Production losses in laying hens during infestation with the poultry red mite

Dermanyssus gallinae

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\begin{abstract}
A research centre with 30,568 laying hens, kept in enriched cages and in aviaries, had become naturally infested with poultry red mites (PRM) in 32 of its 48 bird units. Therefore, at the age of 52 weeks all hens were treated with fluralaner through the drinking water. After this treatment, PRM were no longer observed. As all birds were of the same age, and since production figures were measured daily in all 48 units, this offered a unique opportunity to examine how PRM had affected performance. Statistical analyses were done to compare the evolution of production data from the pre-treatment to the post-treatment period in units that were visually free of PRM or infested with PRM to different levels. Production standards provided by the breeding organizations were used as a reference. The results demonstrated significant posttreatment increases of laying percentage, egg weight, egg mass, percentage first choice eggs, feed intake and body weight in heavily infested hens of one or both housing systems, as compared to the non-infested controls. These data confirm that PRM infestations can impact the main performance traits related to profitability of laying hen farms as well as the hens’ general condition.
\end{abstract}

\section{Introduction}

Dermanyssus gallinae (de Geer, 1778), often called the poultry red mite (PRM), is highly prevalent in most parts of the world, especially in farms of laying hens (Sparagano \textit{et al.}, 2009; Sigognault-Flochlay \textit{et al.}, 2017). In uncontrolled conditions PRM populations can grow to very high numbers, commonly reaching up to 50,000 parasites per bird (Sparagano \textit{et al.}, 2014).

Especially at night, adult PRM and nymph stages bite hens to suck blood (Sparagano \textit{et al.}, 2014; Tomley & Sparagano, 2018), thereby irritating the chickens and preventing them from sleeping well (Kilpinen \textit{et al.}, 2005). Infested hens may become agitated and develop feather pecking or even cannibalism (Sparagano \textit{et al.}, 2014; Sigognault-Flochlay \textit{et al.}, 2017; Tomley & Sparagano, 2018). Due to the blood loss, long-term infestations can lead to anaemia and weakening of the birds, which in turn can make them more susceptible to infections and associated mortality. Furthermore, it has been demonstrated that PRM may act as vectors for specific chicken pathogens and thereby spread disease within and between flocks (Valiente \textit{et al.}, 2009; George \textit{et al.}, 2015; Sommer \textit{et al.}, 2016; Sigognault-Flochlay \textit{et al.}, 2017). PRM thus also compromise chicken health.

Poultry farmers worldwide invest heavily in trying to prevent or control PRM infestations in laying hens (Sparagano \textit{et al.}, 2009). PRM therefore have a significant economic impact for the layer industry. However, performance losses that result from PRM infestations might be even more important (van Emous \textit{et al.}, 2005). Some losses, like the downgrading of eggs with blood spots resulting from squashed PRM on the shells, can objectively be associated with the infestation. Other performance declines, such as lower egg production and increased feed conversion, have been ascribed to PRM as well (van Emous \textit{et al.}, 2005) but this was often based on theoretical assumptions and on field observations that may have been difficult to substantiate. To the best of our knowledge, the impact of PRM on the performance of laying hens has not been examined under well-controlled conditions.

The present studies aimed to identify performance traits that can be affected by PRM infestations through an observational study in a poultry research centre that had become naturally infested and where hens were kept in well-controlled conditions, closely resembling a field situation.

\section{Materials and methods}

\subsection{Study design}

The present study was performed in a poultry research centre that had become naturally infested with PRM. The set-up was purely observational, without applying any experimental procedures.
At the age of 17 weeks, 30,568 laying hens had been transferred simultaneously from two different conventional rearing farms to the research centre. Twenty-four thousand four hundred and twenty-four Isa Brown hens were derived from the first rearing farm and 6144 Dekalb White hens from the second. They were housed in 12 similar compartments resembling a field situation. In each compartment the birds were distributed over individually managed units to obtain 48 separate observational groups in total (Figure 1).

The first four compartments each contained eight units. Each unit consisted of a row of enriched cages, housing 384 hens. Per compartment, the eight rows were organized into two separate blocks of four levels high. To obtain a homogenous distribution of breeds over the compartments, the rows alternately were filled with hens of the Dekalb White and Isa Brown breeds.

The other eight compartments each contained two units of Isa Brown hens in aviary systems, constructed by two different producers. The first type of aviary was installed in four compartments and housed 960 hens per unit. The second aviary type was also used in four compartments and comprised 1325 hens per unit.

