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MiteControl: Ensuring food safety, animal health and welfare standards through development of innovative IPM programmes to control poultry red mite infestations

IPM report: Implementation of IPM programmes to control PRM on farms

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Content

MiteControl: Integrated Pest Management (IPM) for the sustainable control of Poultry Red Mite

Introduction

As part of WP3 within the MiteControl project, three Integrated Pest Management (IPM) strategies were composed, tested and demonstrated on 10 commercial pilot farms throughout the NWE region as well as 2 types of housing systems at the EPC (Geel, Belgium). These demonstrative trials are considered as case studies and are reported as such.

The developed IPM strategies are integrated approaches for the control of Poultry Red Mite (PRM) on layer, pullet and broiler breeder farms and focus on prevention (e.g. thorough cleaning and disinfection during the empty period, upholding adequate biosecurity measures both in between and during flocks), monitoring of the red mite population, and actions to undertake when infestation levels increase (e.g. management actions, increase of frequency in using phytoadditives to support hen health, apply products targeting PRM in the environment of the hens). Three such IPM programmes were developed wherein two non-chemical products were combined: one product was administered to the hens (i.e. either phytoadditives via drinking water or an experimental, autogenous red mite vaccine) and the second was applied in the hen house (i.e. either the release of predatory mites or the use of silica).

Before being able to compose the IPM strategies for implementation on pilot farms, the possibilities for combining individual products needed further investigation as well as assessing if there was room for improvement of the efficacy of the products. This research was instrumental to enable the choice for the best IPM combinations. A short trial on a semi-commercial scale at the EPC included testing and demonstration of different combinations under practical farm-circumstances. The semi-commercial trial together with results from lab experiments on resistance and synergisms conducted by UPVM3 (Montpellier, France) were essential steps in the development of the IPM strategies. These studies therefore of course contributed to the investigation and research into the proof of concept of the chosen combinations. The results fed the decision on products to combine in the three final strategies to implement in the WP3 trials: (i) IPM1 was the combination of an autogenous red mite vaccine (technology and protocols developed and provided by the Moredun Research Institute, Scotland) and predatory mites (bred and commercialised by Koppert BV, The Netherlands), (ii) in IPM2 predatory mites (Koppert BV) were combined with the phytoadditive Lentypou+ (produced by Eurotec'h, France), and (iii) the final IPM3 strategy used the phytoadditive Nor-Mite (produced by Norfeed, France) to support the hens and synthetic silica Fossil Shield Instant White (distributed by DaemEco, Belgium) to treat the housing system. Information on the specific products from the manufacturers can be found in Appendix of the current report.

In WP3, apart from the EPC, ten commercial layer farms (2 in BE, 4 in FR and 4 in the UK) were selected where one of the three strategies was piloted and the flocks were followed up for an entire production cycle by applied research partners ITAVI (PP), ADAS (PP) and the EPC. The pilot farms adhered to protocols that were provided by the research partners. A survey was developed and conducted with farmers in all three countries to collect information on their previous experience with PRM and e.g. management actions or treatments to control PRM. IPM manuals were drawn up that included information for farmers on (i) the purpose of the project in general and the pilot farm trials specifically, (ii) the purpose of monitoring PRM, (iii) preparation of the hen house for the flock to be followed during the IPM trial, (iv) biosecurity measures to uphold before the start and for the whole duration of the IPM flock, (v) management actions to undertake to reduce the PRM infestation level, and (vi) the use of non-chemical products for the control of PRM. Decision trees were constructed for every strategy and included in the manuals.

In WP4, the scope of the project was widened and research was carried out on sustainable PRM control (using IPM strategies) in two additional poultry sectors: (i) pullet rearing and (ii) broiler breeders. This research was led by the EPC and Belgabroed (for broiler breeders) and ITAVI (for pullet rearing). Two initial IPM strategies that were developed within WP3, i.e. IPM2 and IPM3 were adapted for implementation on pullet and broiler breeder farms. Ultimately, IPM2 was implemented on one broiler breeder farm in Belgium, whereas IPM3 was used on another broiler breeder farm in Belgium and one pullet farm in France.

Apart from prevention and the targeted use of non-chemical products, another important aspect of IPM is monitoring of the pest species. However, routine (manual) monitoring is not widely implemented on commercial farms. Such techniques often require quite some time from the farmers throughout the flock. Within WP1 a novel, innovative monitoring method was developed by KU Leuven (Belgium) using the activity index of the nighttime behaviour of the hens. This behaviour was captured with cameras. At first, a small scale experiment was carried out in the biosafety environment at the EPC. To finetune and validate the findings of the biosafety experiment, cameras were also installed in the hen house at the EPC and on pilot farms. Afterwards, the video data were analysed by KU Leuven to establish a link between increased activity of the hens at night and an increase in the PRM population.

Both conventional as well as organic farms were recruited for the pilot farm trials in WP3. Furthermore, a variety of different housing systems were included such as aviaries, free range (with or without wintergarten) and enriched cages. Both single and multitier systems were considered. Follow-up of an entire flock trialing one of the three IPM programmes was done where monthly on-farm visits were organised to discuss the

progress of the trial and to inquire about the farmers' experience with the chosen strategy. Intensive monitoring was carried out by the farmers and feedback with advice on how to proceed with PRM control were provided after consultation with the PP and product suppliers involved.

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Development of the IPM strategies

The use of IPM strategies for sustainable control of Poultry Red Mite in Europe: a literature review

An extensive literature review was conducted on the possibilities for IPM strategies in European laying hen farms for the improved control of PRM prior to developing the strategies to be tested on commercial laying hen farms:

Decru, E., Mul, M., Nisbet, A. J., Vargas Navarro, A. H., Chiron, G., Walton, J., Norton, T., Roy, L. and Sleeckx, N. (2020). Possibilities for IPM strategies in European laying hen farms for improved control of the Poultry Red Mite (*Dermanyssus gallinae*): details and state of affairs. Front. Vet. Sci. 7:565866 (doi: 10.3389/fvets.2020.565866)

Background

The Poultry Red Mite, *Dermanyssus gallinae*, is a major threat to the poultry industry worldwide, causing serious problems to animal health and welfare, and huge economic losses. Controlling PRM infestations is very challenging. Conventionally, *D. gallinae* is treated with synthetic acaricides, but the particular lifestyle of the mite (most of the time spent off the host) makes the efficacy of acaracide sprays often unsatisfactory, as sprays reach only a small part of the population. Moreover, many acaricides have been unlicensed due to human consumer and safety regulations and mites have become resistant to them.

A promising course of action is IPM, which is sustainable for animals, humans and the environment. It combines eight different steps, in which prevention of introduction and monitoring of the pest are key. Further, it focuses on non-chemical treatments, with chemicals only being used as a last resort. Whereas IPM is already widely applied in horticulture, its application is still in its infancy to control *D. gallinae* in layer houses.

Decru *et al.* (2020) presents the currently-available possibilities for control of *D. gallinae* in layer houses for each of the eight IPM steps, including monitoring techniques, established and emerging non-chemical treatments, and the strategic use of chemicals. As such, it provides a much-needed baseline for future development of specific IPM strategies, which will allow efficient and sustainable control of *D. gallinae* in poultry farms.

Some key aspects of IPM for the sustainable control of PRM are covered below. For more detailed information and the full article, please refer to Decru *et al*. (2020).

Importance of an Integrated Pest Management approach

IPM is a concept to control pest species, which is sustainable for animals, humans, and the environment. IPM consists of eight steps, in which prevention of introduction, and monitoring of the pest are key for sustainable control. For successful IPM, all ecological and biological knowledge, including biotic and abiotic factors, of the pest species should be integrated.

Monitoring is crucial to identify the best moment for applying treatments. Principally, environmentally-safe, non-chemical methods and measures are used for prevention and control of the pest species. Only when non-chemical measures have failed and an action threshold is exceeded is a chemical treatment deployed as a last resort. Preferably, a selective acaricide should be used in order to avoid killing non-target species, and the use of chemicals should be in an as limited way as possible (e.g. hot-spot treatments). Actions to avoid resistance against products should be implemented, and finally, thorough evaluation of the IPM strategy is needed to optimise it.

Considerations for IPM combinations for the control of PRM

IPM in animal husbandry

At present, IPM is primarily used to control plant pests, and the practical implementation of IPM in animal husbandry is in its infancy compared to horticulture. Monitoring is only applied on a minority of farms and, concerning the use of non-chemical alternatives, livestock farming is lagging far behind. A lot of synergies exist between the arthropod pest control in horticulture and the control of *D. gallinae* in layer farms. However, the principles of IPM can also be applied in the poultry industry.

The importance of PRM monitoring

Preventive actions alone are often not sufficient to fully control the pest, and curative means often need to be implemented. Even then, complete eradication of *D. gallinae* is virtually impossible, and control measures should instead be aimed to keep the infestation under a so-called economic threshold. This to avoid negative effects on the hens, humans and production.

A critical point in an IPM strategy is the timing of the appropriate actions (e.g. altering preventive measures or adding treatments) to prevent the increasing pest population from causing damage. By using this ‘action threshold’ treatment/action is not performed too soon and too much, avoiding negative effects on the environment, redundant costs, and resistance emergence. Treatment is also not performed too late so efficient control is still possible.

Unfortunately, such general thresholds are not available for controlling *D. gallinae*. This lack of thresholds largely hampers the development of generally applicable IPM strategies for layer houses. Several monitoring techniques or treatments (see further) provide their own thresholds where they advise treatment is necessary, though these are not scientifically proven.

Preventive and curative non-chemical products

Decru *et al.* (2020) provides an overview of the non-chemical products and treatments that can be used for the control of PRM (Table 1): (i) plant-derived products, (ii) vaccines, (iii) predatory mites, (iv) entomopathogenic fungi, nematodes and bacterial endosymbionts, (v) light regime, (vi) inert dusts, (vii) oils, and (viii) Q Perch®. For more detailed information on the specific products, please consult the full article.

Table 1: Overview of non-chemical treatments to be used for the control of PRM*

Treatment	Mode of action	+	–	P/C	Comm.
Plant-derived products	Acaricidal, toxic	Short environmental persistence	Short effect	C	X
	Repellent	Potential in attract-and-kill	Lack of standardization	P	X
Vaccines	Boost immunity	-Low risk for resistance -No workload during production	Further research needed for commercialization	P	
Biological control					
Predatory mites	Prey on PRM	No negative effect on environment (natural enemies)	Also affected by other treatments (silica, acaricides,..)	P(/C)	X
Entomopathogenic fungi	Penetrate host	Potential in traps	Suboptimal conditions in layer houses	C	X
Nematodes + endosymbionts			Much research still needed		
Physical control					
Inert dusts (on system)	Dessication of PRM	-Resistance less likely (mainly physical mode of action)	-Health hazards (esp. crystalline) -Variability in effectiveness	P/C	X
Q perch	Electrify PRM	-No harm to hens -Resistance less likely	Expensive, change in infrastructure	P	X

*(*Treatments not allowed in the EU are not included in the table. Main advantages (+) and disadvantages (-) are listed, as well as their use (P: preventively; C: curatively) and whether they are commercially available (Comm.). For more information, please consult the full publication of Decru et al., 2020)*

Current control mechanisms on their own are not sufficient for controlling PRM in layer houses, thus the focus of the MiteControl project was on combining two or more non-chemical products to improve the efficiency of the control strategy. However, not all treatments can be used in combination, and some could probably have antagonistic effects. Broad-spectrum approaches like silica or heat treatment, might e.g. have an adverse effect on the use of natural enemies.

Apart from combining two or more individual treatments they can also easily be combined with simple management actions such as cleaning places where hotspots are found with water and soap to keep the infestation under control, which has proven to be effective. The influence of different housing systems and of parameters such as temperature and humidity on the efficacy of any treatment (combination) has also been illustrated. Using

(or building) housing systems that are less beneficial for PRM, and limiting the number of potential mite hiding places could also help control infestations. All this illustrates that a holistic approach (i.e. integrating biosecurity and prevention measures, appropriate monitoring, attention to different conditions in different housing systems and interactions with environmental conditions) are indispensable for effectively controlling PRM in layer houses.

Products tested in IPM strategies

Farm-specific, autogenous vaccine

Studies carried out in recent years have shown that there is a potential place for vaccines within IPM strategies targeting PRM. Both farm-specific, autogenous vaccines and the use of recombinant antigens have been tested in small scale and laboratory trials. Acquiring authorisation for the use of an autogenous vaccine could be easier than the recombinant versions. However, producing a farm-specific vaccine is more labour intensive since PRM need to be sampled on each farm in order to produce autogenous vaccines. Moreover, the efficacy of the autogenous vaccine cannot be quantified although Bartley *et al.* (2017) reported promising results of the autogenous vaccine in a field study with a 78% reduction in PRM. Therefore, the autogenous vaccine is an interesting option to explore further, particularly with regard to IPM since it is low-risk both for contamination of the environment and the emergence of resistance in PRM. Currently, the vaccines can only be administered through injection, which means that the birds need to be vaccinated at a young age before the enter the layer house. In the future it would need to be investigated how PRM vaccines could best be administered during the production cycle, e.g. via the drinking water.

Predatory mites

Natural enemies of PRM can be used for biological control. Predators such as *Androlaelaps casalis, Cheyletus eruditus* and *Hypoapsis aculeifer* are naturally found in the hen house and can already play a role in the control of PRM. Some species can also be artificially reared and release in hen houses. The use of genuine, naturally in the hen house occurring predators implies that the risk of a substantial impact on non-target biodiversity is probably limited. Although *Hypoapsis* have a high predation capacity, their mobility is very limited. Moreover, obtaining an established population in poultry houses seems impossible to achieve. *A. casalis* is highly mobile, an active hunter, prefers a humid microhabitat and primarily feeds on juvenile stages of PRM. *C. eruditus* is less mobile, prefers dry places in the hen house but feeds on all stages of PRM. Both species are thus complementary and can be used together. The specifics of the releases (e.g. location, frequency) depends on factors such as the number of hens present and the housing system. Care should be taken when applying other treatments against PRM since these might also have deleterious effects on natural predators.

Q Perch

The Q Perch is mushroom-shaped with two electric wires and insulators. It is designed in a way that the hens cannot be harmed, whereas PRM are killed when they come into

contact with the wires. The efficacy is not yet demonstrated in scientific literature, however further research is being carried out to improve and finetune the technology.

Plant-derived products

Plant-based products are reported to have toxic (acaricidal), repellent or attractive effects. Often only low concentrations are required to act as toxicants or repellents for animals as well as the environment. The efficacy of essential oils is mainly determined by the volatile components. This means that PRM can also be affected in their hiding places, however the effect is rather short-lived. The lack of standardisation in the formulation is another drawback of these products and means acaricidal efficacy also varies between batches. Care should be taken that the products used do not have a negative effect on the hen's health or egg production. Efficacy testing of plant-derived products has mainly been done in laboratories and not in real-life, commercial poultry houses where factors such as humidity and dust also play a role. It is recommended to combine plant-derived products with other treatments to improve their efficacy because of their volatile characteristics.

Plant-based food or drinking water additives improve the health and immunity of the hens thus ensuring the hen's odour is less attractive for PRM. PRM might then feed less, moreover, starved mites seem to be more affected when acaricides or desiccants are used.

Silica-based products

Silica's are one of the few biocides that are allowed for the control of PRM. Both synthetic and natural formulations of silicon dioxide are available. While natural products are predominantly based on diatomaceous earth with a small amount of crystalline silicon dioxide, the synthetic variants are comprised of amorphous silicon dioxide only. The crystalline particles in natural silica's are more harmful to human and animal health as well as the environment than the amorphous forms. The fine dust particles are harmful to the respiratory tract, therefore there is a rise in the use of liquid as opposed to dry silica-based products to reduce these hazardous effects.

The mode of action is entirely mechanical by drying out the exoskeleton of PRM. Even with repeated treatments throughout the flock, however, silica is not sufficient enough as a stand-alone treatment against PRM. The effect of repeated treatments decreases over time, possibly due to the flock age or accumulation of dust and debris in the hen house. Removal of dust and debris prior to silica application is therefore recommended.

Evaluation of IPM

To assess the efficacy of an applied IPM strategy, and to determine whether adaptations are necessary, a good evaluation of the strategy is needed throughout the whole process. This is primarily done by monitoring the *D. gallinae* population continuously to evaluate the effect of the different treatments (preventive or curative, and non-chemical or chemical), and the IPM strategy as a whole. Apart from information on the effectiveness of a treatment, frequent monitoring also provides insight into the duration of the effect. The latter is useful to determine the cost-benefit of a certain strategy. At the stage that

IPM strategies will be implemented, the balance between efficacy and (time) costs for a strategy needs to be evaluated, including economic benefits.

The aim should thus be to develop dynamic IPM strategies, with different options under different circumstances. Also in horticulture, IPM strategies are composed in such a way, with farmers often hiring IPM advisors for a continuous follow-up and counsel regarding the IPM measures and strategy. Decru *et al*. (2020) highlights which options are available within each IPM step for the control of *D. gallinae* in layer houses, and which important knowledge gaps still need to be tackled to develop practical and efficient IPM strategies, with guidance of advisors.

PRM population kinetics according to treatment combinations at semi-commercial scale

Materials and methods

A field trial was conducted at the EPC to test combinations of the non-chemical control tools under study and to see whether or not these were effective in reducing the PRM population. The start of the experiment was planned in the middle of the flock and on spontaneous mite infestation (i.e. no artificial inoculation of PRM). The small scale semi-experiment started on 14th October 2019 and ran until 9th March 2020 after which all hens were sent off to the abattoir. The trial ran between 61 weeks and 82 weeks of age.

Table 2: Combinations of non-chemical products tested at the EPC (Del.T2.2.2)

Combination		Enriched cages (number of compartments)	Aviary type 1 (number of compartments)	Aviary type 2 (number of compartments)	Total (number of compartments)
Vaccine + predatory mites + Lentypou+	*(V + P + L)*	1			1
Predatory mites + Nor-Mite	*(P + N)*	1	1	2	4
Predatory mites + Lentypou+	*(P + L)*	1	1	2	4
Nor-Mite + Lentypou+	*(N + L)*	1			1
Q perch + predatory mites + Nor-Mite	*(Q + P + N)*		1		1
Q perch + predatory mites + Lentypou+	*(Q + P + L)*		1		1

Since the set-up was a field study (Figure 1), no true replication was possible and therefore no negative control. The evolution of the PRM numbers trapped was assessed before, during and after the trial. Two monitoring techniques were used: cardboard traps and water traps. Combinations of non-chemical products were used from the start of the trial (Table 2). Additional interventions were carried out when PRM numbers in the traps exceeded 1000 and after discussion amongst project partners.

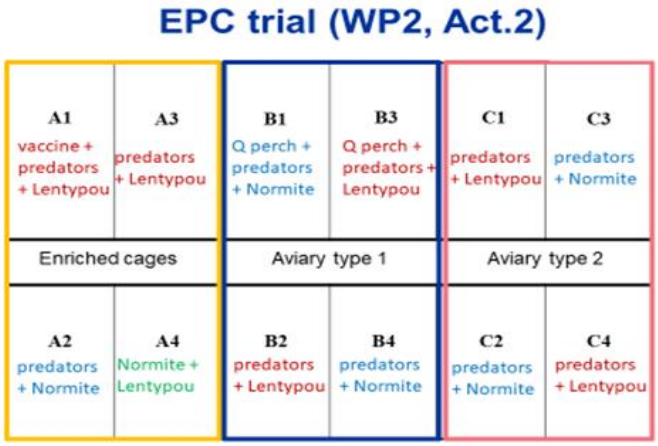


Figure 1: Floor plan of the organisation of compartments at the EPC and the respective treatment combinations tested during the WP2 trial

Results

Figures 2, 3 and 4 illustrate the mean cardboard counts in all compartments in the hen house between 11th October 2019 and 6th March 2020 for all treatment combinations. During a meeting with all PP in January 2020 it was decided to treat compartments A1, A3, B2, B4, C2 and C4 with silica.

