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Monitoring of *Dermanyssus gallinae* in free-range poultry farms

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Abstract Various methods for monitoring *Dermanyssus gallinae* infestations within free-range egg production units were compared. The study was carried out in five egg-producing free-range poultry buildings infested with *D. gallinae*. Each farm was divided into six zones (each zone including nest boxes, perches and duckboard) for placing two types of traps (corrugated cardboard and thick card traps) or examining dried droppings for presence of mites. Traps were removed 24 h later, placed into bags and mites were counted at the laboratory using binocular magnification. Droppings were also inspected by eye and mite numbers were estimated. All the methods used allowed us to detect mites although their efficacy differed. The number of mites collected was independent of the type of trap used. Examination of the droppings did not differentiate between buildings with differing mite populations. Placing traps in the nest boxes is a less reliable indicator than placing them on the perches. It appears that the most coherent method for evaluating the *D. gallinae* population within a free-range flock is to place thick card traps throughout the building, on perches favoured by birds.

Keywords Parasite · Red poultry mite · Trapping method · Laying hen · Alternative farming methods

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Introduction

There are two types of poultry farm raising laying hens. The battery farms include very standardised farms with several tens of thousands of battery-caged birds. The free-range farms include those farms where the laying hens are not caged, but are housed in deep litter or perchery/aviary systems with outside scratching area. These farms may include several thousand birds sharing the same space (Guillou 1988).

Dermanyssus gallinae (De Geer 1778), also known as the "red poultry mite", is the external parasite with the greatest impact on laying hens in Europe (Chauve 1998). This hematophagous acarian only parasites its host during blood meals. The rest of the time it lives hidden in the farm buildings. It is responsible for huge financial losses in French poultry farms breeding laying hens.

In battery farms, the economic impact of *D. gallinae* is partly due to the downgrading of eggs stained by the blood of squashed mites. This downgrading of egg quality has a financial impact with a proportion of second-quality eggs increasing by 2–14% (Van Emous et al. 2006). During the course of a massive infestation, the hens also suffer from anaemia which is further responsible for a reduction in their egg production and can lead to the death of the bird. Indeed, report of field outbreaks documenting severe anaemia and mortality invariably also include drop in egg production, regularly of 10–20% (Kirkwood 1967; Jungmann et al. 1970; Ambrosi and Flores 1972; Cosoroabă 2001; Cencek 2003).

In free-range poultry farms, the stress caused by this ectoparasite leads to pecking behaviour, often considered to have irreversible consequences and characterised by an increase in the number of pecks given to other birds (Roy et al. 2006); this can cause fatal lesions and increase the likelihood of cannibalism within the flock. It further causes an increase in the number of downgraded eggs when aggressive behaviour from the other birds causes the cloaca to become soiled with blood.

One study has found that 94% of battery flocks and 75% of free-range farms in south–east France had been treated with acaricides in an attempt to combat the proliferation of this acarian (Lubac et al. 2003). These treatments are expensive and further reduce the profit margins of the farmers.

One of the characteristics of infestation by red mites is that once they are present in a flock they are almost impossible to eradicate (Chauve 1998). However, while a low level infestation may be deemed acceptable since it causes only minimal losses, the difficulty for the farmer is to know exactly when is the best time to treat the flock as the adult mites are less than a millimetre in size and difficult to see with the naked eye. Furthermore, they hide away in cracks and crannies of the building, laying their eggs during the day, far away from the light (Collins and Cawthorne 1976).

Studies on the dynamics of *Dermanyssus* populations have already been carried out in battery farms (Levot 1991) and in perchery/aviary production units (Nordenfors and Chirico 2001; Chirico and Tauson 2002; Lundh et al. 2005), but never in free-range production units commonly found in France. However, it is important to assess, even semi-quantitatively, the mite population in such farms for at least two reasons: evaluation of control measures together with the optimal period for treatment and in situ studies of the parasite. The aim of our study was to compare the various methods available for quantifying parasitic infestation and to define those areas within a free-range production unit building best suited to testing.

Materials and methods

The farms

This study was carried out in five farm buildings (A, B, C, D and E) in four free-range farms breeding laying hens in the departments of the Ain, the Ardèche and the Rhône (France). Three of the farms raised organic chickens, and the fourth certified birds, meeting very precise specifications as to their feed etc. The time the pullets spent on the farm varied from 7 to 33 weeks.

