essential elements in animal breeding, scientific research and in-situ conservation of animal genetic resources. Currently single cages are widely used for commercial poultry breeding which facilitates the recording of individual data. However, changing consumer preferences and new animal welfare regulations are having a strong impact on the conditions of poultry production. It can be anticipated that in Europe conventional cage systems for commercial egg production will be replaced by alternative housing systems in which chickens are allowed to move freely in groups. These housing systems may considerably improve the welfare of the birds (Blokhuis, 1994). Without nest boxes that permit individual data recording and the assignment of eggs to individual hens no efficient breeding can be set up. Such a nest box system has to satisfy three basic requirements: (i) isolating the hen during laying, (ii) identifying the hen in the nest box, and (iii) recording the order in which eggs are laid, and thus, recording of the parentage of the chick.

The major objective of the present study was to evaluate the prototype of a newly developed nest box system, which we refer to as the automated identification nest system "Auto-Nest" designed for automated hen identification and parental attribution to individual eggs in group holding systems for laying hens.

Material and Methods

Components of the "Auto-Nest"

The Experimental Nest Box

The nest box prototype was similar to commercially available chicken nests (Europa Nest, BRUJA GmbH, Hammelburg, Germany). The floor space of the nest box was 900 square cm (30 cm x 30 cm) and the height was 50 cm. The nest box prototype was constructed with an aluminium frame using a construction set (PVS Kanya, Zarian GmbH, Marktredwitz, Germany), and the walls and the bottom were made of plastic panels. An aperture in the floor of the nest box enabled the laid eggs to roll down into an egg collection device. The floor was carpeted with Astroturf.

The entrance

For the correct assignment of an egg to a hen, it is critical that only one hen is able to enter the nest at a time. To achieve this, a special entrance has been designed. This entrance consists of two flaps arranged at an angle of 100° to each other. The one blade, the entry flap, rests on the inner edge of the entrance sill when the nest box is empty (Fig. 1A). In entering the nest box, the hen pushes the entry flap forward and upward to the roof of the nest box. Since the second blade, the blocking flap, is fastened at a fixed angle to the entry flap, it comes down behind the hen until it rests on the outer edge of the entrance sill, causing the entrance to be closed (Fig. 1B). As long as the hen remains in the nest box the entrance is blocked and no other hen can enter. To leave the nest box, the hen is able to reverse the process by pushing outward on the blocking flap causing it to swing upwards and setting the entry flap at its initial position ready to be used by the next bird. A counterbalance (CB in Fig. 1) insures that the entrance is either completely open or completely closed.

Transponder system

Several transponder systems for identification of a single hen have been recently described (Rauch, 1997; Müller et al., 2001). Similar to these, a transponder system based on the Reader IDC 20-2 RS232 (MOBA Mobile Automation GmbH, Dresden, Germany) was adapted to the needs of the present project. Each hen carried a TIRIS-WEDGE transponder (Texas Instruments, Freising, Germany) fastened to its right wing. A receiver antenna was mounted inside each nest box. In the present experiment, two antennas were interrogated by one reader which logged data to a computer file. The transponder ID (hen identification number), the duration of nest occupation, and the nest identification were registered.
The egg collection device

Once laid, the egg rolls down the inclined floor of the nest box toward a central aperture through which it drops onto a metal collection track. The track holds the eggs in the order in which they arrive. While rolling down the track, the egg passes through a photoelectric detector (Fig. 1) which, in the present study, activated a light at the front of the nest.

Other components of this study

Animals, housing and data recording period

At 18 weeks of age, a group of chickens consisting of one New Hampshire cock and 10 hens was housed in a floor pen and allowed access to feed and water ad libitum. The hen group was composed of four White Leghorn and six New Hampshire females originating from experimental lines maintained at the Institute in Mariensee. The floor space of the pen was 12 square meters which included a feeding area, a scratch area, perches and four “Auto-Nest” boxes. The hens had free access to the nest boxes. Individual laying data for each hen were recorded on 38 days within a time period of six weeks beginning at 30 weeks of age. During this initial trial, only six of the 10 hens regularly used the nests as discussed later.

Video surveillance

A video camera monitoring the front of the “Auto-Nest” box recorded the behaviour of hens outside the nest, the amount of time that each hen spent in the nest and the time when the egg was collected as indicated by the light signal on the front of the cage. The video system was used as a tool in this experiment to evaluate the prototype of this new nest box system, and data will be directly logged to the computer in the future.