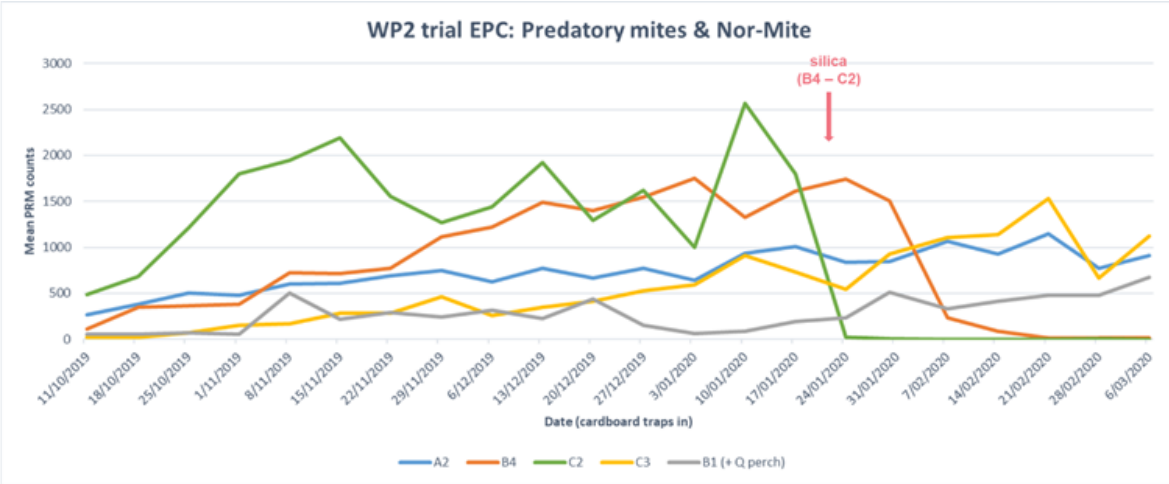


Figure 2: Mean cardboard counts in EPC compartments trialling the combination of predatory mites and Nor-Mite during the WP2 trial

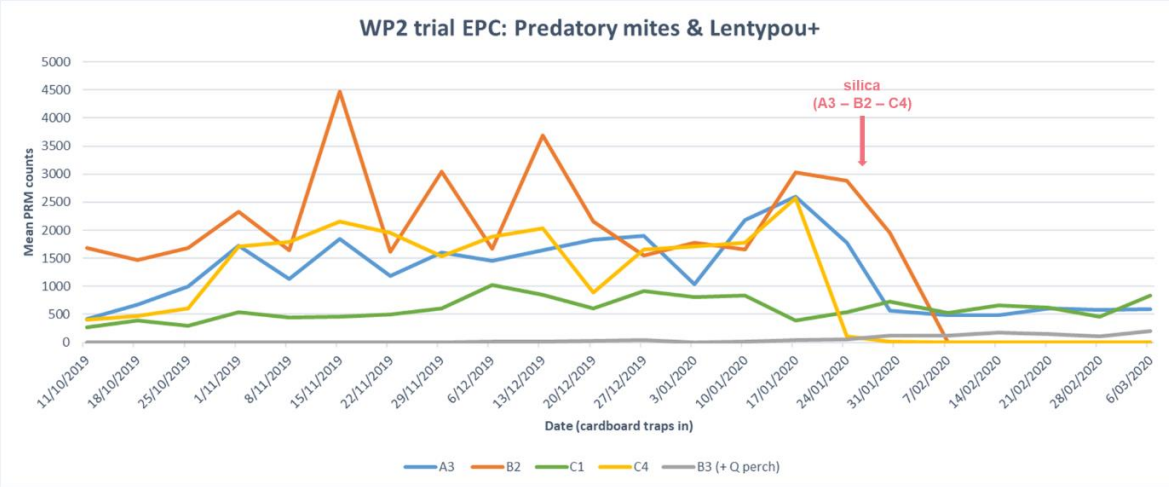


Figure 3: Mean cardboard counts in EPC compartments trialling the combination of predatory mites and Lentypou+ during the WP2 trial

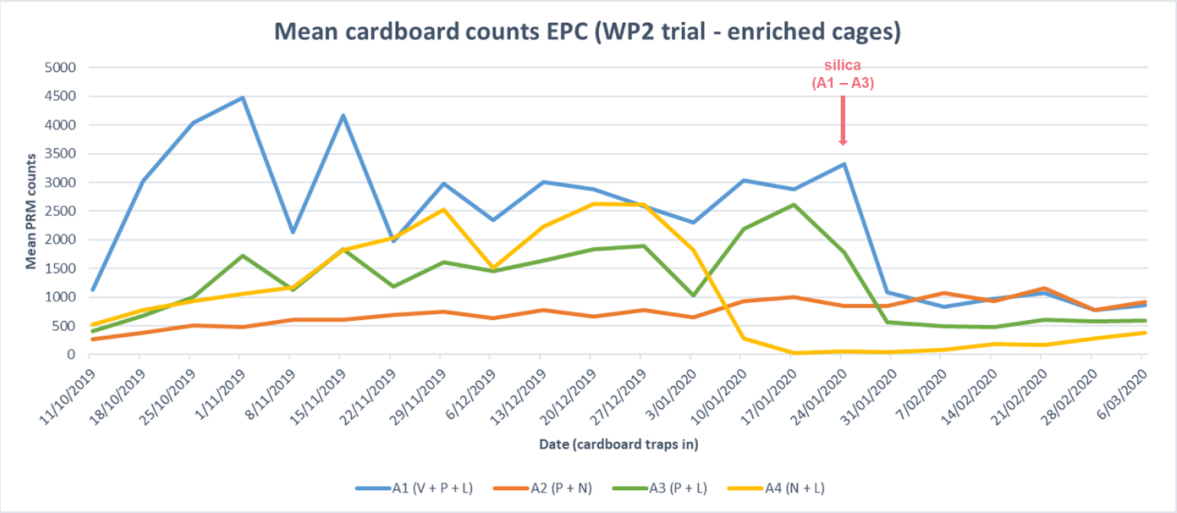


Figure 4: Mean cardboard counts in EPC enriched cage compartments trialling the combination of vaccines, predatory mites and Lentypou+ (A1); predatory mites and Nor-Mite (A2); predatory mites and Lentypou+ (A3); Nor-Mite and Lentypou+ (A4) during the WP2 trial

No significant differences were found between treatment combinations and mean PRM counts from the cardboard trap monitoring. PRM infestations were more difficult to get under control however in compartments with higher start infestations (i.e. at 61w old). After 73w/74w, it was decided by the project partners to treat seven out of twelve compartments with silica (mean PRM counts trapped > 1000). Reduction in PRM numbers trapped after the silica treatments indicate the treatment was effective (Figure 5). The silica used during the trial was a natural type, based on diatomaceous earth.

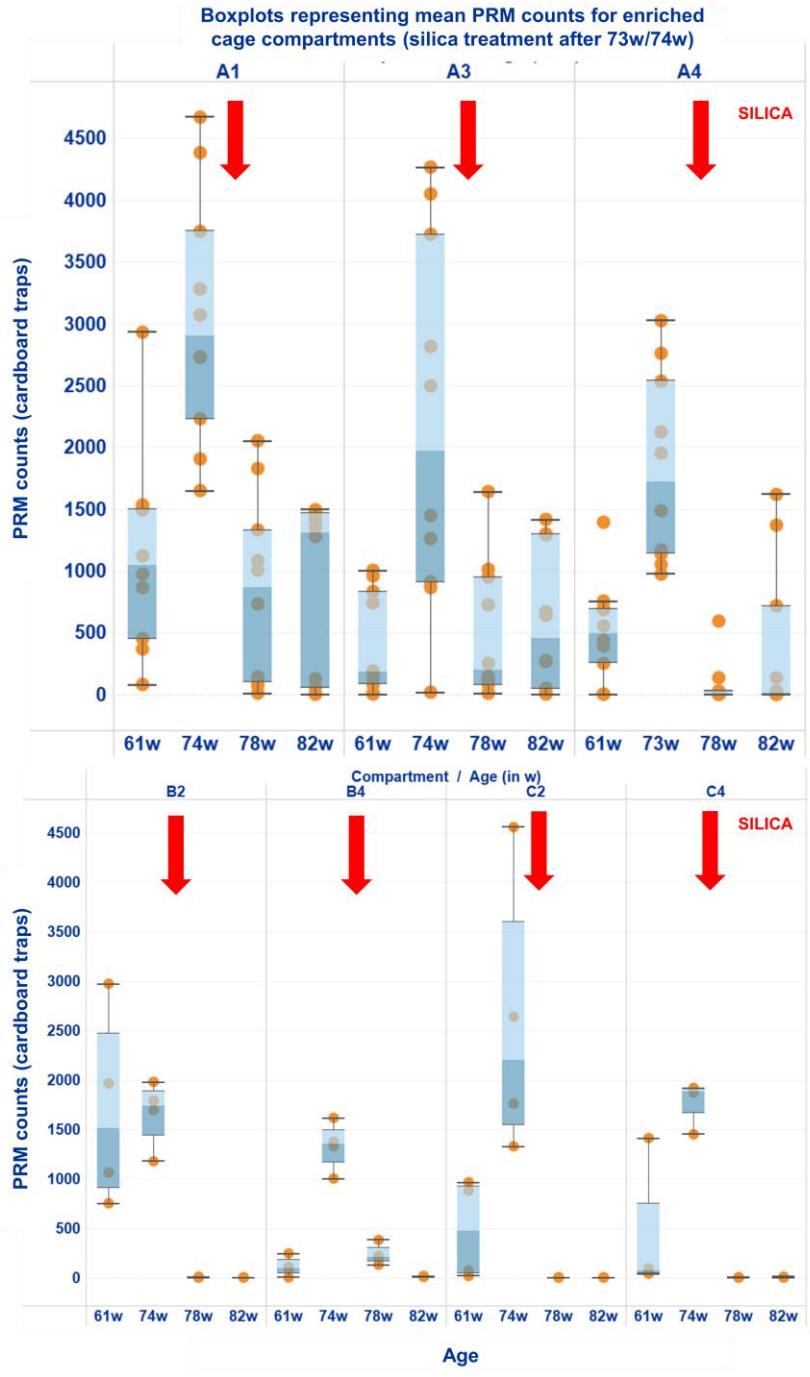


Figure 5: Boxplots representing mean PRM counts in enriched cage compartments (A1, A3, A4) and aviaries (B2, B4, C2, C4) at the start of the trial (61w), before (73w/74w) and after silica treatment (78w), and at the end of the trial (82w)

Conclusion

From the WP2 field study, no significant reductions in PRM monitoring results were found for any of the initial combinations used from the start of the trial. However, it should be noted that the trials did not start at the beginning of the flock after thorough cleaning and disinfection which reduce PRM numbers in the hen house. Instead, the trial commenced at the age of 61w by the time of which the population had already increased greatly. Silica treatment was used as an intervention when infestation increased in a compartment

(mean >1000 PRM) and proved to be effective based on the number of mites trapped the weeks after the treatment.

IPM strategies implemented on commercial poultry farms

IPM manuals

For the WP3 trials on laying farms, three IPM strategies were developed (Figure 6). Within each of the strategies, two or more products/treatments were combined.

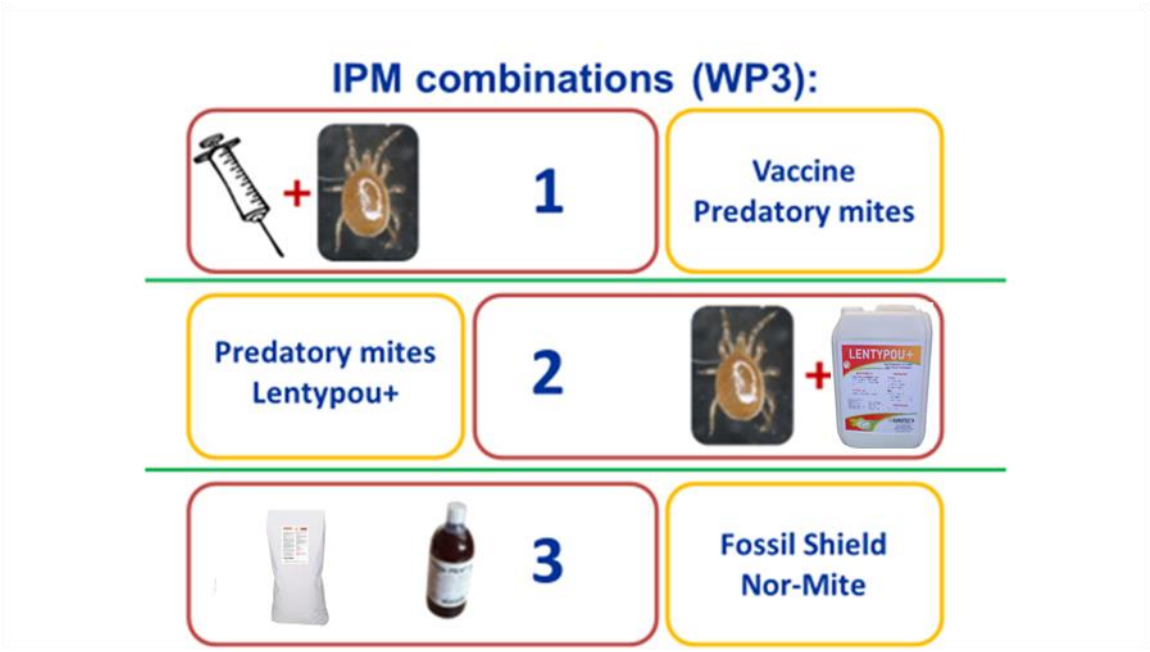


Figure 6: Combinations of non-chemical products in three IPM strategies to be tested during the WP3 pilot farm trials: IPM1 = autogenous vaccine, predatory mites (and Q perch at the EPC); IPM2 = predatory mites, Lentypou+; IPM3 = silica (Fossil Shield), Nor-Mite

The manuals contained (i) introductory information on the aim of the project and the pilot farm trials, (ii) instructions on two monitoring techniques, i.e. Rick stick and cardboard traps, (iii) IPM management actions to be carried out during the empty period, after pullet delivery and during the IPM flock, (iv) protocols for the application of preventive actions (i.e. vaccine, phytoadditives, predatory mites, silica), (v) thresholds to be used for determining whether additional action is required during the flock (with a decision tree), and (vi) recording sheets for Rick stick and cardboard monitoring.

During the IPM flock, short, monthly visits with the pilot farmers were planned. Questionnaires were conducted with the farmer to inquire about their experiences using the IPM strategy for the past month. On these visits, monitoring traps and the respective forms were collected from the farms. Where necessary, issues were discussed and together with the farmer, MiteControl partners and suppliers the protocols were adapted or revised.

After concluding the trials on layer farms, IPM2 and IPM3 were adapted for implementation on pullet farms (IPM3) and broiler breeder farms (IPM2 and IPM3).

Monitoring PRM

As stated previously, IPM is an integrated approach combining important principles such as prevention, monitoring, and the use of sustainable non-chemical treatments for pest species.

Monitoring of PRM infestations not only allows farmers to discover if PRM are present in the poultry house, but also gives an indication of the evolution of the infestation over time and enables farmers to assess the effectiveness of the actions they undertook to reduce the infestation. Monitoring is a corner stone of the IPM concept. However, it is not frequently done on farms in NWE although multiple, simple techniques are available (Table 3).

Table 3: Overview of characteristics of manual monitoring methods for PRM

Monitoring method	Quick to do?	Cheap materials?	Easy for farmer to analyse?	Provides information on spatial distribution?	Suitable for all housing systems?	Scores (categories) or numerical (weights/mite counts)?	Remarks
MMS	N	Y	Y/N	Y	Y	Score	Might be difficult to get used to in the beginning and requires experience to identify suitable monitoring points
Stick trap	Y	Y	Y	N	Y	Score	Useful method to identify when the population starts to increase but less informative as the infestation progresses
Tape trap	Y	Y	Y	N	N	Score	Useful method to identify when the population starts to increase but less informative as the infestation progresses
Corrugated cardboard trap	N	Y	N	N	Y	Numerical (counts)	The monitoring process and analysis take longer than for the methods above since counting mites is labour intensive
AviVet Red Mite TrapTM	Y/N	N	Y/N	N	Y	Numerical (weights/ counts)	Traps are purchased, which makes it more expensive than self-fabricated traps Outsourcing the analysis to a veterinarian reduces the effort required from the farmer; Veterinarian will provide results and advise on actions to take

(Y = yes; N = no)

Manual monitoring techniques

In general, the manual monitoring techniques can be divided in two categories: non-trapping methods (e.g. Mite Monitoring Score or MMS) versus trapping methods (e.g. cardboard, stick, and tape traps) (Figure 7).

The choice for a specific monitoring technique is to be made by the farmer. Routine monitoring (ideally at least once per month) is key. Some techniques that have been used during the MiteControl trials are briefly discussed below. For more detailed information,

please refer to the MiteControl webpage where more practical guidelines on monitoring are available.

Non-trapping methods

Visual assessment

These techniques rely on visual assessment alone and can technically be done without the need of any materials (apart from a pen and scoring sheet to write down the results). Farmers who have been confronted with PRM in the past, usually know where on the housing system PRM first appear. Regularly checking these spots in the poultry house is a very basic monitoring method and indicates whether PRM are present or not.
Another example is to collect some manure in a ziplock bag. Leave the bag on the floor for a few moments and then check for movement inside of it. PRM like to hide in between and under dust and manure. Movement in the bag implies the presence of PRM.

MMS

The Mite Monitoring Score (MMS) is a visual technique with a delineated protocol. At least twelve monitoring places in the hen house need to be identified and scored frequently. For each monitoring place, an area of $1m^2$ is scored. Based on the appearance of PRM a score is given between '0' (no PRM seen) and '5' (PRM aggregates (> $3cm^2$) seen in unprotected places of the housing system). The mean score gives an indication of the PRM infestation level.

Trapping methods

Some other monitoring techniques rely on installing PRM traps in the poultry house. These traps can easily be made with materials that can be found in any hardware store.

Cardboard

A piece of corrugated cardboard (8cm x 8cm) is rolled up and placed in a 10cm long PVC tube. The tube is fixed under a perch or in the support structures from the housing system with cable ties. A minimum of 12 traps are required for good reference. The plastic tube itself can remain in place throughout the entire flock. Cardboard is inserted on a regular basis (e.g. once per month) and left in the tube for 48hrs. This will allow for PRM to hide in the trap. After 48hrs, the cardboard is removed, stored individually in a ziplock bag and then frozen for another 48hrs until PRM are dead. Afterwards, PRM trapped can be counted, either manually or if many PRM are seen with image analysis software (e.g. ImageJ). The mean counts give an indication of the PRM infestation level.

Stick traps

Similar to the cardboard method, at least 12 PVC tubes of 10cm length are fixed in the poultry house. Instead of inserting a piece of corrugated cardboard, a stick is inserted. In the middel of the stick a screw is placed to ensure the stick remains in its place and the hens do not get a chance to pluck it out of the tube. Sticks remain in the tube for the entire length of the flock. Every week, they are taken out of the traps to be scored for the presence of PRM on a scale of '0' (no PRM seen) to '4' (many PRM, large clusters, huge infestation, uncountable). Immediately clean the stick and tube with a bottle brush to remove remaining PRM and re-insert the stick in the tube. The mean score of the stick traps gives an indication of the PRM infestation level.

Tape traps

This trapping method can only be used in enriched cage systems. A piece of blue painter's tape is folded around a wire or bar. Enough space should be left for PRM to crawl in the trap, so it should not be placed too tight. After one week, tear open the pieces of tape and score for the absence ('0') or presence ('1') of PRM.

Cardboard trap

(Rick) stick trap

Mite Monitoring Score (MMS)

Figure 7: Manual monitoring techniques used during the WP3 trials

No monitoring technique currently available can answer the question 'How many PRM can be found in the hen house?', but routine monitoring provides more insight into the situation and growth of the PRM population. Therefore, monitoring is important to raise awareness on the infestation levels (Table 4).