Description of the traps used

Two types of trap were used (Fig. 1a, b, c). The first type, based on the description by Nordenfors and Chirico (2001), was made up of a 3 mm thick sheet of corrugated cardboard, measuring 10 × 7 cm. The cardboard was cut in such a way that the corrugations were open on the longer side. The second type of trap, inspired by Levot (1991), consisted of a 20 × 7 cm piece of thick cardboard (210 g/cm^2) folded in two and held together by two staples to give a trap measuring 10 × 7 cm. Both types of trap were protected from being attacked by the hens with a 1 mm thick auto-adhesive rigid plastic sheet.

Fig. 1 **a** Open thick carboard trap with *Dermanyssus* after 24 h of freezing; **b** Pair of corrugated cardboard and thick cardboard traps in a nest box; **c** Fixation of a trap on a perch; **d** Dried dropping sample showing *Dermanyssus* on the underside

Examination of the bird droppings

Dried dropping samples around 5 cm long were taken from the duckboards (Fig. 1d), and the undersides examined. Based on the number of mites found in the dropping samples and on the underside of the duckboard scores were given as follows: 0: no mites, 1: 1–20 mites, 2: 20–200 mites, 3: more than 200 mites. The final mark given to the sample was obtained from the average of the scores from four dropping samples taken in any one area of approximately one meter square.

Experimental design

The first experiment was to compare different methods for quantitative evaluation of the presence of *D. gallinae* in a flock. Two different type of trap were tested in the farms with different infestation burdens (corrugated cardboard and thick cardboard traps as described previously). They were placed in pairs, one of each type, at a distance of 20 cms in nest or on perches (Fig. 1b). They were fixed in the nest boxes using double-sided sticky tape, and at the top of the perches using metal wire. They were taken down 24 h later and immediately placed in hermetically sealed bags for transport to the laboratory where they were frozen at −20°C for 24 h. The number of mites was individually counted with the help of a binocular magnifier after opening the traps. Seventy-six pairs of traps were tested. Counting *Dermanyssus* from traps were also compared to examination of dropping. In this experiment, 498 values from the five farms were analysed. Finally, data from 174 traps placed on the perches and 174 traps in the nest boxes were compared to evaluate the place to put the traps.

The second experiment compared the performance of the various assessment methods when there is a sudden fall in the population of *Dermanyssus*. To obtain this variation in infestation burdens, we have taken advantage of a trial of various acaricides in these farms. We placed traps in nest boxes and perches and examined droppings before (D0) and 7 days after (D7) the use of an acaricide and compared the differences in results from traps or dropping examination made exactly at the same place. Data from 30 traps in nest boxes, 30 traps on perches and 120 examination of dropping were used in this experiment.

The last experiment aimed to evaluate variation of infestation burdens observed in different areas of one building. We have defined a sampling zone which could be found in any free-range poultry farms regardless of its architecture as a area including nest boxes, perches and duckboards at proximity. For each farms, six different sampling zones were determined. For each sampling zone, two traps were placed (one in nest boxes and one on perches) and four examination droppings were made.

Statistical data analysis

Means comparisons were carried out using an ANOVA and the Statview programme in comparing: (1) the two type of traps, (2) the relative sensitivity of using traps or examining droppings to determine infestation levels, (3) the traps placed on the perches or in the next boxes, (4) the data obtained before and after use of an acaricide and (5) the data obtained from six areas of the same building. The correlation coefficient from data of the corrugated cardboards and thick cardboards was calculated using Spearman's

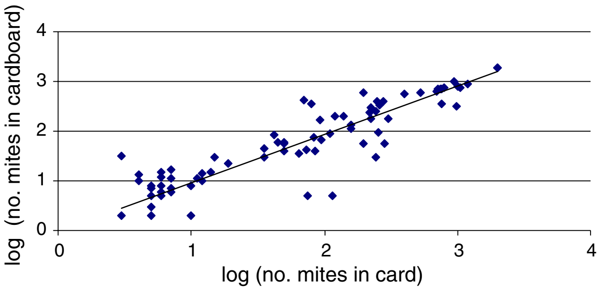

Fig. 2 Comparison of the number of red poultry mites present in the thick card and corrugated cardboard traps (Spearman's correlation $r^2 = 79.9\%$)

correlation coefficient. All information concerning the data tested was added to the experimental design section.

Results

Comparison of the different methods for quantitative evaluation of the presence of *Dermanyssus gallinae* in a flock

– Comparison of the two types of trap:

Data was obtained from 76 pairs of traps and the number of mites found in the corrugated cardboard and thick cardboard traps studied. The average number of mites collected was 239.5 ± 375 mites for the corrugated cardboard traps and 260.6 ± 471 mites for the cardboard traps, with no significant difference between the two types of trap.