DNA Fingerprinting

Eggs were individually attributed to each hen using the transponder data (hen identification number) and their sequence in the collection tray. In this study, the accuracy of the attribution was evaluated by DNA fingerprinting using microsatellites. This check allowed us to verify the functionality of the newly developed “Auto-Nest” using a completely independent system for the analysis. For this purpose, DNA was isolated from blood samples of the parents, and from 5-day incubated eggs. DNA isolation and marker typing were done as described recently (Kleinveld and Ellendorff, 2000; Romanov and Weigend, 2001). Ten highly polymorphic microsatellite markers were selected for DNA typing. Six of these were informative, i.e. displayed unique alleles or allele combinations which allowed us to associate eggs with hens with absolute accuracy (Table 1). For example, hen 3 carried allele 196 at locus MCW0104 which did not appear in any other hen. Hence, hen 3 laid all eggs carrying this specific allele.

Results and Discussion

In the present study, a total of 150 eggs were laid by six hens in the four prototype boxes of the “Auto-Nest” in
38 days of observation. For six eggs (4% of 150) no corresponding transponder signal for a hen was recorded. This was presumed to be due to lack of response from the transponder in the time in which a hen was in the nest box, indicating that further improvement of that system is required. For all remaining 144 eggs it was possible to assign them individually to one of the six hens based on the transponder signals and by applying a correction rule which takes into account the specific laying behaviour of chickens (Table 2).

It was necessary to apply a correction rule based on known pre-laying behaviour of hens as described by Gerken (1989) since in a preliminary test it was found that in a few cases eggs laid in the nest box did not roll down into the egg collection device immediately after laying. This phenomenon would cause a problem for the assignment of these eggs to the correct hen. In particular, in defining the correction rule we considered that hens never lay eggs without taking some time to investigate the nest box. The duration of nest use and the time when the egg passed the light detector in the egg collection device were studied in video records. An egg detected more than five minutes after a hen entered the nest was assigned to that hen while an egg registered within the first five minutes of entering was attributed to the hen which previously used that nest box. The remaining six hens which started to lay after removal of the litter laid all their eggs in the nest box without exception. This could be verified by the analysis of the timing of egg laying for these six hens which reflected a normal pattern of laying behaviour.

The 144 eggs identified were incubated for five days which revealed that only 102 were fertilised. Much of this fertilisation failure could be attributed to hen 4 from which all 25 eggs were unfertilised. It is obvious that DNA could only be isolated from the 102 fertilised eggs and that only these eggs could be used to test the accuracy of paternal assignment by molecular marker analysis. In 100 out of 102 cases (98%) the hen number assigned to the egg as recorded by the electronic system agreed with the DNA fingerprint data. It appeared that the two mislabelled eggs were exchanged during the egg collection process. DNA fingerprinting revealed that the hen assigned to the first egg in reality produced the second egg and the hen assigned to the second egg actually laid the first one. These two eggs were laid on the same day but in different nest boxes and the only way they could have been switched is human error. The detection of this difference also reflects the value of DNA fingerprinting as a tool to verify the correctness of individual assignment of eggs to one of the six hens in this experiment.

Only six of the ten hens maintained in the floor pen with access to the new nest box system used the nest boxes for laying in this study. The four hens which nested on the floor litter instead of using the nest box began to lay during a pre-trial phase, when deep litter was used on the floor of the pen. Apparently, the deep litter on the floor did not motivate the hen to go to a nest box for laying. Although most of the litter was subsequently removed from the floor, this group of four hens never learned to use the nest box. The remaining six hens which started to lay after removal of the litter laid all their eggs in the nest box without exception. This could be verified by the analysis of the timing of egg laying for these six hens which reflected a normal pattern of laying behaviour.

Obviously each hen preferred one specific nest box (Table 2) but if that nest box was already occupied, an alternative nest box was chosen. It appeared that whichever nest box was used the first time became the preferred box for all subsequent laying. This phenomenon requires further investigation in future experiments.