Table 4: Overview of monitoring results indicative of rough PRM infestation level on-farm

Infestation level	MMS	Stick traps	Tape traps	Corrugated card-board traps	AviVet Red Mite TrapTM
	(mean score)	(mean score)	(% of traps positive)	(mean counts)	(mean weight in mg)
Low	< 1	< 1	< 20%	1 - 250	≤ 50
Medium	1 - 2	1 - 2	20-50%	251 - 500	51 - 250
High	> 2	> 2	> 50%	> 500	> 250

Routine monitoring (at least once a month, preferably more often) is good practice. Monitoring during the MiteControl trials was done every week for stick traps/MMS and every fortnight with cardboard traps at the EPC. On commercial pilot farms, weekly Rick stick monitoring was done. Cardboard traps were initially inserted by the farmer once a month until PRM were first found. Afterwards, the frequency was increased to fortnightly cardboard trap monitoring if this was feasible for the farmer.

Automated monitoring

At the start of the MiteControl project it was hypothesised that the nigh-time activity of laying hens would increase with increasing PRM levels. In order to test the hypothesis, several infrared cameras were installed at EPC and on pilot farms in order to capture and store night time video recordings of the hens throughout the production cycle. In order to investigate the link between night-time activity and the presence of PRM, a motion detection-based algorithm was developed and subsequently deployed on 'small-scale' video data (e.g. 8 hens/cage; experimental phase) and 'large-scale' video data (i.e. semi-commercial aviaries at EPC and commercial aviaries at the pilot farms).

Analyses for the small scale video data revealed that night-time activity could be effectively quantified by the algorithm and linked to increasing PRM levels. For the large-scale video data, differences in the quantified nigh-time activity were reported when a silica treatment was involved. Therefore, the developed algorithm shows potential to be further improved into an early-warning system for PRM.

In order to develop it into an effective early-warning tool, some obstacles still have to be overcome:

- Synchronize camera with farm management practices:
    - Filter out video data when sprinkler system blocks the camera
    - Filterout video data when changes in contrast occured (e.g. dust accumulation on lens)
    - Record continuously using a Network Video Recording instead of using a Windows PC and recording software (BlueIris)
    - Storage and backing up video data
    - Setup camera to record as many birds as possible
    - Density of birds underneath a camera can change over time
- Proposed solutions:
    - Use of a docking station where the camera can be cleaned daily

      Also unload recorded video data for semi-real time processing

- Use a movable railing system in order to overcome the problem when no birds are in the field of view. This would also reduce the final cost of the early-warning system
- A good understanding of camera installation, setup and optimization

In addition, a novel monitoring method such as the automated mite counter developed by M. Mul could aid in the development of an early-warning system. The current monitoring methods (traps/MMS) are performed every week/two weeks, which makes it more difficult to link daily activity measures to weekly performed counts.

Overview of layer farm characteristics

Ten commercial pilot farms were recruited for follow-up of one production round using one of the three IPM strategies designed within the project. In addition the EPC also served as a pilot location where IPM1 was implemented in eight aviary and two enriched cage compartments. An overview with farm characteristics is provided in Table 5.

Table 5: Overview of the characteristics of WP3 pilot farm trials

IPM	IPM1	IPM2	IPM3	Remarks
N° farms	2	6	5	IPM1 was only tested at the EPC (2 housing systems)
HH (range)	6144-18280	3000-38000	3072-33430	IPM3 including 1 compartment at the EPC
N° conventional	2	2	4	
N° organic		3		
N° speciality breeds		1		
Housing system				
Aviary	1	1	2	
Free range		2		
Single tier		3	1	
Enriched cages	1		2	IPM3 including 1 compartment at the EPC
Country				
BE	2	2	1	IPM3 including 1 compartment at the EPC
FR		1	3	
UK		3	1	

The smallest flock counted 3000 hens while the largest one was comprised of 38000 birds. Apart from conventional farms, also organic and specialty breed enterprises were included in the trials. The pilot farms were selected in a manner that different types of

housing systems were considered. This was done to make sure most of the layer farm types in the Northwest Europe region were represented. However, it is important to stress that the IPM strategies were only piloted on a small number of farms. Therefore, results are not to be extrapolated or generalised, but only serve as case studies to demonstrate the observations and findings for the individual farm trials. At the end of this report, some recurring findings however are listed per IPM strategy as well as recommendations for furthering research and improving the current approaches available to tackle the issue PRM form for European poultry farmers.

Below, results from individual pilot farms are compiled per IPM strategy in order to demonstrate the differences in results between the trials. No comparisons on the effectiveness of the IPM strategies can be made since the farms are all subject to different conditions (e.g. farm type, housing system, but also external factors such as climate).

However, some interesting features that were noticed during the trials are highlighted, especially when occurring on multiple farms. Also, farmer opinions were surveyed at the end of the trials by means of an end of flock questionnaire and their perceptions on e.g. the usefulness of monitoring techniques or the perceived effectiveness of the products are briefly touched on. These are subjective opinions though that are not necessarily supported by the scientific results from the experiments carried out in light of the project and/or the monitoring results from the on-farm trials. Therefore, and since the sample size is extremely small, again these opinions cannot be generalised or considered statistically relevant.

Overview of pullet farm characteristics & results

The main project aimed at introducing and improving sustainable, non-chemical control of PRM on laying farms in NWE. However, PRM causes problems beyond the laying hen sector. However, very little to no research has been done in the past with regard to the PRM problem in other sectors of the industry. With the capitalisation (WP4), the MiteControl project was extended and the research on sustainable PRM control expanded towards two new target sectors: pullet rearing and broiler breeder farms.

ITAVI took the lead on the activity relating to PRM on pullet farms, whereas the EPC together with new PP Belgabroed developed and followed up on IPM trials on two broiler breeder farms.

Activity 1: Pullet rearing

Very little information is available on the presence of poultry red mite (PRM) on pullet farms and on the risk of dissemination to layers via transport trucks/crates. In order to improve the understanding and knowledge on these issues, a study was conducted to assess the PRM population in pullet farms and to evaluate the risk of introduction of PRM in layers via pullet transport in order to propose solutions to reduce the risk of transfer of PRM populations in layers. The action plan was the following:

- Completing surveys by a diversity of actors (including farmers) to receive feedback on the PRM problem in the rearing sector
- Monitoring and evaluating the PRM control strategy in 11 farms
- Implementing an IPM strategy if the current PRM control strategy is non-satisfactory

Results of the pullet farmer questionnaires

Eight farmers were interviewed in the West of France and four in Belgium, with various sizes of farms, buildings and production systems (Table 6). Only three farms reported a history of PRM infestation. Results from the farmer questionnaires are presented below.

Table 6: Overview of pullet farms surveyed and/or monitored

Farm ID	Country	Nb of pullet houses	Nb of pullets	Laying houses?	Production system	PRM history?
Poul1	FR	1	18626	No	Barn flat deck	No
Poul2	FR	12	251000	Yes	Barn flat deck	No
Poul3	FR	12	251000	Yes	Barn flat deck	No
Poul4	FR	3	52000	No	Barn flat deck	No
Poul5	FR	2	60000	Yes	Free-range aviary	No
Poul6	FR	2	87000	Yes	Enriched cage	Yes
Poul7	FR	1	20440	No	Barn flat deck	No
Poul8	FR	1	34000	No	Barn flat deck	No
BE_R1	BE	1	30000	No	Conventionnal cages	Yes
BE_R2	BE	3	57000	No	Conventional cages/barn aviary	No
BE_R3	BE	1	31200	No	Conventional cages	Yes
BE_R4	BE	3	44000	No	Barn aviary	No

Information about PRM problems in pullet rearing

In the three farms with a historic infestation, PRM appeared only from 3 months of age:

- Poul6: On every flock, on feed and drink lines, cages structures, staff complains.
- BE_R1: On 3 out of the 10 previous flocks PRM were seen on the manure belt and structures of housing system
- BE_R3: On 9 out of the 10 previous flocks PRM were seen, but not anymore after treatment with Exzolt. Historic infestation of 30 years on the farm where in the past PRM were seen on feed and drinking lines and structures of the housing system.

Five French farms, including Poul6, found that crates were sometimes dirty (e.g. feathers, broken eggs, droppings). This was not a frequent finding and depended on the

transporter. Other farms did not report that crates were dirty. Farmers did not report PRM on crates (one respondent did not know). Only three French farms (and not Poul6) report that trucks were seldom dirty. No complaints from laying farms were reported except from one Belgian farm (BE_R3).

PRM monitoring on pullet farms

No monitoring was performed by pullet farmer respondents in France. However, in Belgium, farmers were already using one or several monitoring methods. Three Belgian farmers were already using cardboard traps, two performed visual checks every two weeks, and one collected manure in a plastic bag. On BE_R3, the farmer was always perceptive for presence of PRM.

Control methods applied on pullet farms

PRM control strategies should include preventive (e.g. biosecurity measures, cleaning and disinfection during the empty period) and curative actions (non-chemical or as a final resort the use of chemical products). Respondents were surveyed on which measures they were already taking against PRM. The effectiveness was estimated for treatments done during the flock (presence of mites) on a scale from 1 (not effective) to 5 (very effective). The most important findings are summarized below.

- All farmers performed a wet cleaning of the pullet house and a disinfectant.
- During empty period:
    - Poul5 and Poul8 used a disinfectant twice
    - All but Poul6 use an insecticide against litter beetles (Elector, Alphi, QuickBayt, Topkill, Mystic, Mefisto Shock).
    - BE_R1, BE_R2 and BE_R3 use silica (BE_R1 not for every flock, BE_R2 every flock, on BE_R3 silica was used in the past).
- During the flock:
    - Poul6 treats at 13-14 weeks when first PRM are seen with Byemite (1 time 400 €, effectiveness perceived by farmer 4/5)
    - BE_R1: Exzolt at 12 weeks (effectiveness 4/5)
    - BE_R3: Exzolt at 14 weeks (effectiveness 5/5)

Monitoring, evaluation of PRM control strategies and transmission risk to hen farms in the rearing sector

The objective of this first part was to check the state of PRM infestation in the pullet houses with monitoring, evaluate the current control methods and evaluate the transmission risk to the laying houses. The previous farms that responded to the questionnaire (except Poul8) were included in the first part of the study. Monitoring on BE_R2 and BE_R4 farms was done in two pullet houses. On all other farms, monitoring was done in one house.

Monitoring of PRM populations in the houses was done at least once at the end of the flock (due to HPAI) and if possible monthly throughout the whole flock. The cardboard trap method was essentially used for monitoring. Water traps, being an attractive trap have also been used in some trials in order to increase the chance of capturing PRM. In

total, ideally 24 traps were placed per house. First traps were placed upon arrival of the chicks and replaced on a monthly basis until the end of the flock.

Transport of pullets to the layer house

If PRM were found during the monitoring (more than 5 PRM per cardboard trap), a transport follow-up was also done. If no or very few mites were found, the transport follow-up was optional.

Four transport follow-ups were done in the farms Poul6 (PRM found during the monitoring), BE_R1, BE_R2, and BE_R4 (prior to the start of the monitoring trial). On the three latter no or very few mites were found and no additional treatment was implemented.

Two types of sampling took place:

- Before loading of the pullets: evaluation to see if the transport alone was a risk factor for the dissemination of PRM:
    - Visual check of the cleanliness
    - 10 swabs from crates
    - 10 swabs of the floor of the truck
- After the pullets were loaded to see if mites were transferred from a ¨R% positive pullet flock to a hen house:
    - 10 swabs from crates
    - 10 swabs of the floor of the truck

In case PRM were found, they were counted and sent to the University of Montpellier for genetic analysis.

Results from monitoring trials on pullet farms

An overview of the monitoring results on the pullet farms are presented in Table 7 below.

The results of this study were the following:

- The PRM monitoring revealed only 3 houses out of 14 that were positive (Poul6, BE_R2 (house 1), and BE_R4 (house 3) on the second flock). On the three that were positive for PRM, only Poul6 had a significant PRM problem showing an inappropriate control, on the two other farms only a few PRM were found.
- For BE_R2, BE_R3 and BE_R4, either only a few PRM were found and/or the farmers reported a history of PRM. These farmers did an application of silica (not necessarily at every empty period) which is a control action against PRM. Moreover, BE_R1 and BE_R3 have used Exzolt in past flock(s) when the PRM pressure was high. The control method set in place was an IPM strategy which allowed them to keep the PRM populations under control and limit the use of chemical products.
- BE_R4 did not yet take action against PRM in the past other than the standard approach of cleaning and disinfecting during the empty period. No PRM were seen in the past. At the end of the second monitoring trial on BE_R4, one single PRM was found. Therefore, the farmer was advised to continue monitoring as they already did prior to the MiteControl trials and to adapt control actions in case the PRM population rises.

- All other farms did not implement a lot of control actions, nor practice monitoring. However, no PRM were found during the trials. It is advised for them to start monitoring PRM at the end of the flocks.

In conclusion, only Poul6 had a PRM issue with an unsatisfactory control method. For Poul6, PRM were also found during transport. Before loading of the pullets, PRM were present. The truck was not cleaned properly before collecting the pullets. The day before, the truck had transported pullets from a different pullet house on the same farm which also had PRM problems. After loading of the pullets, more PRM were seen than before. As a result, it could be concluded that the risk does exist that a pullet house with a PRM infestation can contaminate a laying house.

It is advised that cleaning the truck and equipment is essential after transport and that a pullet house with a PRM infestation must take action to avoid contaminating the laying house.

Table 7: Results from monitoring trials on pullet farms

Pullet house code name	Country	Production type	Number of cardboard traps	Number of water traps	Number of monitoring per flock	PRM found?	Transport follow-up?
Poul1	FR	Flat deck	24	0	1	No	No
Poul2	FR	Flat deck	24	0	1	No	No
Poul3	FR	Flat deck	10	10	3	No	No
Poul4	FR	Flat deck	12	12	2	No	No
Poul5	FR	Aviary	12	12	2	No	No
Poul6	FR	Cage	10	10	2	Yes (1800 mites/trap)	Yes
Poul6 bis	FR	Cage					
Poul7	FR	Flat deck	12	12	3	No	No
BE_R1	BE	Cage	0	8	1	No	Yes
BE_R2 (house 1)	BE	Aviary	10	0	1	Yes (<1 mite/trap)	Yes
BE_R2 (house 2)	BE	Aviary	10	0	1	No	Yes
BE_R3	BE	Cage	24	12	4	No	No
BE_R4 (house 2)	BE	Aviary	12	0	4	No	No
BE_R4 (house 3)	BE	Aviary	24	0	4	No	No

On BE_R3 and BE_R4 a second flock was followed up with monitoring – the results are presented below in Table 8.

Table 8: Follow-up of consecutive flocks on BE_R3 and BE_R4

Farm ID	Number of cardboard trap	Number of water traps	Number of monitoring during the flock	PRM found?	Transport follow-up?
BE_R3	15	0	3	No	No
BE_R4 (house 3)	24	0	3	Yes (<1 mite/trap)	No

Conclusion of the monitoring trials

After finishing the monitoring trials, on Poul6 an IPM approach was implemented to reduce PRM infestation. Since no or very few PRM were found on the remaining pullet farms that took part in the study, no IPM approaches were implemented elsewhere. The standard approach of the pullet farmer with regard to PRM control was considered to be efficient. Therefore no further treatments were warranted.

Overview of broiler breeder farm characteristics

Selection of broiler breeder farms

For WP4, Belgabroed joined the consortium as project partner to aid with the selection and follow-up of the IPM strategies tested on two broiler breeder farms in Belgium. For this purpose, two breeder farms were found with a known PRM history.

BBr1 is located in the province of East-Flanders. The farm consists of four houses for broiler breeders, housing 15.000 (house 1), 6.000 (house 2), 6.000 (house 3) and 18.000 (house 4) birds respectively. In total, approximately 47.000 are kept. Placement of the IPM flock was on 23/03/2022. House 2 was followed up as the IPM flock.

BBr2 is located in the province of Antwerp. The farm is comprised of three poultry houses for broiler breeders, housing 10.000 birds per house. In total, approximately 30.000 hens are kept. Placement of the flock was on 30/03/2023. House 3 was followed up as the IPM flock.

Both are conventional farms, housing the birds in flat deck systems.

IPM strategies trialled on broiler breeder farms

The basis of the IPM strategies trialled on the broiler breeder farms remainded the same as for the WP3 trials. Preventive actions during the empty period included the same protocol for thorough cleaning and disinfection. The cleaning and disinfection protocol was already carried out on both farms as standard actions during the empty period. Monitoring was done throughout the flocks to follow-up on the PRM infestation and to be able to estimate the effect of the treatments applied. On BBr1 farm, 14 cardboard traps

were placed and the farmer was asked to perform weekly monitoring. This was decided because cameras were installed in house 2 for the purpose of video recording for the development of the automated monitoring system (led by KU Leuven). On BBr2 farm, 12 cardboard traps were placed and the farmer was also asked to do a weekly visual assessment in order to keep a close watch on the PRM infestation. For this purpose, the Mite Monitoring Score (MMS) protocol was slightly adapted to limit the time needed by the farmer to carry out the visual monitoring.

The IPM strategy implemented on BBr1 was IPM2 with the combination of predatory mites (4 releases during the flock) and Lentypou+ (supplemented via drinking water.

The IPM strategy implemented on BBr2 was IPM3 where Fossil Shield Instant White was applied before placement. Because in the WP3 trials on some farms where Nor-Mite was used there were issues with the formation of biofilm in the drinking lines due to suboptimal maintenance, it was ultimately decided not to include Nor-Mite in the current IPM3 strategy to limit the risk of problems with biofilm arising in the broiler breeder flock.

Case study results from the IPM trials

In the next section, results from individual pilot farms are compiled per IPM strategy in order to demonstrate the differences in results between the trials. No comparisons on the effectiveness of the IPM strategies can be made since the farms are all subject to different conditions (e.g. farm type, housing system, but also external factors such as climate). Moreover, the trials were conducted in different sectors: on 10 commercial laying farms, at the EPC, on two broiler breeder farms and on one pullet farm. The trials are therefore considered to be case studies and results can therefore not be extrapolated to other farms or be generalised.

However, some interesting features that were noticed during the trials are highlighted, especially when occurring on multiple farms or in multiple sectors. Also, farmer opinions were surveyed at the end of the trials by means of an end of flock questionnaire and their perceptions on e.g. the usefulness of monitoring techniques or the perceived effectiveness of the products and briefly touched on. These are subjective opinions though that can often not be supported by the scientific results from the experiments carried out in light of the project and/or the monitoring results from the on-farm trials. Therefore, and since the sample size is extremely small, again these opinions cannot be generalised or considered statistically relevant.