Furthermore, an important correlation in mite numbers was found when comparing the results obtained from each pair of traps (Fig. 2).

Statistical analysis of the results was carried out using Spearman's correlation method (Rho = 79.7% with $P < 0.0001$). The two variables are therefore strongly correlated which implies that using either type of trap to measure the mite population gives similar results. For practical reasons, we continued the study using only the thick card traps as these were easier to use.

– Comparison of the relative sensitivity of using traps or examining droppings to determine infestation levels.

All three methods (traps on the perches, traps in the nest boxes, examination of droppings) were used in the five buildings, all of which were infested to varying degrees. Four hundred and ninety-eight readings were used for this comparison. Univariate variance analysis carried out on our results show that, contrary to the traps, examination of the droppings did not allow differentiation between the various buildings (data not shown). Therefore it follows that examination of droppings is a less sensitive test than using traps.

– Comparison between the traps placed on the perches or in the nest boxes.

This comparison was carried out on 174 values for each of the two trap sites. The average number of mites (±Standard Deviation) obtained from the traps placed in the nest boxes was 64.3 (±165) and 364.2 (±490) for the traps placed on the perches. Within any one farm, the number of mites found in the traps on the perches is from 1.7 to 77 times that of the nest boxes (Fig. 3).

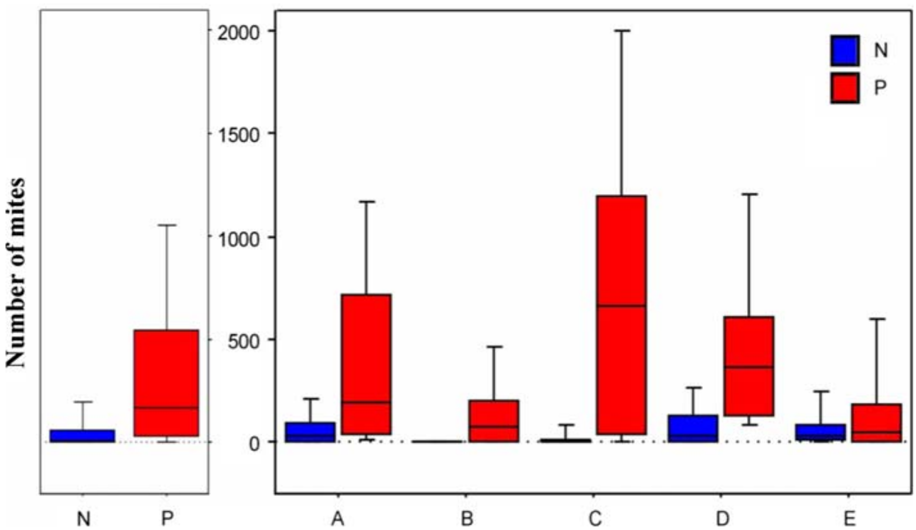

Fig. 3 Comparison of the number of red poultry mites collected from the nest boxes (N) and the perches (P). (1) overall and (2) by farm building (A, B, C, D, E) (shown as a boxplot-median, 25 and 75% percentiles and extremes)

Performance of the various assessment methods when there is a sudden fall in the population of *Dermanyssus gallinae*

A quantitative assessment of the number of mites was carried out using all three methods (traps on the perches, traps in the nest boxes, and examination of droppings) both before (D0) and 7 days after (D7) use of an acaricide in the production unit.

The data obtained from examination of the traps gave the greatest differences before and after treatment (Fig. 4). The number of mites found in the traps placed in the nest boxes showed a reduction of 82%, on the perches of 81% but only a reduction of 39% was noted from examination of the droppings. As *Dermanyssus* are mobile during the night, we can assume that treatment has the same impact on mites in the different places and this reinforces the reduced interest of using examination of droppings as an assessment method.

Comparison of the number of mites obtained from six areas of the same building

The lack of significance of the study of the droppings and the low number of mites collected in the nest boxes lead us to analysed only data from traps placed on perches. The number of mites collected from these traps was studied in relation to the six areas as defined in the Materials and methods section (Fig. 5).

Variations were noted in relation to the buildings studied: the results obtained from buildings B and E are similar in all zones, whereas in building C the difference ranges from 1 to 5. One area show there aren't any mites present in the trap (area 3, building C). But, univariate variance analysis carried out for each of these buildings did not allow us to show any significant difference between the six sampling areas.