To identify performance parameters that were impacted by the PRM infestations, it was intended to examine changes in performance after implementing a highly effective treatment to the hens. For the latter (Thomas et al., 2017), fluralaner (Exzolt®, MSD Animal Health) was administered through the drinking water twice with a 7-day interval at a dose of 0.5 mg/kg, providing the chickens with effective blood levels for approximately 2 weeks (Brauneis et al., 2017). Fluralaner was administered in the infested as well as in the non-infested units, all at the same time. The treatment was started when the chickens were 52 weeks old. At that time, 18 of the 32 enriched cage units and 14 of the 16 aviary units (Figure 1) were visually infested with the PRM *D. gallinae*.

**Monitoring infestation level and performance**

In all 48 observational groups, the PRM infestation level and performance of the hens were monitored on a routine basis.

Visual scoring for the presence of PRM was done weekly, at 3, 9 and 18 predefined spots in each unit of enriched cages, first aviary type and second aviary type, respectively. For this purpose, the Mite Monitoring Scoring system (MMS) of Cox et al. (2009) was applied. Briefly, MMS uses visual criteria for evaluation of the PRM infestation level as follows: Score 0 = no mites observed at all; Score 1 = mites observed hidden in cracks and notches; Score 2 = mites also observed in unprotected places; Score 3 = mite clusters bigger than 1 cm² observed in cracks and notches; Score 4 =

|   |   | Score |   |   |   | Score |   | Score |
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**Figure 1.** Infrastructure of the layer hen compartments and average MMS scores of the units at onset of fluralaner treatment (*").

*Bold lines indicate the separate compartments, dashed lines the observational units.*

Mentioned figures: average MMS scores (Cox et al., 2009) in the 48 different units, measured immediately prior to onset of treatment.
mite clusters bigger than 1 cm² also observed in unprotected places.

To follow up the performance of the units, daily figures were obtained for laying percentage, percentage of first-choice eggs, average egg weight, average feed consumption, feed conversion and mortality. Further, in all aviary units the body weight of hens was monitored continuously by automated weighing scales. In the enriched cage compartments, the body weight was determined by manually weighing 10 birds per unit at 6-week intervals, i.e. at 2 weeks before and at 2 weeks after onset of the fluralaner treatment.

Data handling and statistics

All performance data were first processed to weekly figures. Subsequently, they were compared to production standards established by the Dekalb White and Isa Brown breeding companies for hens kept in cage systems or aviary systems (Hendrix Genetics, 2018a, 2018b), if available. To avoid possible age-related and breed-related effects, the percentage difference with the production standard was calculated for each measurement. Thereafter, the values were averaged over three subsequent periods, namely the 4-weeks pre-treatment period, the 2-weeks treatment period and the 4-weeks post-treatment period. Significances of changes between the pre-treatment and post-treatment periods were examined statistically, separately for the enriched cages and the aviaries. The 48 observational groups of laying hens were considered the statistical units. All tests were performed using IBM SPSS Statistics version 25.0 software (IBM, Chicago, IL) at a significance level of 0.05.

For the 32 units of enriched cages and for the 16 units of aviaries, bivariate Spearman rank correlations (Kutner et al., 2005a) were calculated between MMS values and post-treatment performance changes standardized as mentioned above. Further, tests of Kruskal–Wallis (Kutner et al., 2005b), with infestation level as the main factor, were used to compare performance changes before and after fluralaner treatment between flocks with different PRM infestation levels. Infestation levels were defined on the basis of average MMS scores of the units, as measured immediately prior to the onset of treatment:

- Level “no visual infestation”: average MMS score 0
- Level “low to moderate infestation”: average MMS score between 0 and 3
- Level “high infestation”: average MMS score 3 or higher

If Kruskal–Wallis results indicated significant differences, Dunn’s tests (Kutner et al., 2005b) were performed post-hoc to identify these in relation to the pre-treatment infestation level. The units with no visual PRM infestation were considered negative controls.

Results

PRM infestation levels

The results of visual mite scoring immediately prior to the onset of fluralaner treatment in the 48 units of enriched cages and aviaries, are summarized in Figure 1. For the enriched cages, 14 units were not visually contaminated with PRM, nine units were low to moderately infested and nine units had a high infestation level. For the aviaries, PRM were visually absent in only two units. Low to moderate and high levels of infestation were found in eight and six units, respectively.

Immediately after treatment and up to the end of the observation period, mites were no longer macroscopically observed in any of the units; they all had an MMS score 0.

Performance

For the units of enriched cages, significant correlations were measured between MMS scores and post-treatment increases of laying percentage ($r = 0.504, P = 0.003$), egg weight ($r = 0.450, P = 0.010$), egg mass ($r = 0.537, P = 0.002$), percentage first-choice eggs ($r = 0.441, P = 0.012$) and feed intake ($r = 0.512, P = 0.003$).