Results IPM1 trials: Autogenous vaccine & predatory mites (+ Q Perch®)

Case study 1: Enriched cages at the EPC

Effect of actions on PRM monitoring (Figure 8)

- Cardboard monitoring was carried out fortnightly from the start of the flock
    - 10 traps per compartment
- IPM1 (vaccine + predatory mites) was trialed in compartments A1 and A3
    - 3072 per compartment → 6144 hens in total

- Not enough doses of vaccine available, so IPM3 (Fossil Shield + Nor-Mite) was trialed in compartment A2

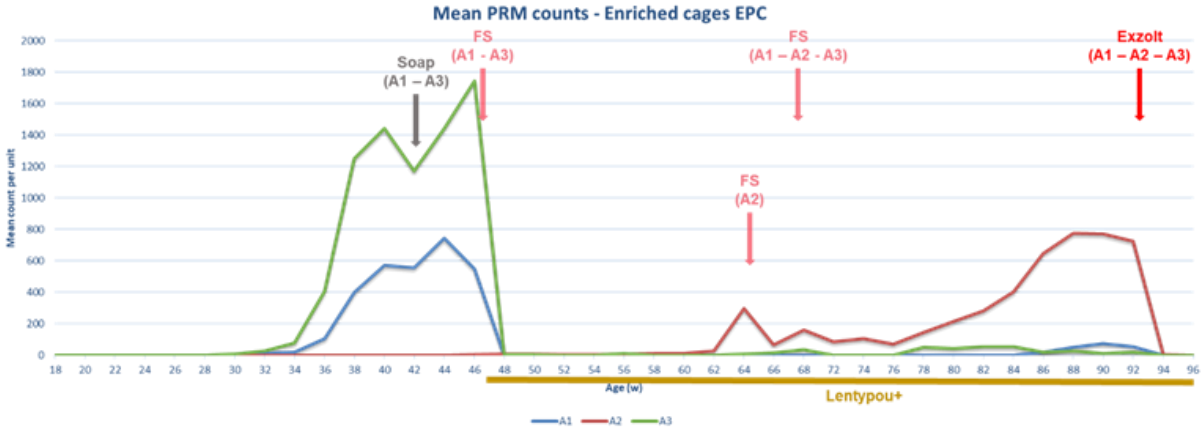


Figure 8: Mean monitoring results (cardboard counts) for the enriched cage compartments at the EPC and actions or treatments carried out for the control of PRM

- A1 & A3:
  - An increase in PRM monitoring was visible from the age of 32w
  - Soap was sprayed at 40w but had only very little effect
  - The first Fossil Shield (FS) application was carried out at 47w and from then on Lentypou+ was added to the drinking water
    - No more predatory mites were released after 47w of age
    - Additional FS treatments kept the PRM infestation under control until the end of the flock
  - Before depopulation Exzolt was used in all enriched cage compartments (at 92w and 93w of age)

Based on the monitoring results, only Exzolt and Fossil Shield had a clear and immediate effect reducing the PRM population.

Perception of effectiveness by animal caretakers at the EPC

The animal caretakers are responsible for the daily care of the hens, applying IPM products and carrying out monitoring. Therefore, monthly meetings were organised where the IPM questionnaires were conducted. At the end of the flock, the end of flock questionnaire was conducted together with them as well. Based on what they witnessed in the hen house and the monitoring results throughout the flock, Exzolt was considered to be most effective, followed by FS and cleaning by spraying soap. The perceived effect of predatory mites, the autogenous vaccine and phytoadditives (i.e. Lentypou+ and Nor-Mite) was more difficult to establish.

Case study 2: Aviary systems at the EPC

Effect of actions on PRM monitoring (Figure 9 & Figure 10)

- Two types of aviary system (8 compartments in total)
  - Type 1 = 1920 hens per compartment (7680 hens in total)
  - Type 2 = 2650 hens per compartment (10600 hens in total)
  - Both type 1 and type 2 systems = 10280 hens

- Cardboard monitoring was carried out fortnightly from the start of the flock
    - 10 traps per compartment
- Aviary type 1:
    - IPM1: combination vaccine + predatory mites was trialed in compartments B2 and B4
    - IPM1: combination vaccine + predatory mites + Q perch® trialed in compartments B1 and B3

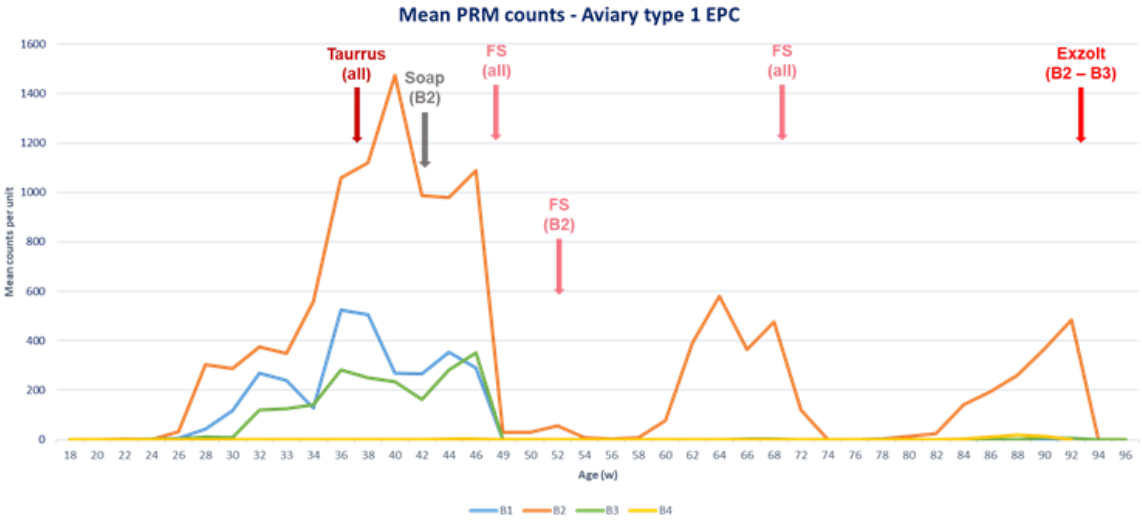


Figure 9: Mean monitoring results (cardboard counts) for the aviary type 1 compartments at the EPC and actions or treatments carried out for the control of PRM

    - The earliest increase in PRM monitoring numbers was seen in B2 at around 26w of age, in B1 an increase was seen from 28w and in B3 from 32w
        - B1 and B3 are equipped with a Q perch® which at first sight could explain why the increase in PRM was captured later on and why PRM infestation stayed lower throughout the flock (compared to B), however…
        - B4 had consistently low PRM monitoring results throughout the entire length of the flock while the same IPM approach was used here as in B2
        - An additional release of Taurrus at 37w of age was not clearly effective
        - After application of FS, the PRM infestation in B1, B3 and B4 remained low for the remainder of the flock
        - Lentypou+ was supplemented via drinking water starting from 47w
        - In B2 (highest infestation before FS application) the PRM infestation was more difficult to control as can be seen from the monitoring results: PRM counts increased more rapidly
        - Exzolt was used in B2 and B3 at the age of 92w and 93w and was very effective in reducing the PRM counts
- Aviary type 2:
    - IPM1: combination vaccine + predatory mites was trialed in compartments C1, C2, C3 and C4

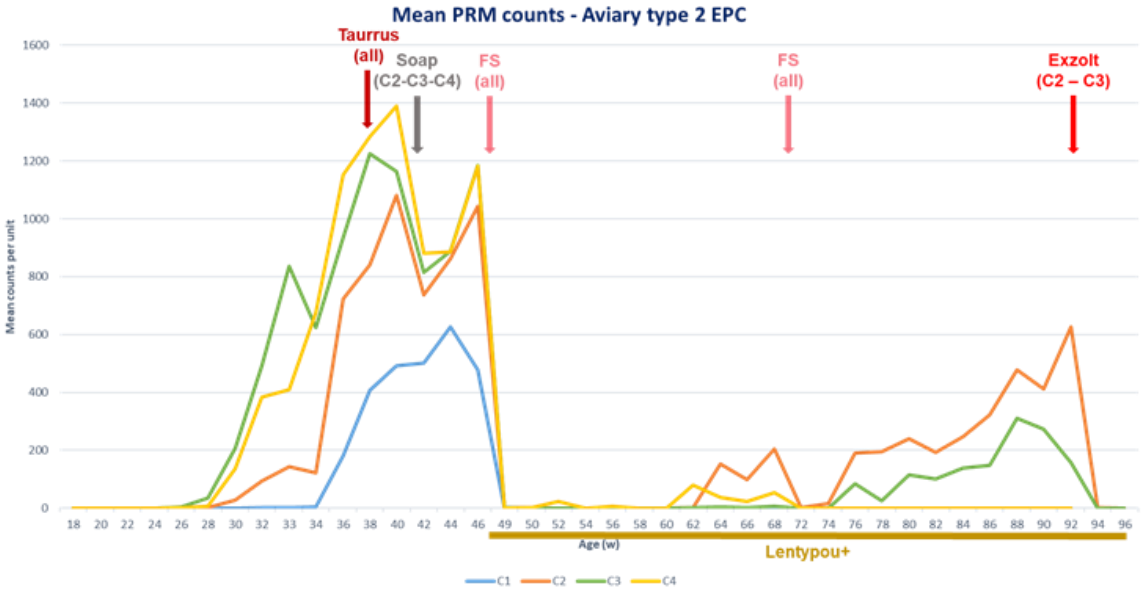


Figure 10: Mean monitoring results (cardboard counts) for the aviary type 2 compartments at the EPC and actions or treatments carried out for the control of PRM

- The earliest increase in PRM monitoring numbers was seen in C3 and C4 at around 26w of age, in both compartments PRM counts increased rapidly
    - An additional release of predatory mites at 37w was not effective in reducing PRM counts
    - Soap used in C3 and C4 showed only a limited effect
    - At 47w FS was applied by which PRM counts in the traps were almost brought back to 0 (from this moment on, Lentypou+ was supplemented via the drinking water)
        - PRM counts remained very low in C4 for the remainder of the flock, while in C3 counts increased more rapidly (particularly from the age of 74w)
    - Exzolt was used in C3 (not in C4) at 92w and 93w and was very effective in reducing PRM counts
- An increase in PRM counts in C2 was apparent from the age of 30w and although the initial large increase was seen later than for C3 and C4, the monitoring results showed a similar pattern for C2
    - A release of predatory mites at 37w generated no real reduction in PRM counts
    - Applying soap had only a very brief effect on the monitoring results
    - FS applied at 47w was effective to reduce PRM counts, however it was reported by animal caretakers that local clusters of PRM were formed again and it was more difficult to control PRM infestation in C2
    - Exzolt was used at 92w and 93w of age and was very effective based on PRM counts
- The PRM counts in C1 started to quickly increase from the age of 34w

- The monitoring results in C1 never quite reached the same level of the other aviary type 2 compartments
- At 47w FS was applied and turned out very effective in reducing PRM counts and for the remainder of the flock in C1 PRM counts stayed low

Perception of effectiveness by animal caretakers at the EPC

Similar as for the enriched cage compartments, Exzolt was considered to be the most effective treatment, followed by FS and cleaning by spraying soap. However, the effectiveness of predatory mites and the autogenous vaccine was difficult to establish since an increase in PRM monitoring results was seen early on after which it was decided to apply Fossil Shield and keep supporting the hens themselves with phytoadditives through the drinking water.

Results IPM2 trials: Predatory mites & Lentypou+

Case study 1: BE1

- Conventional farm
- Aviary
- 2 floors
- 19000 hens per floor → 38000 hens in total
- IPM2 (predatory mites + Lentypou+)

Effect of actions on PRM monitoring (Figure 11)

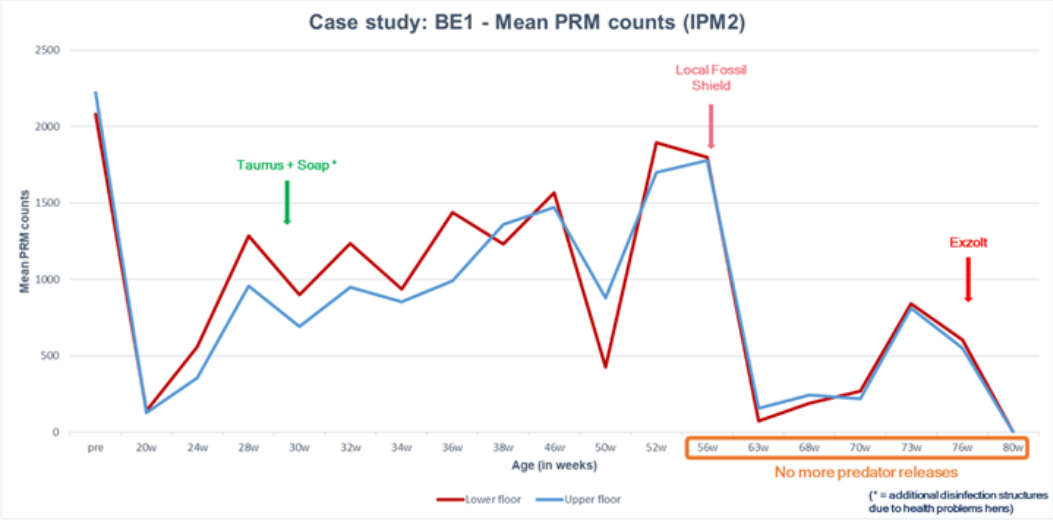


Figure 11: Mean monitoring results (cardboard counts) for farm BE1 and additional actions or treatments carried out for the control of PRM outside of the predefined protocol

- The PRM infestation was already high early on although the farmer used the cleaning protocol (with wet cleaning) provided by the MiteControl researchers
- Wood abundant in the hen house, difficult to clean
- Rapid increase in PRM counts (from 24w)
- Cleaning with soap + release of extra predators in the whole hen house at 31w old

- Due to health issues (severe E. coli + pecking) the farmer used additional products in the hen house and on the material, however this did not seem to effect the PRM counts but it is not known what the effect was on predatory mites
- Because of severe pecking and cannibalism, hens were housed under red light from approx. 32w old until the end of the flock

- The farmer continued to use Lentypou+ and to release predatory mites on a monthly basis (Androlis®)
  - Due to problems with breeding the predators, no predatory mites were released on-farm after 56w old and an alternative had to be found for the predators
    - The farmer was willing to carry out a local treatment with silica at 62w which appeared to be very effective according to the PRM counts although it is well-known that only a local treatment is far from ideal
    - Lentypou+ was continued until the end of the flock
    - Exzolt was applied at 76w and 77w and was very effective

Perception of effectiveness by the farmer

The farmer considered Exzolt as most effective, followed by silica (although this was only applied locally in the hen house) and soap. The farmer was unsure about the effectiveness of predatory mites and Lentypou+.

Case study 2: BE2

- Organic free range with wintergarten
- 1 house
- 15000 hens
- IPM2 (predatory mites + Lentypou+)

Effect of actions on PRM monitoring (Figure 12)

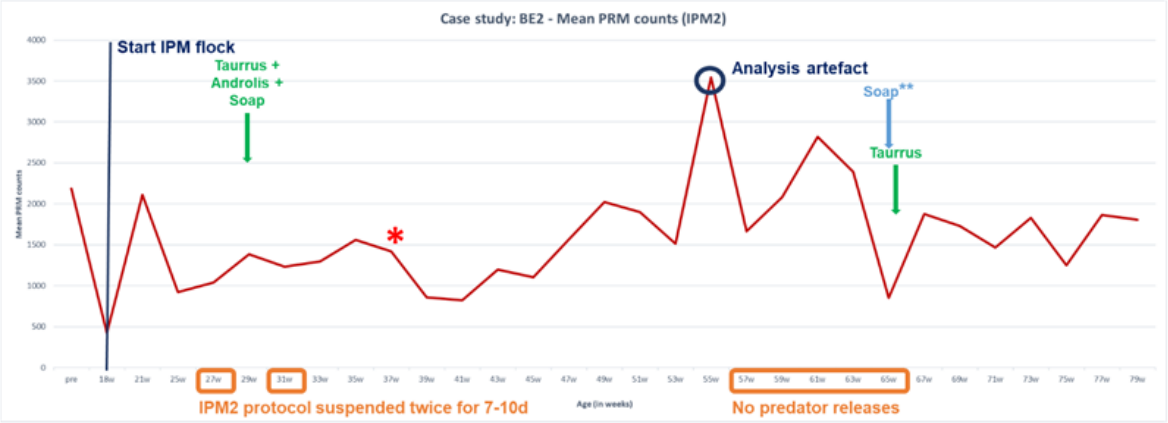


Figure 12: Mean monitoring results (cardboard counts) for farm BE2 and additional actions or treatments carried out for the control of PRM outside of the predefined protocol

- PRM infestation was already high early on (mean > 2000 at 21w old)
- Additional release of predatory mites at 29w had no clear effect

- Health issues were seen from the start of the flock and were very difficult for the farmer to get under control, therefore the MiteControl protocols were suspended for 7-10d on two occasions to prioritise the health and welfare of the hens
- From 37w the hens were confined due to HPAI and had to remain indoors until 62w
    - During this period the farmer tried not to cause any unnecessary stress to the birds
    - The farmer adapted the Lentypou+ protocol according to the needs of his own flock and increased the frequency from 49w onwards (2 days of Lentypou+ every 2 weeks)
- Due to issues with the breeding process of the predatory mites, no predators were released between 57w-65w
    - No silica was used to replace the predatory mites
    - Prior to releasing Taurrus again at 65w, the farmer sprayed soap on the housing system (mostly near the nest areas and egg belts)

Perception of effectiveness by the farmer

The farmer was satisfied with the effect of Lentypou+ but was skeptical with regard to the effectiveness of the predatory mites. Local cleaning with soap was perceived as effective, but only a temporary relief. The farmer indicated they wanted to keep using Lentypou+ in future flocks.

Monitoring with cardboard traps generated useful information for the farmer.

Case study 3: FR1

- Organic farm
- 1 house
- 9270 hens
- IPM2 (Predatory mites + Lentypou+)

Effect of actions on PRM monitoring (Figure 13)

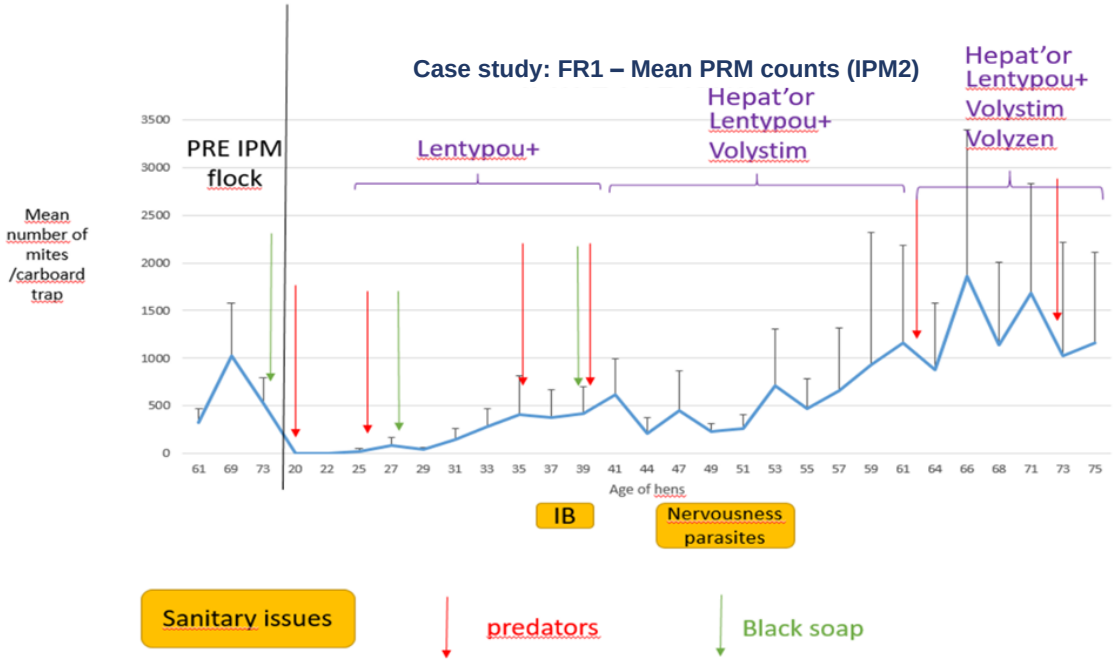


Figure 13: Mean monitoring results (cardboard counts) for farm FR1 and actions or treatments carried out for the control of PRM

- An increase in PRM counts first became visible via monitoring around 25w of age
- Perches were cleaned with water and soap at 27w
- Because PRM counts kept increasing, additional predator releases were done at 35w and 39w
    - At 39w also perches were cleaned again with water and soap
- PRM counts reached a peak at 61w after which an additional release of predators was scheduled again (at 62w)
- Since PRM counts kept increasing in the Summer period, another release of predators happened at 73w
- Management actions that had an effect of reducing the PRM population such as the removal of manure crusts (6 times) and dust from the nest areas (3 times) were carried out throughout the duration of the flock

Perception of effectiveness by the farmer

In the opinion of the farmer, the IPM strategy had been effective in the control of PRM on their farm. In their experience, both Lentypou+ and predatory mites as well as cleaning with soap were effective. From the two products in the combination, the farmer was most satisfied with Lentypou+ and indicated they were planning to keep using it for future flocks.