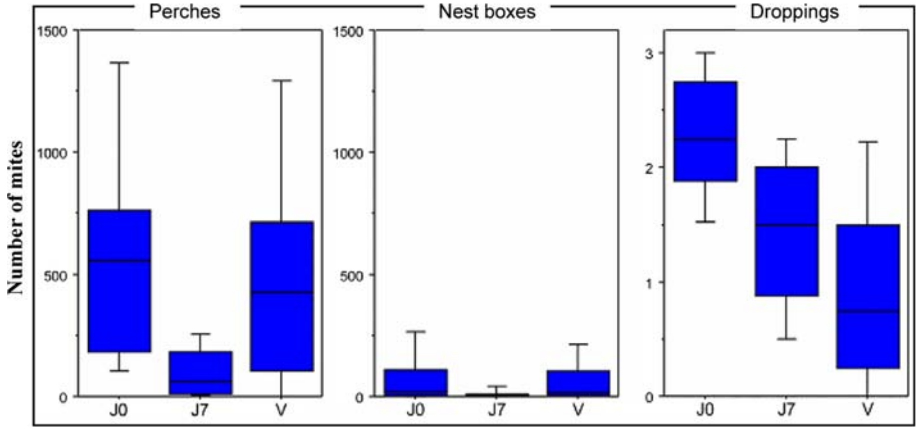

Fig. 4 Representation of average red poultry mite populations detected before (D0) and 1 week after (D7) application of an acaricide treatment. The variation (V) corresponds to the average of the observed differences for any given area between the populations before and after treatment (shown as a boxplot—median, 25 and 75% percentiles and extremes)

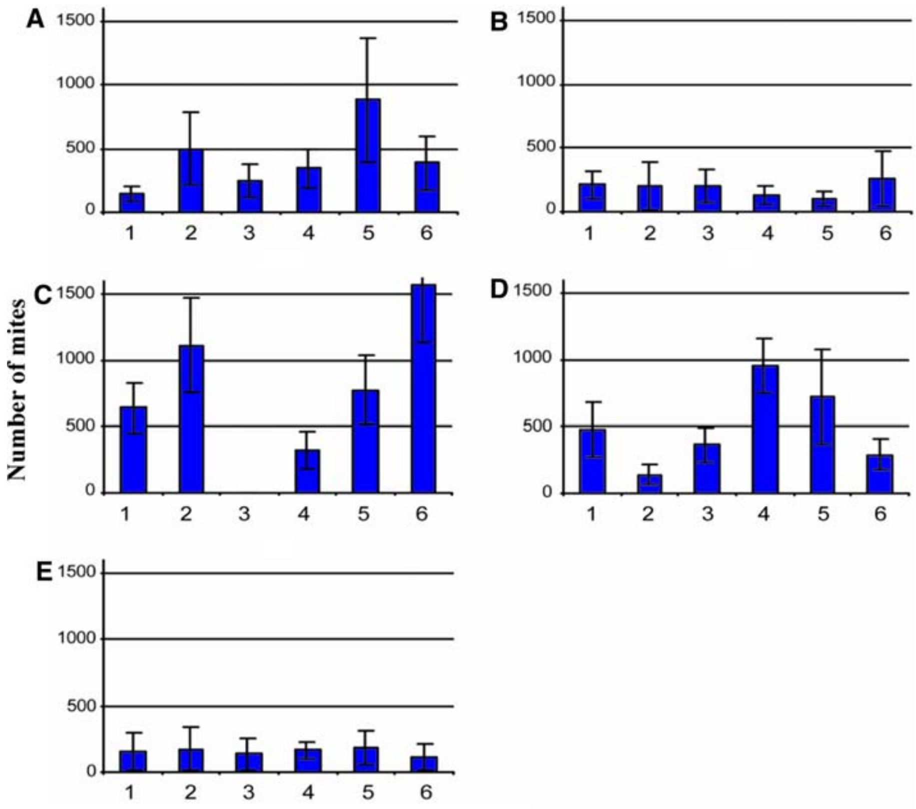

Fig. 5 Averages of red poultry mites collected from the perches in each of the six areas in the five buildings

Discussion

One of the problems faced in studying flocks with red mite infestation is evaluation of the parasite burden contained within the building and their distribution throughout the flock (Levot 1991; McGarry and Trees 1991; Nordenfords and Chirico 2001). From this point of view, it was therefore interesting to compare the various techniques available for quantitative evaluation of the mite population.