In conclusion, six hens laid all of their eggs in the experimental nest boxes on the 38 days analysed and all their eggs except for two were correctly identified demonstrating the principle functionality of the “Auto-Nest” pro-

Table 2. Distribution of eggs laid by six hens using four nest boxes; fertilisation and accuracy of the assignment of eggs to individual hens

<table>
<thead>
<tr>
<th>ID</th>
<th>Nest 1</th>
<th>Nest 2</th>
<th>Nest 3</th>
<th>Nest 4</th>
<th>Total number of eggs</th>
<th>Fertilized eggs</th>
<th>Correctly assigned eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>hen 1</td>
<td>9</td>
<td>19</td>
<td>1</td>
<td>0</td>
<td>29</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>hen 2</td>
<td>24</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>29</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td>hen 4</td>
<td>23</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>hen 5</td>
<td>2</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>hen 6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>15</td>
<td>16</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
<td>43</td>
<td>28</td>
<td>15</td>
<td>144</td>
<td>102</td>
<td>100</td>
</tr>
</tbody>
</table>

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* underlined numbers indicate informative alleles or allele combinations to distinguish any egg of a hen from all others
** na - not analysed

Table 1. Parental microsatellite alleles which were used to verify the assignment of eggs to individual hens

<table>
<thead>
<tr>
<th>Animal ID</th>
<th>Microsatellite Loci</th>
</tr>
</thead>
<tbody>
<tr>
<td>cock</td>
<td>MCW0104 ADL0268 MCW0004 MCW0123 MCW0295 MCW0216</td>
</tr>
<tr>
<td>hen 1</td>
<td>214/190 112/112 216/180 88/88 102/90 145</td>
</tr>
<tr>
<td>hen 2</td>
<td>210/206 112/112 216/180/180 82/82 98/98 143</td>
</tr>
<tr>
<td>hen 3</td>
<td>196/90 112/112 216/180 88/88 102/90 141</td>
</tr>
<tr>
<td>hen 4</td>
<td>206/190 112/110 216/180 82/82 198/92 141</td>
</tr>
<tr>
<td>hen 5</td>
<td>210/206 112/112 216/180 82/82 98/92 141</td>
</tr>
<tr>
<td>hen 6</td>
<td>214/190 114/114 216/180 88/88 90/90 141</td>
</tr>
</tbody>
</table>
totype. DNA fingerprint analysis and video observation confirmed the high accuracy of the “Auto-Nest” for isolation and identification of individuals during laying and the reliable attribution of an egg to the hen that laid it under group holding conditions. The observations that not all hens used the nest boxes and that not all eggs were fertilised were due to causes unrelated to the design of the “Auto-Nest”. The “Auto-Nest” prototype provides a promising basis for the further development of a completely automated system for the assessment of parentage and performance of chickens maintained in groups. To be used on a large scale in the future, video recording which was used as a tool to evaluate the functionality of the newly developed nest box system in this study, will be replaced by computerised control and recording devices.

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Summary

The functionality of a new nest box system developed at the Institute for Animal Science and Animal Behaviour Mariensee for performance testing and parentage control of laying hens in floor pens was evaluated. The system, which we refer to as the automated identification nest system “Auto-Nest”, is based on a chicken nest box similar to commercially available ones; a special entrance door consisting of two flaps to isolate hens during laying; an automated identification and recording system; and an egg collection device to maintain the order in which eggs are laid. It was shown that in a sample of 102 fertilised eggs laid in the “Auto-Nest”, 98% percent were correctly assigned to the hen.

Key words

Laying hens, floor pens, nest box, automated identification

Zusammenfassung

Ein automatisches Nestsystem zur individuellen Lege- und Abstammungskontrolle bei Legehennen in Gruppenhaltung

In vorliegender Untersuchung wurde die Funktionsfähigkeit eines Legenestes für die Leistungs- und Abstammungskontrolle bei Legehennen in Bodenhaltung experimentell geprüft, welches am Institut für Tierzucht und Tierverhalten Mariensee entwickelt wurde. Das Legenest mit automatischer Tieridentifikation (“Auto-Nest”) wurde in Anlehnung an kommerziell verfügbare Legenester konstruiert. Es ist mit einer speziellen Schwingtür als Eingang und einem automatischen Identifikations- und Aufzeichnungssystem ausgestattet. Eine Einsammelvorrichtung sicherte die Erfassung der Reihenfolge der gelegten Eier. In dem Experiment konnte gezeigt werden, dass 98% der 102 befriedeten Eier, die in das Auto-Nest gelegt wurden, korrekt der Henne zuzuordnen waren.

Stichworte

Legehennen, Bodenhaltung, Legenest, automatische Tiererkennung

References


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