Monitoring generated useful information for the farmer, in particular Rick sticks were rated highest.

Case study 4: UK2

- Organic

- 2 houses: in one IPM2 was implemented, the second served to compare IPM vs no-IPM ('control')
- 3000 hens (trial flock) + 3000 hens (control)
- IPM2 (Predatory mites + Lentypou+)

Effect of actions on PRM monitoring (Figure 14)

- First PRM spotted in IPM2 flock at 21w of age
- Mean PRM counts in the IPM2 house started to increase at 24w old and peaked at 31w
    - Between 24w and 51w, PRM counts in the IPM2 house were consistently higher than the control house
    - Use of the IPM2 products did not appear to affect the growth
- An additional course of Lentypou+ was given in response to rising PRM
- At 27w a soap solution was sprayed on hotspot areas (nest box lids and around perches)
- At 31w an additional release of predators scheduled (Taurrus around nest boxes, Androlis around slats paying attention to where PRM clusters could be found)
- From 32w on PRM counts declined in the IPM2 house
- At 34w slow release bottles of predatory mites hung up on perches
- An extra two days of Lentypou+ was scheduled in response to health issues
- Soap was sprayed for hotspots between 40w and 52w (local: perches, egg belt lids, in-between slats)
- From around 50w, PRM counts were comparable for the two houses
    - The decline in mean PRM counts matched the reduction in observed in-house temperature, so it is likely that the temperature was the primary driving factor for this change in PRM population growth
- Additional predatory mites in slow release bottles hung up on perches
- Both flocks were depopulated early (at 69w) due to health and performance issues
- Entering Spring and Summer, mean PRM counts remained low in both flocks suggesting that the IPM strategy may offer similar protection to the diatomaceous earth product used in the control flock towards a later part of the flock cycle
    - Impossible to say whether that trend would have continued as the temperatures increased since the flocks depopulated early

Perception of effectiveness by the farmer

The farm manager was content with the level of PRM control provided by the IPM strategy. They believed that both the treatment products trialed had an effect in keeping PRM infestations under control in the trial flock. Predatory mites were thought to be more effective than Lentypou+ although the farm manager stated that it was difficult to determine which treatment product was most effective. Monitoring of PRM via the traps was thought to be useful, particularly for identifying problem areas and the farmer is considering using the monitoring methods for future flocks.

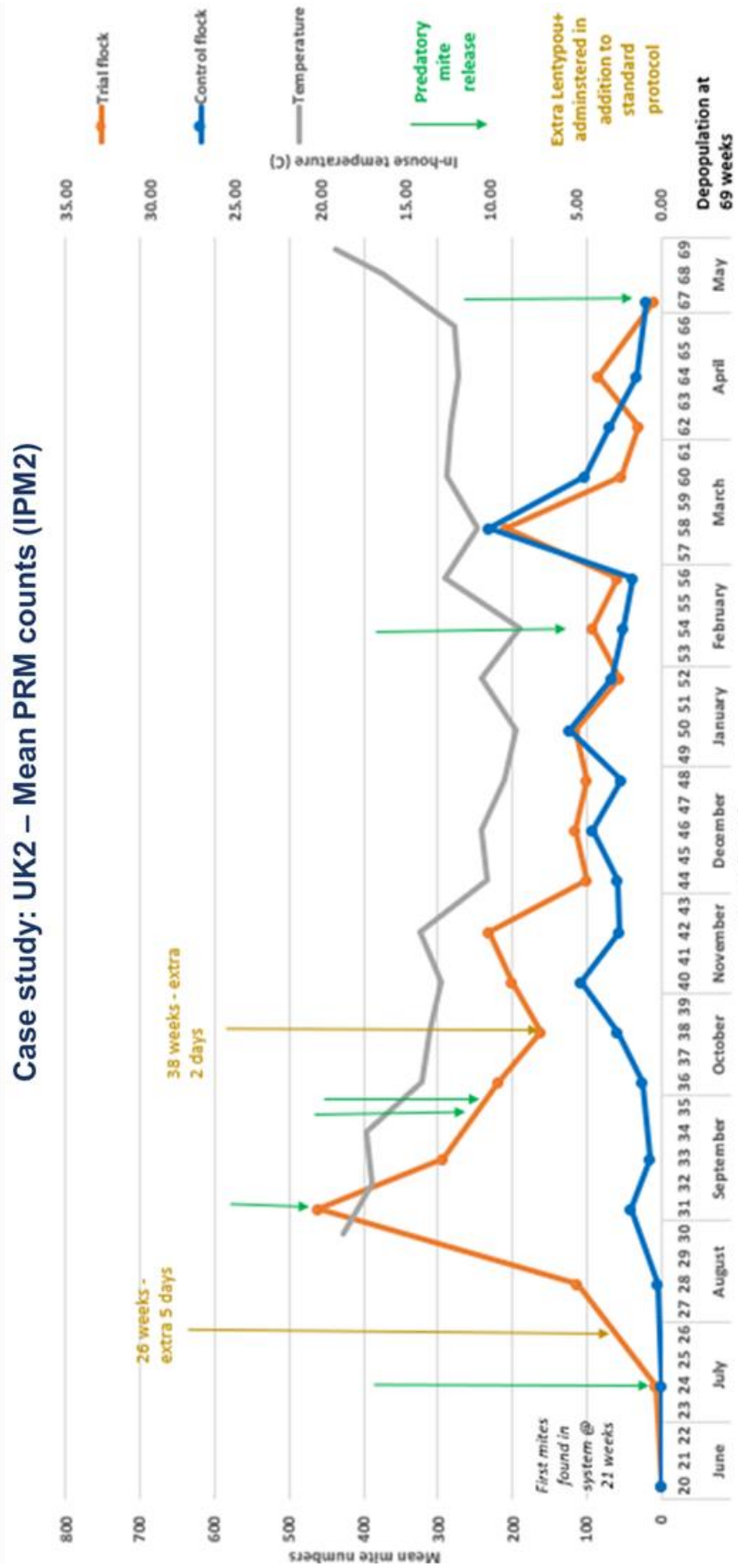


Figure 14: Mean monitoring results (cardboard counts) for farm UK2 and actions or treatments carried out for the control of PRM

Case study 5: UK3

- Flat deck, mobile shed
- 3000 hens (trial flock)
- IPM2 (Predatory mites + Lentypou+)

Effect of actions on PRM monitoring (Figure 15)

- PRM were first found in the Rick stick traps at the age of 29w but not yet observed in the poultry house
- At 36w, PRM were found in the cardboard traps and a very small number of PRM were present in the feed track perch supports
    - PRM mean counts in the cardboard traps were maintained at very low levels up until the birds were 40w old after which temperature started to rise as Summer months approached
- PRM in the traps and observed in the hen house increased, particularly around the perches at 44w
    - Additional treatments were discussed but as predatory mites had been released at 39w, it was decided that no further action was needed
- At 52w, 56w and 60w, water and soap were sprayed on hotspot areas, particularly around the perch supports and inside the edge of the nest boxes
- Subsequent releases of predatory mites and the continued use of Lentypou+ were not effective in preventing a substantial increase in PRM mean counts reaching a peak when hens were aged 56w
    - As temperatures decreased, PRM mean counts also decreases until they reached similar levels observed in the pre-IPM flock at a comparable time during the previous year
- Depopulation of the trial flock aged 77w – PRM levels in the house and in the traps had reduced substantially since the peak in September (around 56w)

Perception of effectiveness by the farmer

The farmer believed that the IPM strategy was effective in keeping PRM infestation under control in the trial flock. However, the farmer thought that the chemical acaracide sprays used in previous flocks was more effective in managing PRM infestations levels. Monitoring for PRM using the traps was effective in identifying PRM before mites were observed in the poultry house and equipment (6 weeks before) and the farmer believed that the monitoring methods were informative and helpful for allowing earlier control actions to be taken. However, using the monitoring methods throughout the flock cycle took over 24 hours and the time commitment required was difficult for the farmer during certain periods of the year. Considering the performance of the IPM strategy and cost compared to the traditional acaricide sprays this is going to a significant barrier to uptake.

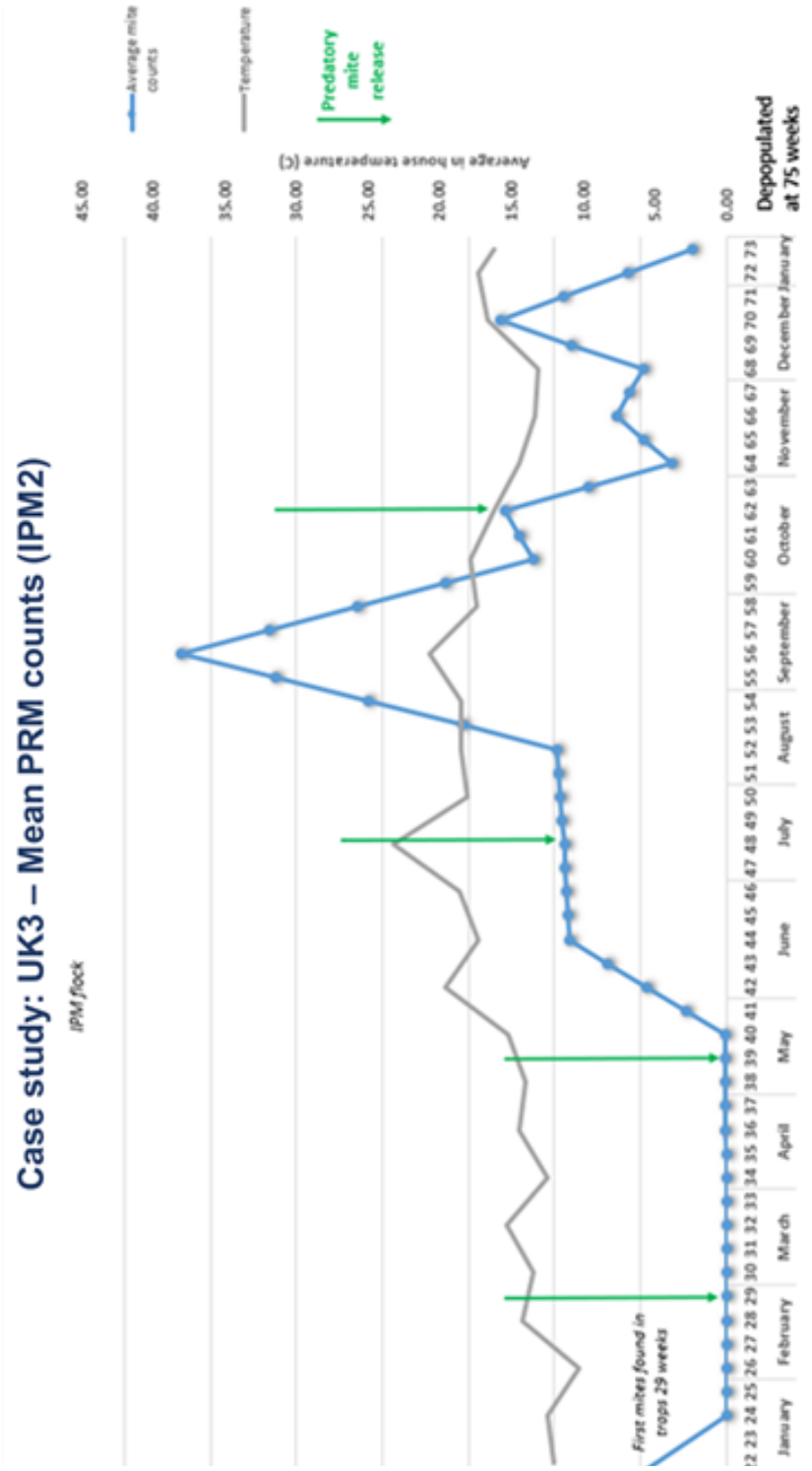


Figure 15: Mean monitoring results (cardboard counts) for farm UK3 and actions or treatments carried out for the control of PRM

Case study 6: UK4

- Mobile sheds (3 in total)
- 2 flocks: in one IPM2 was implemented, the second served to compare IPM vs no-IPM ('control')
- 3000 hens (trial flock) + 3000 hens (control)
- IPM2 (Predatory mites + Lentypou+)

Effect of actions on PRM monitoring (Figure 16)

- First mites were spotted in both houses on the feed track, but not in the traps at 18w
- First positive cardboard traps at 20w old
    - Mean PRM counts rose from 20w on in both houses
    - A peak was reached at 28w (Summer) and then slowly decreased until the end of the trial at 55w (temperature is expected to have been a driver)
- Soap sprayed on nest box lids and perches where mite clusters were observed at 26w, 32w and 34w
- Farm staff complaining about PRM at 32w
- Due to other commitments on the farm, farmer stopped using Lentypou+ at 46w
- The trial was ended at the age of 55w

Perception of effectiveness by the farmer

Unfortunately, due to other farm commitments the farmer was not deeply involved in the trial. To reduce the amount of the PRM monitoring carried out by the farmer, stick traps were only checked by the researcher during each visit, either every two weeks or every month depending on the frequency of farm visits. From week 46 onwards, the cardboard traps were also placed and collected solely by the researcher every two weeks.

The farmer found that monitoring the PRM population in the house was time consuming and arduous. However, the farmer judged that monitoring PRM using traps was a good tool to assess the PRM population, providing information to allow the farmer to react timely to an increasing PRM infestation. The farmer found that the treating the water with Lentypou+® was an easy task and quick to carry out and the release of predatory mites in the house was also judged to be easy. As the farmer's participation in the trial was limited, their perspective on the other aspects of the trials and treatment products tested is limited.

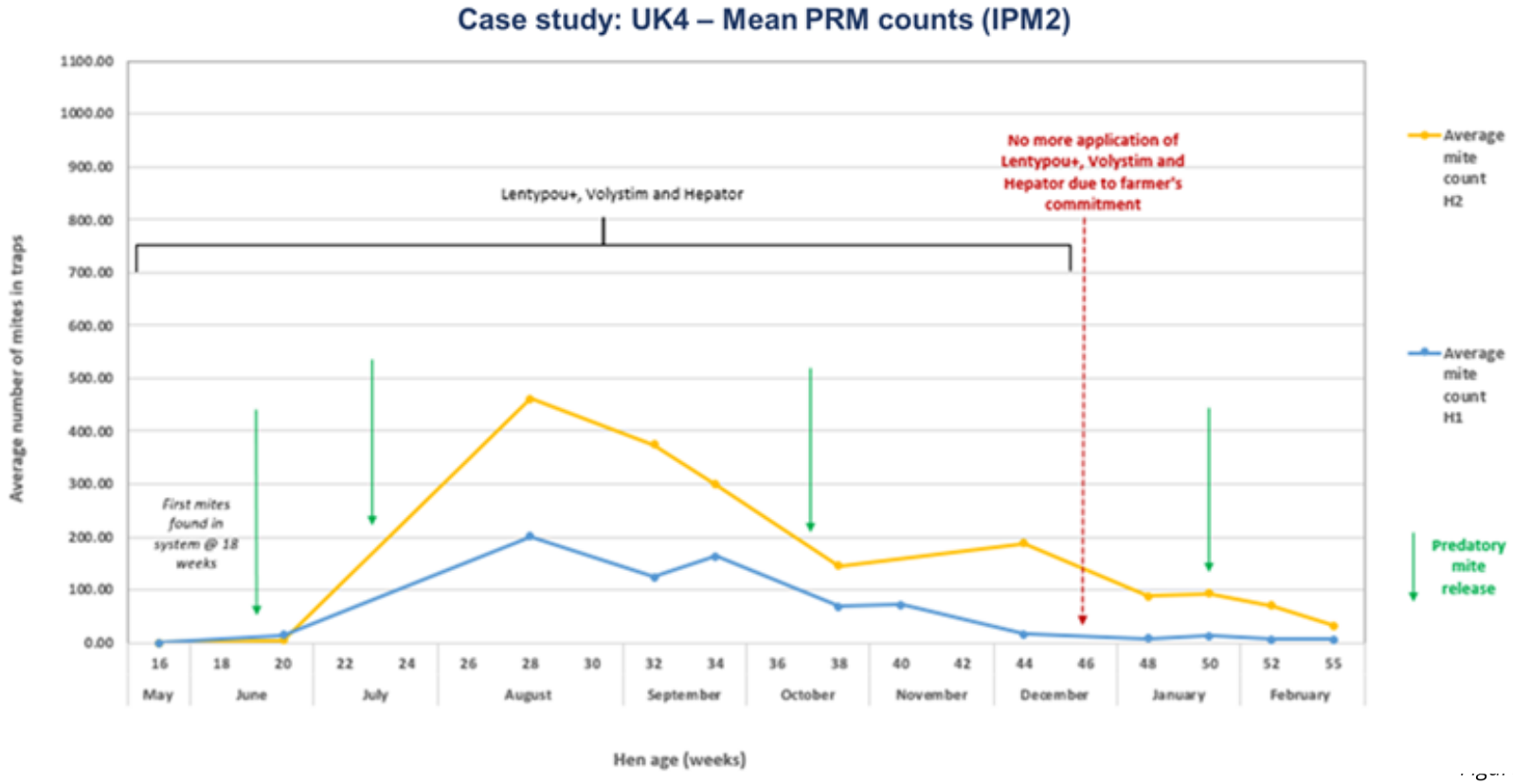


Figure 16: Mean monitoring results (cardboard counts) for farm UK4 and actions or treatments carried out for the control of PRM

Case study 7: BBr1

- Conventional broiler breeder farm
- 4 houses flat deck (indoors)
- 47.000 birds in total – trial flock of 6.000 birds (house 2)
- IPM2 (Predatory mites + Lentypou+)

Effect of actions on PRM monitoring (Figure 17)

- IPM start-up visit was done on 7/04/2023 with the technical advisor of Belgabroed, the EPC, KU Leuven (for camera monitoring), Eurotec'h and Koppert BV
    - Predatory mites were released during this first visit and repeated releases at strategical times during the flock were scheduled
    - A calendar indicating when Lentypou+ should be supplemented via the drinking water was provided – similar as with the WP3 trials, it was advised by Eurotec'h first to supplement Lentypou+ for one entire week with the ultimate goal after approximately a month to have reached the standard frequency of providing Lentypou+ one day every 4 weeks
    - Cardboard traps (n = 14) were placed for the first time on 7/04/2023 and collected two days later
- From the start of the trial, PRM were found although a very small number at first (mean PRM count of 0.54)
- After one month and a half of monitoring and a very low PRM infestation, the mean counts in de cardboard traps started to increase (mean PRM count of 23 at the end of May '22)
    - On 14/05/2022, in addition to PRM also litter beetles were found in the cardboard traps
    - Litter beetles are known to be voracious predators, although they do not target PRM specifically. Litter beetles are non-selective predators and feed on different species of small mites and insects that are naturally present in the poultry house
    - Although being natural enemies of PRM, litter beetles can also destroy isolation material and equipment, thus causing damage to the hen house. Moreover, they can carry and transmit infectious diseases (e.g. Salmonella and E. coli) and therefore are health hazards for poultry as well
- At the beginning of June '22, two months into the IPM trial, mean PRM counts had reached 498
    - In addition, also the number of litter beetles found in the cardboard traps increased over time. These numbers were also registered because of the known capacity of litter beetles to predate on PRM, thus potentially coming into competition with the predatory mites used in the IPM strategy.
- One week later (13/06/2022), mean PRM counts had increased to 1148.
    - Mean litter beetle counts of 20 were registered in the cardboard traps on this date
- Because of the high infestation levels shown through cardboard monitoring, a new on-farm visit was scheduled to assess the situation in the hen house

- Upon visual inspection, the farmer did report seeing any abnormal situation, on the contrary: they did not see PRM in the treatment house
- On 15/07/2022, the technical advisor from Belgabroed, together with researchers from the EPC and KU Leuven visited the treatment house and found only very few PRM
    - When lifting slats and inspecting the house, many litter beetles were found, however there numbers were not abnormally high so the farmer had not treated against the beetles
    - To compare, they visited the neighbouring (similarly structured and equipped) poultry house where no IPM combination was used and also there only very few PRM were found, whereas litter beetles were frequently seen
    - After describing the situation during visual inspection at the poultry house, no further action was advised by the partnership
- After reaching peak numbers on 13/06, mean PRM counts kept decreasing
    - A new release of predatory mites was done a few days before the visit of 15/07
    - Because at the time of the release also the litter beetle population had increased, it is however not possible to draw firm conclusions regarding the reliability of the PRM counts, some possible explanations are the following:
        - PRM counts started to decrease because of the presence of predatory mites and litter beetles in the poultry house (natural enemies)
        - PRM counts started to decrease because PRM were no longer willing to crawl into the cardboard traps because of the presence of litter beetles (avoiding their natural enemies)
- Because of this, it is not possible to draw conclusions on the effectiveness of the IPM2 combination
    - In cases where litter beetles are present, in the future it might be more appropriate to advise the use of non-trapping methods for PRM monitoring (such as the Mite Monitoring Score or MMS) to avoid luring litter beetles into the cardboard traps
    - Further research into the population dynamics and effects of litter beetles on PRM populations in commercial poultry houses would be of interest to be able to estimate the effect and contribution of litter beetles as natural enemies for the control of PRM. However, care should be taken to condone the presence of litter beetles in the poultry house given their ability to cause damage to the isolation and equipment and the possibility of introduction of infectious organisms in the poultry house.