Overall performance changes after fluralaner treatment of PRM-infested hens and non-infested controls in enriched cages, are given in Table 1. Kruskal–Wallis and Dunn analyses confirmed that laying percentage, average egg weight, produced egg mass, percentage of first-choice eggs and feed intake significantly increased ($P$-values < 0.05) in the units with a high PRM infestation level, as compared to the negative control units. Changes in feed conversion, weekly mortality and body weight were not found significantly different ($P$-values > 0.05) between these groups. Also, no significant performance changes were observed between units that were not visually infested with PRM and units having a low to moderate level of infestation.

For the aviary units, significant correlations were measured between the MMS score and post-treatment increases of egg mass ($r = 0.504, P = 0.046$), percentage first-choice eggs ($r = 0.539, P = 0.031$) and body weight ($r = 0.665, P = 0.005$). Further, the correlation coefficient measured between MMS score and increase of feed intake after treatment ($r = 0.470$) was close to significance ($P = 0.066$).

Kruskal–Wallis analyses revealed a tendency towards higher feed intake ($P = 0.072$) and increase of body weight ($P = 0.089$) post-treatment in the units with high PRM infestation compared to the non-infested control units. However, significant ($P < 0.05$)
post-treatment differences were not obtained for any of the monitored performance parameters.

**Discussion**

Considering the numbers of PRM that are often found in houses of layer hens and the irritation and weakening these can cause to the birds, it has been hypothesized that heavy infestations are an important cause of production losses (van Emous et al., 2005). However, under field circumstances it is virtually impossible to identify which performance parameters are affected by PRM. Indeed, the performance of laying hens in the field is also influenced by many other factors besides PRM, and usually PRM-negative control groups with birds of the same age and breed kept in the same housing system are not available on a farm level. To abandon the limitations of field observations, the present study was done in a research centre that had become infested with PRM by natural means and where hens were housed in circumstances closely resembling a field situation. A sufficient number of observational units, including negative controls, were available, allowing statistical analyses of observations. Further, the raw data could be optimized for statistics by expressing them as deviations to production standards and by calculating within-group changes after successful treatment for PRM. By working this way, it was demonstrated that the negative influences of PRM infestations on production involved laying percentage, percentage of first-choice eggs, egg weights and overall produced egg mass. Since these traits for a major part determine the income of layer hen farmers, PRM infestations can strongly influence the rentability of their business. Data from both the enriched cage units and aviary units demonstrated that visual PRM infestation scores and magnitude of performance losses are correlated. This may indicate that especially high infestation levels are to be avoided to prevent production declines. Under appropriate conditions, however, PRM populations in houses of laying hens can expand very rapidly (Sparagano et al., 2014). Low PRM infestation levels may thus quickly evolve to high levels of infestation and lead to significant losses. Therefore, under field circumstances, even low infestation levels of PRM may encourage immediate action.

After treating the heavily PRM-infested hens in the enriched cage units, their daily feed intake rose significantly. Most probably the production of more and heavier eggs after the successful removal of the mites had stimulated them to a higher energy intake. Also, restoration of the body weight after the elimination of PRM might constitute an explanation for a higher feed intake. Indeed after treatment of infested hens in the aviaries, their body weight increased, probably indicating they formerly had lost weight because of the mite infestations.

Under field circumstances PRM have often been held responsible for unfavourable feed conversions and increased mortality (van Emous et al., 2005; Sigognaux-Flochlay et al., 2017; De Herdt et al., 2019). The present study, however, did not indicate a significant impact of PRM on these parameters.

The purpose of this study was to examine which production parameters of laying hens can be affected during PRM infestations, not as such to estimate the extent of production losses. The latter might largely depend on how long hens are exposed to high infestation levels. It therefore seems possible that, in conditions where treatment is postponed, the losses may be higher than suggested by the present results.

In summary, this study demonstrated that PRM infestations of laying hens may negatively influence the number, size and quality of produced eggs, which are important parameters for the rentability of farms of layer hens. Successful treatment led to rapid improvement in performance.

**Disclosure statement**

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References

Braunies, M., Zoller, H., Williams, H., Zschiesche, E. & Heckeroth, A. (2017). The acaricidal speed of kill of orally administered fluralaner against poultry red mites (Dermanyssus gallinae) on laying hens and its impact on mite reproduction. *Parasites & Vectors*, 10, 594–601.

Cox, M., De Baere, K., Vervaet, E., Zoons, J. & Fiks-Van Niekerk, T. (2009). Red mites: monitoring method and treatment. In S. Barbieri, V. Ferrante, S. Lolli, & G. Sayegh (Eds.). *Proceedings of the 8th European Symposium on Poultry Welfare* (p. 83). Cervia, Italy.