All the methods used: examination of droppings, traps in corrugated cardboard or thick cardboard, placed in nest boxes or on perches, allowed us to monitor the mites although their efficacy differed. Studying the two types of trap, whether in corrugated cardboard or in thick cardboard, showed that the number of mites collected was independent of the type of trap used. We preferred the thick card trap as it was easier to use. One of the inconveniences of these traps is their lack of resistance to humidity since simple contact with fresh droppings humidifies these traps and renderes them useless for mite collection. Any comparison with Nordenfors' study in Sweden (Nordenfors and Chirico 2001) is difficult even though he also used corrugated cardboard traps as the density of the hens per square metre in Swedish farms, which are of the caged type (14–20 birds per m^2) is well above that in the French farms we studied (6 birds per m^2). This could explain the average figure of 11,500 ± 1,590 mites obtained in Sweden. Furthermore, the traps were left in place for two nights which may also explain the higher number of mites reported by Nordenfors and Chirico. Examination of the droppings, a method routinely used by the farmers themselves and their technical experts, was shown to be unreliable as a method of assessing infestation as it did not allow us to differentiate between buildings with differing mite populations. The variations observed after a rapid fall in the mite population were also too small to consider examination of droppings as a reliable guide to the efficacy of an acaricide. However, this method remains a simple means of observing whether or not poultry red mites are present in the flock.

An interesting point is that of where to place the traps in the farm building. The quantitative difference in the number of mites collected from the traps placed on the perches or in the nest boxes shows that placing the traps in the nest boxes is a less sensitive indicator. One reason for this may be the shorter time that the birds spend in the nest boxes compared to on the perches. The presence of the parasite in any area of the farm building is strongly correlated with the behaviour of the birds themselves. We were further able to observe that the zero samples taken from the perches in building C, corresponded to the fact that the birds did not use these perches as they were some distance from the duckboard. It is therefore necessary to place the traps in areas actually used by the birds. Similarly, in buildings A, D and E, the proximity of the perches to the nest boxes is probably the explanation for the very large number of mites collected from the traps in these nest boxes.

One further question posed at the start of our study was whether the observation of several predetermined areas spread throughout the building, would allow us to evaluate the mite population in the entire building, regardless of its architecture. Each of the areas studied, defined by ourselves included elements common to all alternative poultry farms: the duckboard, the perches and the nest boxes. Unfortunately, the lack of significance from the study of the droppings and the low number of mites collected in the nest boxes rapidly narrowed our study area to finally include only the perches. The statistical study carried out on the data obtained from the perches allowed us to differentiate between the various study areas.

It therefore appears that the most coherent method for evaluating the *Dermanyssus* population within a flock is to place thick card traps throughout the building, on perches favoured by the birds. But as we reduced the sample size, using only those traps placed on the perches, it would be interesting to increase the number of traps, doubling it to 12 traps per building. In order to monitoring *D. gallinae* in poultry house premises, it would be important to optimise the number of traps to obtain reliable data. This Optimum Sample Size (OSS) had already been evaluated for litter beetles in poultry houses. Safrit and Axtell (1984) calculated this OSS at ten tube traps for *Alphitobius diaperinus* whereas Stafford et al. (1988) found OSS at 35 traps to monitor a high density of *Dermestes maculates*. In their study, Nordenfors and Chirico (2001) showed that the number of traps required to monitor *Dermanyssus* at any given level of variability decreased with higher mite densities.

This method gives a quantitative estimate of the mite population, although it in no way gives an actual figure for the number of *Dermanyssus* present in the flock. However, it does allow follow-up of the variations in the acarian population since we believe that the number of mites collected from the traps is certainly correlated to the *Dermanyssus* population present in the building. This method therefore allows for monitoring of the variations in the mite population during an acaricide treatment or during changes in environmental conditions within a building, such as differences in temperature or hygrometry. Incorporation of traps into pest control programmes is thus likely to result in a higher standard of management, involving quality assessment.

One possible use for this method would be in determining the threshold level for initiating control treatment. This threshold, to be defined, would depend both on the characteristics of the farm building, the evident distress levels of the hens and the efficacy of the product to be used in the treatment. The definition of such a threshold level would require long-term studies within a single farm building.

In conclusion, this study has clearly shown that it is possible to have an idea of the level of parasite infestation and to monitor it over time. This technique, even if it does not allow for determination of the exact number of red poultry mites present, does remain a valuable tool for understanding phenomena regarding variation of the mite population within a flock and permits monitoring of the efficacy of control treatments.

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