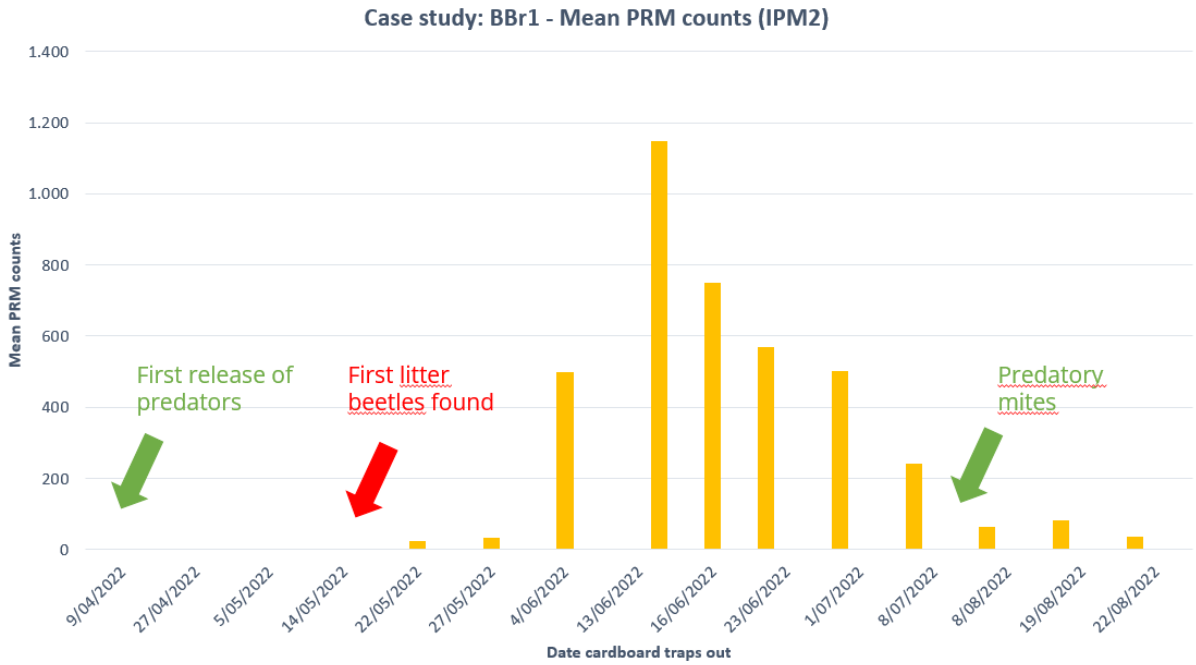


Figure 17: Mean monitoring results (cardboard counts) for farm BBr1 and actions or treatments carried out for the control of PRM

Perception of effectiveness by the farmer

The farmer was undecided about the effect of the IPM2 strategy implemented on-farm. In his opinion, Lentypou+ did not show an effect to control PRM whereas the predatory mites did. Predatory mites were considered more effective than Lentypou+. When asked if he believed the PRM infestation was under control due to the IPM strategy and/or there were less PRM present in the poultry house compared to previous flocks, he indicated he did not know. He was pleased with the effectiveness of the predatory mites and answered he might consider using them in the future. However, he will not be using Lentypou+ anymore since he did not notice any effect of the product, including when they forgot or stopped supplementing it.

Although the farmer believed routine monitoring to be useful to assess the PRM infestation in the house, he indicated he was not considering to continue monitoring with cardboard traps in future flocks.

IPM3: Fossil Shield Instant White & Nor-Mite

Case study 1: FR2

- Aviary (outdoors)
- 1 house
- 33006 hens
- IPM3 (Fossil Shield Instant White + Nor-Mite)

Effect of actions on PRM monitoring (Figure 18)

- PRM counts started to increase from the age of 26w
    - PRM were seen on eggs early in the flock

- Fossil Shield was not applied underneath the egg belt covers during the empty period
    - A re-application was scheduled to treat these areas that had been forgotten
- The PRM counts continued to increase despite two local treatments with Fossil Shield
    - Peak in PRM counts was seen around 39w-40w of age
- PRM counts decreased until the age of 53w-54w
- PRM counts started to increase again from 60w-61w of age
- Monitoring results suggest lower PRM counts found at the end of the IPM flock compared to the end of the pre-IPM flock
- Nor-Mite was suspended twice during the trial: once after a shortage of product in stock and the second occasion was following a problem with the drinking lines
- Management actions such as removal of manure crusts, dust and egg debris were carried out regularly during the flock

Perception of effectiveness by the farmer

In the opinion of the farmer, the IPM strategy was effective in keeping PRM under control during the flock. The effectiveness of silica (Fossil Shield) was rated higher than Nor-Mite. The effect of Fossil Shield was pleasing. The farmer was under the impression that PRM numbers were lower for the IPM flock compared with the previous flocks and also did benefit production numbers. Therefore, the farmer indicated they would consider using silica for future flocks as well.

PRM monitoring generated useful information for the farmer and they considered to keep monitoring PRM in the future.

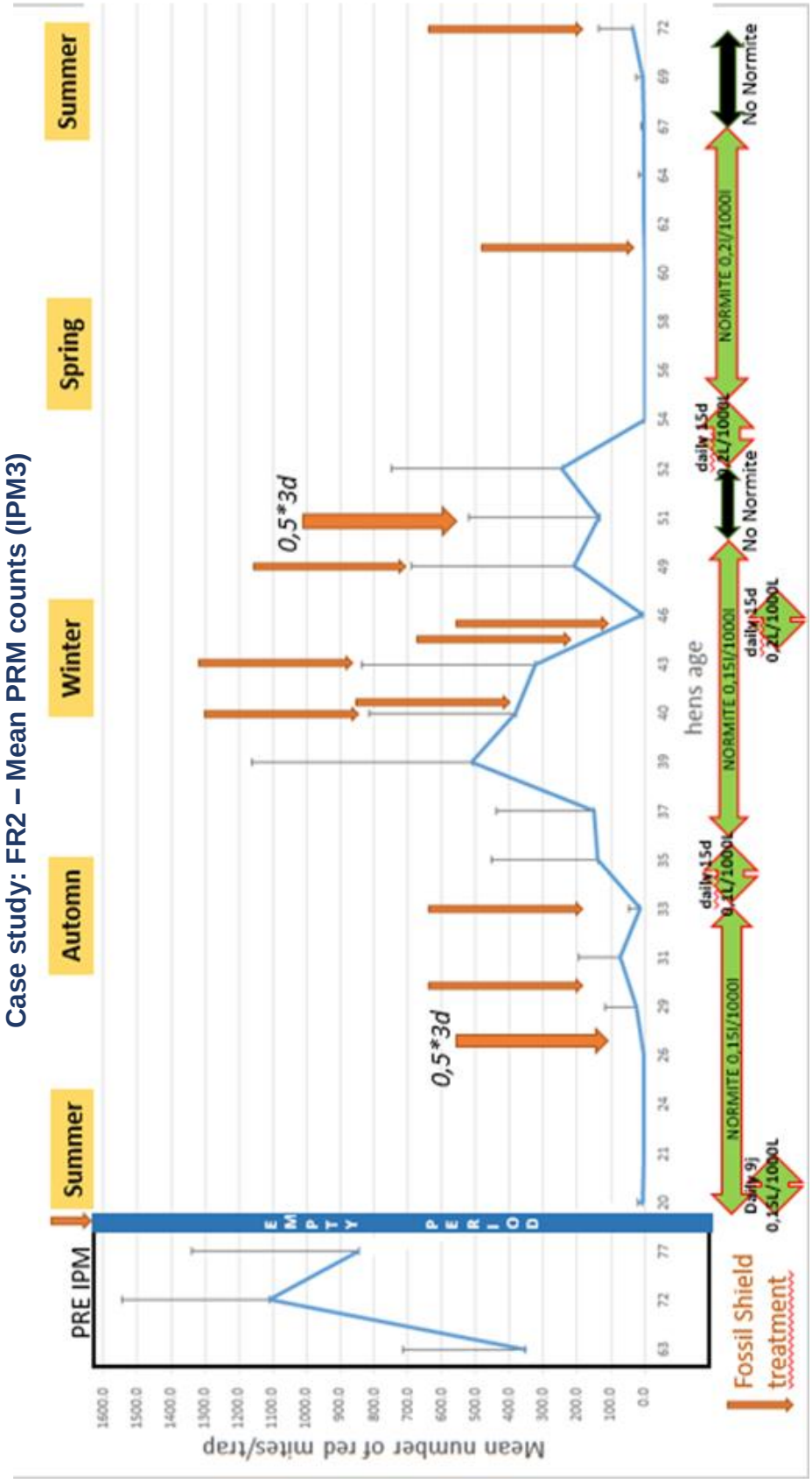


Figure 18: Mean monitoring results (cardboard counts) for farm FR2 and actions or treatments carried out for the control of PRM

Case study 2: FR3

- Aviary
- 30000 hens

- IPM3 (Fossil Shield Instant White + Nor-Mite)

Effect of actions on PRM monitoring (Figure 19)

- The PRM counts started to substantially increase from the age of 54w
    - Before, aggregates were seen by the farmer and researcher and local treatments with Fossil Shield were carried out at 40w, 43w and 50w of age
- PRM counts decreased from 58w after a more general application with Fossil Shield was done with an external company over the course of three days
- Between 33w and 56w Nor-Mite was supplemented daily
- Nor-Mite protocol was suspended twice following blockages of the drinkers caused by mixing with other products
- With regard to more general management actions, manure, dust and egg debris were removed regularly
- The PRM counts indicate a lower infestation at the end of the IPM flock compared with the pre-IPM flock

Perception of effectiveness by the farmer

In the opinion of the farmer, the IPM strategy was effective in keeping PRM under control during the flock. However, Nor-Mite was considered not to have been effective since the farmer rated it as very poor. The effectiveness of silica (Fossil Shield) was rated as good, both when applied during the empty period and the course of the flock. The farmer was under the impression that PRM numbers were lower for the IPM flock compared with the previous flocks and also did benefit production numbers. Therefore, the farmer indicated they would consider using silica for future flocks as well.

Cardboard monitoring generated useful information for the farmer but they also indicated they would not want to do the counting of PRM found in the cardboards themselves. They would however consider to continue with placing and collecting cardboard traps if the actual analysis were to be carried out externally.

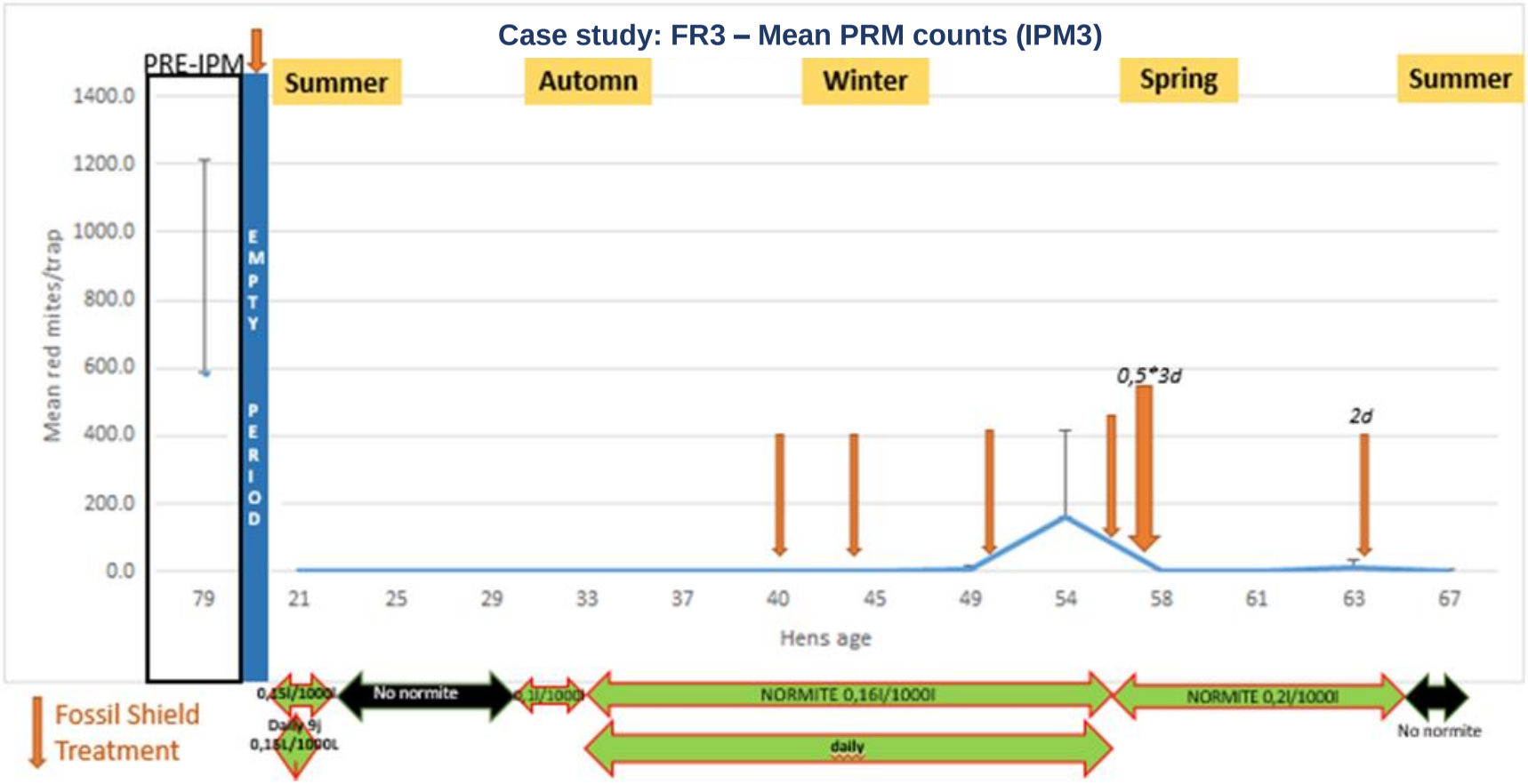


Figure 19: Mean monitoring results (cardboard counts) for farm FR3 and actions or treatments carried out for the control of PRM

Case study 3: FR4

- Enriched cages
- 25000 hens
- IPM3 (Fossil Shield + Nor-Mite)

Effect of actions on PRM monitoring (Figure 20)

- PRM counts began to increase from 36w of age
- At 37w the whole house was treated with Fossil Shield
- From 47w, the PRM counts started to increase again and peaked
- The whole house was re-treated with Fossil Shield at 48w old
- PRM counts were higher at the end of the IPM flock compared to the pre-IPM flock
- Health problems of the hens did occur at around 60w of age but they did not seem to have greatly impacted on their performance compared to the pre-IPM flock
- The protocol of Nor-Mite was suspended indefinitely at 36w because the breeder was wary of the effect of the product on the drinking lines and potential blockages
- From 43w onwards therefore Nor-Mite was replaced by Lentypou+
- Concerning more general management actions, manure, dust and egg debris were removed regularly and scrapers on top of the cages were cleaned throughout the flock

Perception of effectiveness by the farmer

In the opinion of the farmer, the IPM strategy was effective in keeping PRM under control during the flock. However, Nor-Mite was considered not to have been effective since the farmer rated it as very poor. According to the farmer, Lentypou+ performed well. Also the effectiveness of silica (Fossil Shield) was rated as good, both when applied during the empty period and the course of the flock. The farmer was under the impression that PRM numbers were lower for the IPM flock compared with the previous flocks. Therefore, the farmer indicated they might consider using silica (or other non-chemical products) for future flocks as well.

Cardboard monitoring generated useful information for the farmer but they also indicated they would not want to continue cardboard monitoring themselves.