De Geer, C. (1778). Des mittes qui vivent sur les oiseaux. In De Geer, C. (Ed). *Mémoires pour servir à l’histoire des insectes. Tome septième*. (pp. 106–112). Stockholm: Pierre Hesselberg.

De Herdt, P., Boutreux, A., Van Hoye, K., Koopman, R., Van Gorp, S. & Van Erum, J. (2019). Effect of a drinking water conditioner on stability and efficacy of fluralaner in laying hens infested with poultry red mites. *Avian Diseases*, 63, 97–101.

George, D.R., Finn, R.D., Graham, K.M., Mul, M., Maurer, V., Valiente, M.C. & Sparagano, O.A. (2015). Should the poultry red mite *Dermanyssus gallinae* be of wider concern for veterinary and medical science? *Parasites & Vectors*, 8, 178–187.

Hendrix Genetics. (2018a). Dekalb White product guide, cage production system. Retrieved from https://www.dekalb-poultry.com/en/product/dekalb-white/.

Hendrix Genetics. (2018b). Isa Brown product guide, cage production system and alternative production systems. Retrieved from https://www.isa-poultry.com/en/product/isa-brown/.

Kilpinen, O., Roepstorff, A., Permin, A., Norgaard-Nielsen, G., Lawson L.G. & Simonsen, H.B. (2005). Influence of *Dermanyssus gallinae* and *Ascaridia galli* infections on behaviour and health of laying hens (*Gallus gallus domesticus*). *British Poultry Science*, 46, 26–34.

Kutner, M.H., Nachtschein, C.J., Neter, J. & Li, W. (Eds). (2005a). Chapter 2: Inferences in regression and correlation analysis. In *Applied Linear Statistical Models* 5th edn (pp. 40–99). New York: McGraw-Hill/Irwin.

Kutner, M.H., Nachtschein, C.J., Neter, J. & Li, W. (Eds). (2005b). Chapter 18: Anova diagnostics and remedial measures. In *Applied Linear Statistical Models* 5th edn (pp. 775–811). New York: McGraw-Hill/Irwin.

Sigognault-Flochlay, A., Thomas, E. & Sparagano, O. (2017). Poultry red mite (*Dermanyssus gallinae*) infestation: a broad impact parasitological disease that still remains a significant challenge for the egg-laying industry in Europe. *Parasites & Vectors*, 10, 357–362.

Sommer, D., Heffels-Redmann, U., Köhler, K., Lierz, M. & Kaleta, E.F. (2016). Role of the poultry red mite (*Dermanyssus gallinae*) in the transmission of avian influenza A virus. *Tierärztliche Praxis Grosstiere*, 44, 26–33.

Sparagano, O., Pavlicevic, A., Murano, T., Camarda, A., Sahibi, H., Kilpinen, O., Mul, M., van Emous, R., le Bouquin, S., Hoel, K. & Cañiero, M. (2009). Prevalence and key figures for the poultry red mite *Dermanyssus gallinae* infections in poultry farm systems. *Experimental and Applied Acarology*, 48, 3–10.

Sparagano, O.A., George, D.R., Harrington, D.W. & Giangaspero, A. (2014). Significance and control of the poultry red mite, *Dermanyssus gallinae*. *Annual Review of Entomology*, 59, 447–466.

Thomas, E., Chiquet, M., Sander, B., Zschiesche, E. & Sigognault-Flochlay, A. (2017). Field efficacy and safety of fluralaner solution for administration in drinking water for the treatment of poultry red mite (*Dermanyssus gallinae*) infestations in commercial flocks. In *Parasites & Vectors*, 10, 457–465.

Tomley, F.M. & Sparagano, O. (2018). Spotlight on avian pathophysiology: red mite, a serious emergent problem in layer hens. *Avian Pathology*, 47, 533–535.

Valiente, M.C., de Luna, C.J., Tod, A., Guy, J.H., Sparagano, O.A. & Znener, L. (2009). The poultry red mite (*Dermanyssus gallinae*): a potential vector of pathogenic agents. *Experimental and Applied Acarology*, 48, 93–104.

van Emous, R.A., Fiks–van Niekerk, T.G. & Mul, M.F. (2005). Slechtere technische resultaten. In Animal Science Group Wageningen UR (Eds). *Bloedluizen (vogelmijten) op papier en in de praktijk. Praktijkrapport Pluimvee* 17. (pp. 18–19). Retrieved from https://library.wur.nl/WebQuery/wurpubs/fulltext/35928