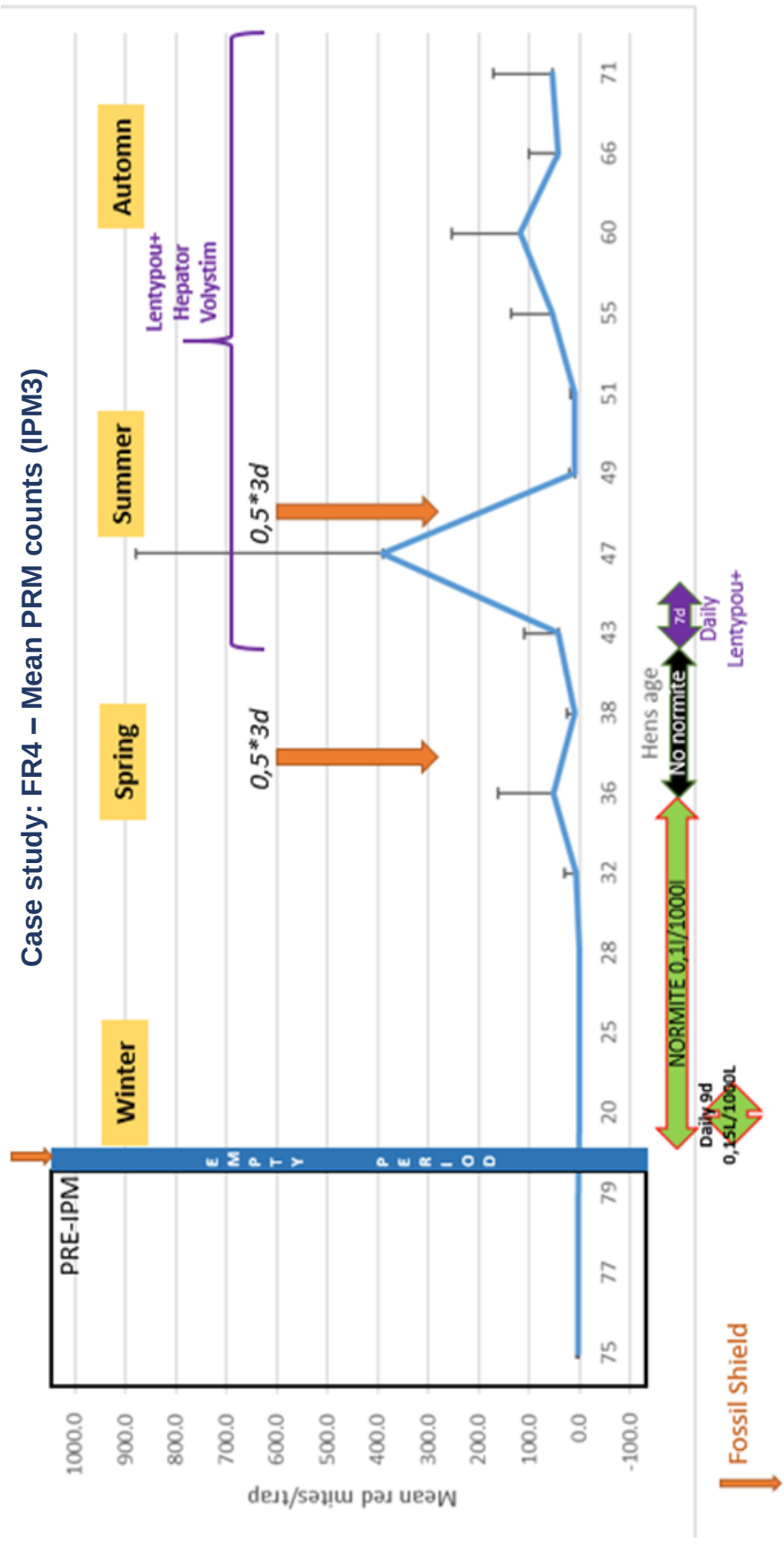


Figure 20: Mean monitoring results (cardboard counts) for farm FR4 and actions or treatments carried out for the control of PRM

Case study 4: UK1

- Free-range, single tier

- 8000 hens (trial flock)
- IPM3 (Fossil Shield + Nor-Mite)

Effect of actions on PRM monitoring (Figure 21)

- Aged 33w, first PRM were found in cardboard traps
- The Nor-Mite protocol was suspended for one week while a course of vitamins was run through the water
- The Nor-Mite frequency was increased to 150mL/1000L every day for two consecutive weeks in response to increasing PRM counts in the traps
- At 48w, PRM were visible in the hen house and localised clusters were found around the eff belt lids
    - Until the age of 48w the IPM strategy appeared to control PRM but upon entering the Summer months, PRM population grew sharply
- Local treatment with Fossil Shield Instant White on the egg belt lids, perch and feed track supports using a nap sack sprayer at 49w
- Soap solution sprayed under the lip of feed tracks and along slat support bars (at 50w)
- The frequency of Nor-Mite was increased again from three times per week to everyday (at 51w)
- Local treatment with Fossil Shield Instant White on egg belt lids as PRM clusters continued to grow in the area (53w)
- Soap solution sprayed on egg belt lids as Fossil Shield application failed to prevent further PRM clusters from reforming (54w)
- Fossil Shield Instant White applied on egg belt lids followed by whole house being treated with Fossil Shield 90.0 powder by an external contractor one week later (56w-57w)
    - Repeated local applications of Fossil Shield and increasing the frequency of Nor-Mite did not satisfactorily control PRM infestation
    - The treatment of the whole house at 57w provided some temporary control but clusters re-appeared within weeks
- Continuous use of Nor-Mite since caused build-up of biofilm in water lines – Nor-Mite was stopped for 9 days while drinker lines were cleaned (60w)
- Local treatment with Fossil Shield Instant White every week to try and control local PRM hotspots (61w to 64w)
- Exzolt treatment scheduled at 65w-66w at the end of the trial (before depopulation of the flock)

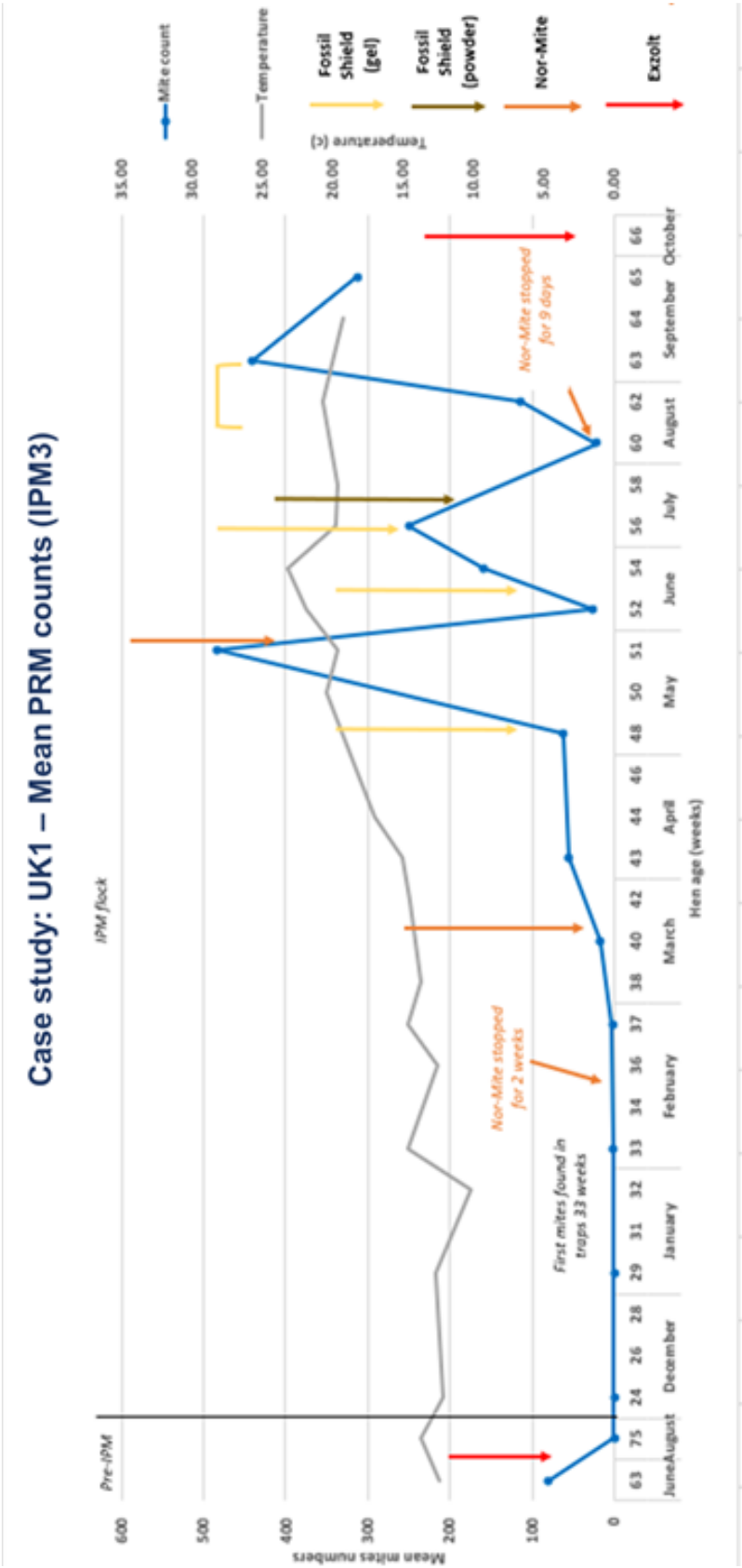


Figure 21: Mean monitoring results (cardboard counts) for farm UK1 and actions or treatments carried out for the control of PRM

Perception of effectiveness by the farmer

Overall, the farmer was disappointed with the results of the trial. Although the farmer felt that Fossil Shield® and Nor-mite® gave some level of control, repeated local treatments

of Fossil Shield were time consuming and the effort required for these local treatments was one the reasons the trial was ended before the flock depopulated. The farmer thought that monitoring of PRM through the traps generated useful information and they would consider using the cardboard traps for future flocks.

Case study 5: BBr2

- Conventional broiler breeder farm
- 3 houses flat deck (indoors)
- 30.000 birds in total – trial flock of 10.000 birds (house 3)
- IPM3 (Fossil Shield Instant White)

Effect of actions on PRM monitoring

- On 23/03/2022, a farm visit was done by the technical advisor from Belgabroed and researchers from the EPC before the start of the trial
- Fossil Shield was applied after disinfection and before re-assembling the hen house (after cleaning and disinfection of all structures)
- Twelve cardboard traps were placed in the treatment house
- No PRM were seen from the start of the flock until the end
    - No additional treatment has been carried out apart from applying Fossil Shield Instant White prior to placement of the birds
    - In contrast, during the flock, the farmer has treated with a chemical acaricide (ByeMite) in the other houses. However, since no PRM were seen in the treatment house (house 3), no acaricides have been used there.

Perception of effectiveness by the farmer

The farmer considered the IPM3 strategy to be effective for the control of PRM in the treatment house and compared to previous flocks, less PRM are present there. He did not believe the IPM strategy had impacted on production. The farmer was pleased with the effect of silica (Fossil Shield) and would consider using silica in the future.

Monitoring provided the farmer with interesting information on the PRM infestation. Cardboard trap monitoring was more relevant or useful for the farmer than visual monitoring. However, he will not be continuing with PRM monitoring himself in the future.

Case study 6: Poul6

Effect of actions on PRM monitoring (Figure 22)

- 40 L of ASEPTOL was used for the disinfection
- The cleaning has been checked as good, except on the left side of the building.
- Fossil Shield was applied before the arrival of the birds.
- From the arrival to the departure of the pullets, three cycles of trapping/collecting PRM was realized (12 cardboard and 12 water traps)
- Very low PRM counts (only in water traps) were found during the flock and none found at the end of the flock

PRM monitoring showed few PRM only in water traps, decreasing to zero at the third trapping session. As a result, no other action was then taken.

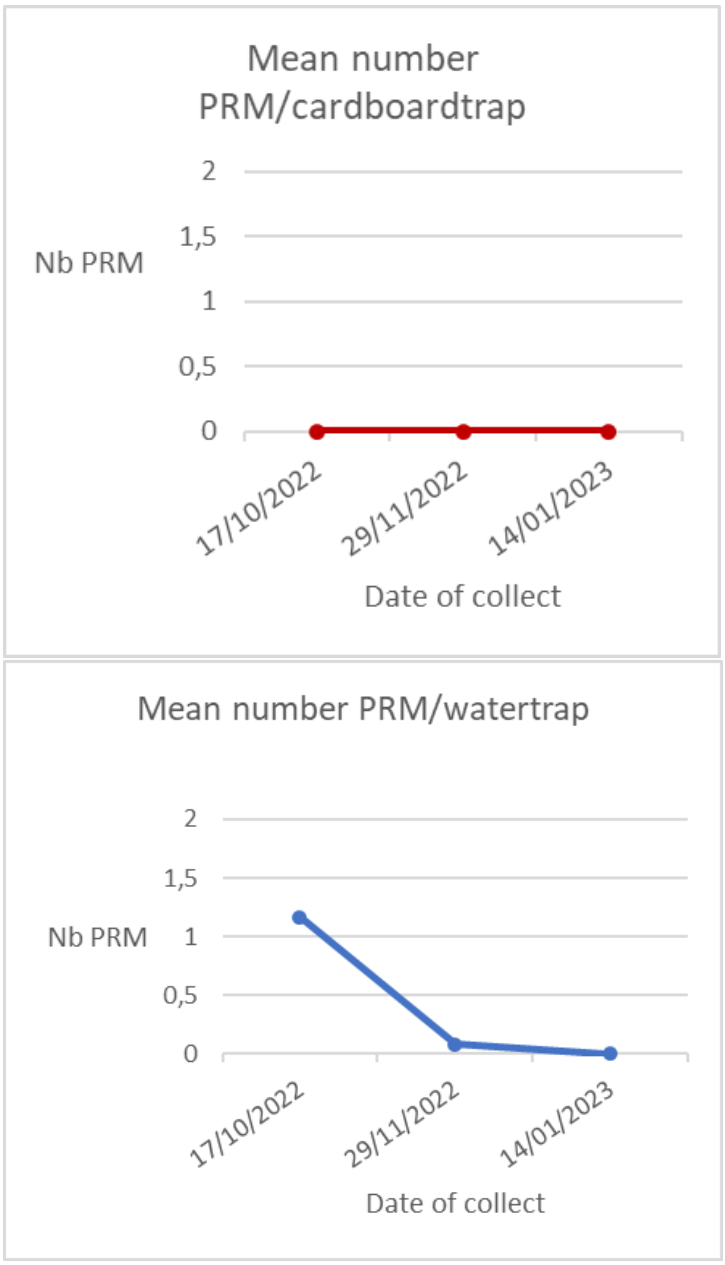


Figure 22: Mean monitoring results (cardboard and watertrap counts) for farm Poul6

During the survey, some farmers reported not using products (silica and Exzolt) systematically in all flocks. In order to test the sustainability of the IPM strategy implemented on Poul6 farm, a third flock was followed.

For that flock, only thorough cleaning and disinfection was done and no products was used.

No PRM were found during the 3rd flock. This shows that the IPM strategy implemented in the previous flock has a sustainable effect and that treatments might not have to be applied at every flock, lowering the cost for the farmer.

Important findings on IPM combinations & recommendations for future research

Based on the research carried out within the different work packages of the MiteControl project, more scientific knowledge is gained (e.g. on the efficacy of the products, the occurrence of resistance and the behaviour of PRM) and experiences or observations from the field are used to showcase results from pilot trials in real life farm conditions. In general, through the project findings a number of questions have been solved. However, also additional questions came up for which more research is currently on-going or needed in the future.

In Table 9, some important features of the products under investigation in the project are listed. In case the feature applies with regard to the individual product, this is indicated as '+', features that do not apply are indicated as '–', 'NA' means not applicable, and '?' marks unknowns or features that require further investigating.

The choice of the products used may vary according to factors such as e.g. historical PRM infestation levels, type of farm or housing system, or preference of the farmer. For all products implemented in an IPM strategy it applies that continuous evaluation is warranted. In case one product does not perform well on a specific farm, the farmer should think critical and seek an to find an alternative that performs better in their specific situation. It is also advised that farmers discuss the use of products to aid with the control of PRM with their farm advisor or veterinarian and seek their advice.

Below more information is provided on some remarkable or interesting findings from the pilot farm trials as well as the lab-experiments conducted previously. Important considerations for users and recommendations on future research are provided as well.

Table 9: Overview of features of the non-chemical products used in the WP3 trials on pilot farms

Pros	Predators	Lentypou+	Nor-Mite	Autogenous vaccine (SME)	Fossil Shield (silica)	Q-perch
No deleterious effect on populations of native predators	+	+	+	NA	?	?
No toxic effect on predators (native and commercial)	NA	+	+	+	-	NA
Allowed on organic farms	+	+	+	-	-	+
Allowed for use out of UK	+	+	+	-	+	+
Easy to use during flock	+/- (sprinkling / bags or bottles)	+/- (simple /complex avoid some combination)	+/- (simple / avoid some combination)	+ / - (labour intensive to collect PRM for production)	+/- (depends if the farmer does it himself)	+
No strong constraint before or at the beginning of the flock	+	+	+	--	+	--
Cost*	-	++	?	--	+/-	--
Availability of suppliers for advice and guidance on field	?	++	--	?	+	?
No obvious harmful effect on the rest of the farm (equipment, water...)	+	+	? (clogging of water system)	+	+	+
Service provided (efficacy from studies)	?	?	?	?	+	?
"Effect" visible by the farmer				-		+/-

IPM1: Autogenous vaccine & Predatory mites (+ Q perch)

Autogenous PRM vaccine

The IPM1 strategy featured the combination of an autogenous PRM vaccine and predatory mites. This strategy was only piloted at the EPC since the autogenous vaccine is not commercially available and registered for use on commercial farms. However, for the EPC trial, the necessary permits and approvals were granted to use the vaccine. Also the aim was to find another pilot farm for the vaccine in the UK. However, during the WP3 trial at the EPC, the number of PRM found in the traps started to increase rapidly early on in the flock, coinciding with findings from a previous small scale trial by Bartley *et al*. (2017). Apart from the monitoring results, it was also very clear at mere visual inspection of the hen house by the animal caretakers that the PRM infestation was increasing rapidly. Following the results from Bartley *et al.* (2017), the initial expectation or hope was that due to the vaccination of the birds at a young age (i.e. first dose of the vaccine was given at the age of 12 weeks and a booster at 16w) an immune response would be generated against PRM and the infestation would again decrease. Unfortunately, no such positive effect from the vaccine was seen. During the laying cycle, there are strict limitations to which medication is allowed to use. In particular, no injections can be given to the hens during production. Therefore, it was not possible to administer a booster injection. The findings of the increase in PRM counts were discussed with Moredun Research Institute, where the vaccine was developed and currently still more research is done into finding the best formula for a PRM vaccine.

These findings together with the time required to sample enough PRM and the high cost for manufacturing of the vaccine (i.e. €0.425 per hen per injection) fed the decision by the project partners to abandon the initial plan of trialing the vaccine on one UK farm as well.

Predatory mites

Two species of predatory mites were used in the IPM1 trials at the EPC, *A. casalis* (market name Androlis®) and *C. eruditus* (market name Taurrus®). Both are commercial lines reared by Koppert BV. Experiments carried out within WP2 showed that the genetic pool *A. casalis* L2 found on commercial farms is more voracious than the marketed Androlis®. However, the sampled L2 line was lost before it could be mass-reared for use in the MiteControl trials. Therefore, the marketed Androlis® product was used.

The effectiveness of predatory mites in the IPM1 strategy could not be confirmed based on the monitoring results and observations in the hen house at the EPC. However, a side note should mention that complicated housing systems and houses with manure belts are not optimal environments for predatory mites.

At the EPC, Taurrus® was released by sprinkling in the nest boxes before the placement of the hens. Androlis® was released by attaching bottles containing predatory mites in the housing system before placement and from then on half of the bottles were replaced every month with new ones. *A. casalis* tends to settle around or on manure. Therefore, the predatory mites are removed from the house via the manure belt and frequent (i.e. monthly) releases were scheduled at the EPC.

Replacing the bottles does require some time (approximately 2 hours on a monthly basis) and effort from the farmer, especially if compared with applying phytoadditives in drinking water (approximately 5 to 15 minutes per application). One additional release of Taurrus® was done at the age of 37w in the aviary compartments because the PRM counts in the cardboard traps kept increasing. However, no distinct effect of the additional release was noticed in the monitoring results or during visual inspection in the hen house. In addition, predatory mites also turned out to be one of the more expensive products on-trial.

Q perch®

The Q perch® was only comprised in the IPM1 strategy. Moreover, this electrified perch was only installed at the EPC. None of the commercial pilot farms had such perch in their hen house.

The installment of the Q perch® is a significant investment for a commercial farmer. Although in both compartments at the EPC where this perch was included in the IPM strategy (B1 and B3, aviary type 1) the monitoring results were consistently lower than in five out of the remaining six aviary compartments, PRM were still found and could also be seen at visual inspection.

Meetings were held with Vencomatic throughout the trial to discuss findings and questions on the use and effectiveness of the Q perch®.

Considerations for users and recommendations for future research

Autogenous PRM vaccine

Although the results from the vaccine trial were disappointing, it has been noticed during study events and demonstrations given that there could be a lot of interest in the potential of an (autogenous) PRM vaccine from the poultry sector. However, more research is still being conducted by Moredun Research Institute on the technology and formulation of the vaccine so it is currently not available to use on commercial farms.

For the MiteControl trials, the cost of the vaccine, both concerning the labour required (by the farmer and the veterinarian) and the actual product cost, were the highest for all individual products tested. High treatment costs are a large constraint for commercial farmers. In addition, thought must be given to the manner of administration of the vaccine. It is not allowed to give an injectable booster to layers in production. Another possible route could be vaccination via drinking water, providing in the future the formulation of the vaccine would allow it.

If the efficacy of the vaccine can be clearly demonstrated through rigorous scientific experiments as well as on-farm trials and the farmers could also see a benefit cost-wise, the vaccine could be a useful addition to include in a concept for the sustainable and non-chemical control of PRM in Europe if legislation permits the use of autogenous vaccines.

Predatory mites

Although the more voracious *A. casalis* L2 line was lost, it would be of interest to look into the potential of this line for further research and ultimately maybe for commercialisation. For *Cheyletus* spp. it was found that the marketed *C. eruditus* was not the most abundant in the layer houses sampled. Instead, *C. malaccensis* was the dominant species in number, while another three were identified. Similar as for *A. casalis*, further research into whether other *Cheyletus* spp. would be more efficient than the currently marketed Taurrus® could be of interest.

Accurate recommendations and guidance are needed for stakeholders or farmers wishing to implement predatory mites for the purpose of biological control of PRM. The more complex housing systems such as enriched cages or aviaries are not well-suited for predatory mites. Therefore, farmers enquiring about the use should be well-informed about these facts. Predator releases can be repeated to try and account for this, as has been attempted at the EPC with monthly Androlis® releases, however, this also has an impact on the costs both related for the product and the labour required by the farmer.

Care should also be taken when combining predatory mites with other (non-)chemical products for red mite control. For example, silica not only has a detrimental effect on PRM but also on predatory mites that come into contact with the product. Experiments have also shown that Androlis® in particular is affected when fluralaner (i.e. a synthetic acaricide for use against PRM) is added to the drinking water. Drafting reasonable and relevant recommendations to stakeholders and farmers on how to apply predatory mites is therefore needed.

Q perch®

Although results from the WP3 trial at the EPC suggest that the Q perch® has a positive effect in keeping PRM infestation under control, it is not possible to draw any firm conclusions. Extensive research has already been carried out by Vencomatic to adapt and finetune the Q perch®. However, more research is still on-going to improve the mechanism and effectiveness of the electrified perch to kill off PRM trying to reach the hens via the Q perch®.

IPM2: Predatory mites & Lentypou+

Predatory mites

In two out of the three IPM strategies developed, predatory mites were included. In the IPM2 strategy, they were combined with the use of Lentypou+ to support the hens.

On two Belgian pilot farms this combination was used. For both farms the same remarks as described above for the use of predators in IPM1 applied: the complex aviary system (on conventional farm BE1 and organic farm BE2) was not optimal. The regular, monthly releases of Androlis® and the (additional) releases of Taurrus® had no distinct effect on the monitoring results or perception of the farmer. Both farmers were also skeptical about the effectiveness of the use of predatory mites based on their experience and observations during the trial.

On the French and UK pilot farms, the predatory mites were released in different, simpler, flat deck housing systems without manure belts. Therefore, the protocols and schedules for their release differed from the Belgian farms and the EPC: less releases were necessary (approximately 4-5 per farm) and both Taurrus® and Androlis® were sprinkled in the hen house. This was easier and quicker to do for the farmer than replacing Androlis® bottles on a monthly basis. Therefore, on one of the WP4 pilot farms housing broiler breeders in flat deck systems, the IPM2 combination was trialled in Belgium.

Lentypou+ (phytoadditive 1)

Lentypou+ is a phytoadditive that is provided to the hens via their drinking water. Due to the formulation of the product, it is claimed to affect PRM indirectly: after the hen ingests the product, the concistency of the hen's blood changes by which it becomes indigestible for red mite. The red mite will appear disoriented and therefore appear more visibly in the hen house (which might alarm farmers in thinking the PRM levels are increasing), but PRM are no longer able to suck blood from the hen, will become more greasy (to be noticed when crushed between finger and thumb), and will ultimately dry out and die. However, these claims could not be supported based on the results from the experiments carried out in light of WP2, nor could the described change in behaviour be observed by all farmers or at the EPC (where Lentypou+ was implemented starting from January '21).

The product cost of Lentypou+ is low compared to the predatory mites that were used in IPM2 as well. However, the producer recommends combining Lentypou+ with other plant-based products or additives to boost the hens' immunity and supports the liver and/or kidney function. If such products are not already used by farmers, this would pose an additional cost.

Lentypou+ is quick and easy to use (5-15 minutes per application), but care should be taken not to mix the product with for example antibiotics.

Considerations for users and recommendations for future research

Predatory mites

The same considerations and recommendations apply as for the use of predatory mites in IPM1. Interesting ways to move forward would be to investigate if other, more efficient or voracious lines of *A. casalis* and *C. eruditus* could be found and mass-reared for commercial use.

It is important to seek appropriate guidance and information when thinking about implementing predatory mites for the control of PRM on-farm.

Care should be taken when using predatory mites in combination with other (non-) chemical products to avoid circumstances where predators will get exposed to and affected by products that are harmful to them as well.

Lentypou+

Through the experiments and trials carried out within the scope of the project, the claimed mechanism of action of Lentypou+ could not be confirmed. Further research into this topic would therefore be of interest to attempt to define how PRM are exactly affected after ingesting the hens' blood. Furthermore, the changes in behaviour or appearance of PRM as described could not be confirmed through observations in the hen house. For this purpose, also further on-farm trials could be carried out only using Lentypou+ (i.e. not in combination with another product such as predatory mites that might also have an altering effect on the behaviour of PRM) would be of interest.

Although Lentypou+ in itself is one of the cheaper products under investigation during the pilot farm trials (depending on the frequency used on the individual farms), it is advised by the producer Eurotec'h to use it in a protocol with products to boost the hens' immunity and liver and/or kidney function.

Lentypou+ is a plant-based product, however it is recommended to refrain from using it in combination with e.g. antibiotics. To ensure the correct use of the product, it is important to seek guidance from the producer.

IPM3: Fossil Shield Instant White & Nor-Mite

Fossil Shield Instant White (silica)

For IPM3 the choice was made to combine a synthetic form of silica, Fossil Shield Instant White, with a second phytoadditive that was distributed to the hens via the drinking water, Nor-Mite. Fossil Shield Instant White is used as a wet application: the product is carefully mixed with water and applied using a pressure vessel. The product dries quickly and sticks well onto the housing system.

Fossil Shield was applied during the empty period, after wet cleaning and disinfection for an optimal effect in trials on laying farms (WP3), on one broiler breeder farm in Belgium (WP4) and one pullet farm in France where PRM were found through a monitoring trial (WP4). During the production round, re-applications were carried out when and where needed, both local treatments and treatments of the entire hen house. In general, this approach was effective in controlling the PRM infestation. Using silica had an almost immediate effect on the PRM monitoring numbers. However, some housing systems were more difficult to treat than others and one of the French pilot farms serves as a good example to show that knowledge of the features of specific brands of housing systems is essential. On a farm which had a complicated brand of aviary system unfamiliar to the firm applying the Fossil Shield, part of the system was left untreated. In these spots, however, soon the first mites already managed to aggregate and re-applications were

warranted. This is an extra cost to the farmer which is of course to be avoided as much as possible.

Nor-Mite (phytoadditive 2)

The second phytoadditive in support of the hens that was administered via the drinking water was Nor-Mite. The portrayed mechanism of action however differs from the previous phytoadditive used. After having ingested Nor-Mite, hens are claimed to emit an unpleasant odour for PRM. Nor-Mite does have a repellent effect on PRM. The frequency of Nor-Mite differs from that of Lentypou+: the basic schedule for Nor-Mite is to administer it for 3 non-consecutive days per week (e.g. Mondays, Wednesdays and Fridays) whereas for Lentypou+ after an initial application of 5-7 consecutive days, the frequency is reduced until it is used one day every month.

Similar as for Lentypou+ however, also for Nor-Mite the experiments carried out in WP2 and the pilot farm trials offered no proof of the mechanism of action claimed by the producer.

Farmers reported seeing more visible red mites due to the application of Nor-Mite, which was a cause for worry to some of them. One farmer halfway through the flock stopped using Nor-Mite after consulting with the MiteControl researcher. Moreover, on few other farms, the application of Nor-Mite generated issues with blockages of drinking lines due to the formation of biofilm. This likely occurred because routine rinsing of drinking lines was not done in an optimal way. Water analyses were done to identify what the cause of the problems might have been and investigations of the drinking lines using endoscopes were carried out on some of the French and UK pilot farms. However, due to the risk of biofilm formation in drinking lines, it was opted not to apply Nor-Mite in the IPM3 strategy trialled on the broiler breeder farm in Belgium.

Considerations for users and recommendations for future research

Fossil Shield Instant White

Fossil Shield, like other silica formulations, is a registered biocide allowed to use as a red mite treatment.

While applying the product, it is necessary to wear protective clothing (i.e. coveralls and a facemask). If Fossil Shield is correctly applied, it causes no harmful effects on other equipment in the hen house. A small percentage of downgraded eggs have been reported on one of the pilot farms after Fossil Shield application.

Thorough application of Fossil Shield is necessary to obtain the best result. A thorough check of the housing system is advised to ensure all structures have been treated. Ideally, the product is applied after wet cleaning and disinfection just a few days before the placement of the hens. One of the most prominent advantages of this approach lies in the fact that in an empty hen house more thorough treatment is possible. However, silica can also be applied during the production cycle when PRM counts increase. In such case, the treatment needs to be repeated after 7 days to interrupt the reproductive cycle of the red mite. Of course since the curative treatment requires more product (i.e. two

applications), the costs are higher compared to when the product is applied during the empty period (only one application). Treatments of the entire hen house are more effective than local treatments. Blowing silica through the aeration tubes of the manure belt is good practice.

Different housing systems have different features, which are important to consider, not only with regard to the effectiveness of the product but also the costs. If not applied correctly at first, more re-applications could be necessary afterwards which implies higher product costs and time required.

Currently, Fossil Shield Instant White cannot be used on organic farms in Belgium or France. However, alternative brands of silica could be used in organic farming instead.

Silica cannot be combined with the use of predatory mites since the product not only kills PRM but also native predators (including *A. casalis* and *C. eruditus*) present in the hen house.

The costs of Fossil Shield is variable and depends on features of the hen house, system, number of hens and whether the farmers is able or willing to carry out the treatment himself or chooses to hire an external company to do the application for him.

The IPM3 strategy generated the best results out of the three trialled. However, because two products are combined in each strategy, no separation can be made between the extent of the effectiveness of Fossil Shield and that of Nor-Mite.

Nor-Mite

The efficacy of the drinking water variant could not be established through the experiments and trials carried out within the MiteControl project. However, the active substance of Nor-Mite is known to be able to generate a repellent effect on PRM, but it remains unsolved whether it could be effective through administration via drinking water. More research into the mechanism and why currently the repellent effect is not reached in the liquid formula is needed.

Care should be taken when administering Nor-Mite whilst using other products in the drinking lines since interactions might occur. Therefore it is important to seek advice and guidance from the product's distributor to learn how to correctly and optimally use Nor-Mite.

Biofilm has formed on some of the trial farms, causing clogging of drinking lines which might greatly impact on the hens if not picked up in time. By applying best practice with regard to rinsing drinking lines, the formation of biofilm should be avoided. Regularly checking the drinking lines is advised. This is another reason to seek appropriate advice from the distributors. It is recommended that Norfeed or the supplier should provide a manual and precise guidance on best practice and how to use the product correctly to the farmers.

Considering the cost of Nor-Mite, this of course depends on the frequency and dosage advised, but it is a relatively cheap product, both with regard to the product cost itself and the time required by the farmer to administer it (5-15 minutes per application).

The IPM3 strategy generated the best results out of the three trialled. However, because two products are combined in each strategy, no separation can be made between the extent of the effectiveness of Fossil Shield and that of Nor-Mite.

Problems encountered during the trials and solutions found

Sanitary conditions: COVID-19 and Avian Influenza

Some of the most pertinent problems encountered during the course of the MiteControl project were related to complicated sanitary conditions, i.e. the COVID-19 pandemic and outbreaks of highly pathogenic avian influenza (HPAI). Because of HPAI, on-farm visits were restricted for a number of pilot farms. During the confinement of the hens, researchers were not allowed to enter the hen house. Instead, the farmer kept them updated on the situation in the hen house by sending photos and short videos where possible.

The COVID-19 pandemic also had a large impact on both the pilot farm trials as well as the laboratory experiments carried out by UPVM3. Because of the pandemic, there was a shortage in equipment and reagents for the lab experiments. Therefore, there was a delay for the last deliverables of WP2. However, UPVM3 provided both the LP and the JS a detailed plan for the remainder of the experiments in WP2. WP2 will therefore continue together with WP4 (capitalisation) since the experiments are complimentary and WP4 partly relies on the results of WP2.

Apart from the shortages in materials, COVID-19 also had an impact on the follow-up of the WP3 trials. For example, one of the researchers involved in the project was put on temporary unenmployment during the first lockdown in the UK. During the lockdowns in the different countries, physical pilot farm visits were suspended. However, similar as for HPAI, farmers kept closely in touch with the MiteControl team via phone, email or text messages. Therefore, there were no significant delays for the follow-up of pilot farms in WP3.

Breeding predatory mites

In March ’21, issues occurred with rearing predatory mites. Therefore, it was decided to suspend the use of predators on the Belgian pilot farms since the PRM infestation was high. On these farms, alternative actions have been carried out: spraying water and soap onto the housing system or local treatment with silica. Although local treatment is not ideal, these actions were effective in at least reducing PRM for a short period. In May ’21, predatory mites could be released again at the organic farm in Belgium. Since silica was applied on the conventional pilot farm and the product would have severely affected predatory mites as well, no more releases were scheduled for the remainder of the flock. Instead, by the end of the trial, the farmer used Exzolt.

The issues with the breeding of predators had no severe effect on the other pilot farms in France or the UK.

Changes in products used on-farm

On one French farm, the IPM3 combination with Fossil Shield and Nor-Mite was implemented from the start of the layer flock. However, halfway through the flock the farmer no longer felt comfortable using Nor-Mite. In consultation with the MiteControl team, Nor-Mite was replaced by Lentypou+ for the remainder of the trial.

Due to the formula of Nor-Mite, it is possible that biofilm can be formed in the drinking lines if these are not regularly rinsed. This was observed during the WP3 trials. Endoscopic investigations were carried out to assess the condition of the drinking lines and check for the presence of biofilms.

For the WP3 trial at the EPC it turned out that not enough vaccines could be manufactured from the PRM sampled for the whole hen house. Therefore it was decided to implement the IPM3 strategy in one enriched cage compartment.

During the IPM1 trial at the EPC it was difficult to keep the red mite infestation under control. The first actions to undertake included local application of soap and additional releases of predatory mites. However, these actions did not generate a lasting effect. Therefore, it was decided to treat the entire hen house with Fossil Shield IW at the age of 47 weeks. Important to note is that at this point in time the red mite infestation was high and the application of Fossil Shield was curative rather than preventive as was the case in the IPM3 strategy. Therefore, an important feature to keep in mind is that more product was used (i.e. two applications one week apart), resulting in a higher product cost. Because predatory mites are also affected by silica-based products, from this moment onwards, no more predators were released during the flock. In case additional actions were warranted, silica was used. At the end of the flock, Exzolt was applied.

For the WP4 trials on the commercial pullet and broiler breeder farms, the IPM strategies were adapted according to the new circumstances. The IPM3 strategy with Fossil Shield Instant White was used on one pullet farm and one broiler breeder farm. However, due to different considerations, it was opted not to use Nor-Mite in the WP4 trials. On the pullet farm, due to the short flock length, the basis of the IPM approach was to perform thorough cleaning and disinfection, routine monitoring and apply silica once before placement of the birds, also attempting to reduce the potential cost associated with the IPM strategy for the farmer. On the broiler breeder farm, the option of including Nor-Mite in the IPM strategy was discussed. However, also the experiences from previous trials where the formation of biofilm due to improper cleaning of drinking lines was discussed with the farmer. This because of the higher value of the breeding stock compared to laying hens or pullets and the fear of issues with drinking lines occurring, affecting valuable birds. Therefore, it was decided not to take any risks and to refrain from using Nor-Mite on the breeder farm.

Economic evaluation of pilot farm trials

Summary

Table 10 summarises the average cost and time spent implementing the three IPM strategies trialed on the layer farms and at the EPC.

Table 10: Average cost and time spent on the three IPM strategies tested on commercial pilot farms and the EPC

IPM strategy	Farm	Cost (€ per bird)	Time spent (minutes per bird)
IPM1 - autogenous vaccine + predatory mites	EPC (average across two systems)	1,42	Carried out under research conditions so not indicative for commercial farms
IPM2 - predatory mites + Lentypou+	BE1	0,32	0,16
	BE2	0,54	4,83
	FR1	0,94	0,36
	UK2	0,40	0,67
	UK3	0,50	0,61
	UK4	0,43	0,41
	Average	0,52	1,17
IPM3 – Nor-mite + Fossil Shield	FR2	0,40	0,45
	FR3	0,42	0,35
	FR4	0,45	0,5
	UK1	0,40	0,56
	Average	0,42	0,47

IPM1 (Autogenous vaccine & predatory mites)

The IPM1 strategy was only tested at the EPC (two enriched cage compartments and eight aviary compartments). Since the set-up at the EPC differed substantially from that on the commercial pilot farms, the labour and time spent are not indicative for a commercial farm.

The autogenous vaccine was the most expensive product trialed of all, one shot cost €0,425. Since the birds were vaccinated twice (at 12w and 16w), the total cost of the product per bird came down to €0,85. The vaccine is not commercially available, so for the moment it is not an option to include in an IPM strategy on a commercial farm.

Predatory mites were released before placement of the hens in June ’20 and half of the Androlis® bottles were replaced on a 4 weekly basis until December ’20, when based on the monitoring results and limited effect of additional actions up until that point in time it was decided to consider the IPM1 trial as completed. The cost of the predatory mites released was €0,23 per hen, or €5.668,50 in total.

Lentypou+ was started after treating the hen house with Fossil Shield at 47w. The cost of Lentypou+ was €0,038 per hen or €928,11 in total. The cost of Fossil Shield Instant White was €0,34 per hen or €8.250 in total.

Total cost for IPM1: €1,42 per hen

IPM2 (Predatory mites & Lentypou+)

IPM2 was trialed on six farms: two in Belgium, one in France and three in the UK. The costs and time spent are approximations for each of the pilot farms.

Case study 1: BE1

Table 11: Labour and costs associated with the implementation of the IPM2 strategies for the control of Poultry Red Mite (Case study: BE1)

Action	Time (in minutes per application)	N° applications	Total time spent (in minutes)	Total cost (in €)
Cleaning (during empty period)	15.000	During empty period (standard approach)	15.000	6.000 (standard approach)
Remove manure and clean scrapers	Standard practice	6/month	Standard practice	/
Remove dust accumulations and clean egg belt (remove egg debris)	Standard practice	Every week	Standard practice	/
Remove hard crusts of manure	Standard practice	Every 2 months	Standard practice	/
Monitoring: stick traps	90	Once per week	3640 (stopped April '21)	/
Monitoring: cardboard traps	90	monthly/ fortnightly	990	/
Application Lentypou+	5	protocol	145	/
Releasing predatory mites	120	monthly	1080	/
Spraying with water and soap	240	Once during flock	240	128,92 (carried out by the EPC)

The product cost for predatory mites released on-farm was estimated to be €0,25 per hen or €9.651,90 in total. Lentypou+ cost €0,069 per hen or €2.622 in total (Table 11).

Total cost: €0,32 per hen

Total time: 0,16 minutes per hen

Case study 2: BE2

Table 12: Labour and costs associated with the implementation of the IPM2 strategies for the control of Poultry Red Mite (Case study: BE2)

Action	Time (in minutes per application)	N° applications	Total time spent (in minutes)	Total cost (in €)
Cleaning (during empty period)	8.400	During empty period	8.400	10.000
Remove manure and clean scrapers	90	2/week	10.980	/
Remove dust accumulations	60	daily	25.620	/
Clean egg belt and remove egg debris	60	daily	25.620	/
Monitoring: stick traps	60	Once per week	3.660	/
Monitoring: cardboard traps	60	monthly/ fortnightly	3.660	/
Application Lentypou+	15	protocol	1.350	/
Releasing predatory mites	120	monthly	1.320	/
Spraying with water and soap	240	During empty period + during flock	240	(covered in cost for cleaning)

The product cost for predatory mites released on-farm was estimated to be €0,38 per hen or €5.649 in total. Lentypou+ cost €0,154 per hen or €2.310 in total (Table 12).

Total cost: €0,54 per hen*

Total time: 4,83 minutes per hen*

*Excluding cleaning during empty period

Case study 3: FR1

Table 13: Labour and costs associated with the implementation of the IPM2 strategies for the control of Poultry Red Mite (Case study: FR1)

Action	Time spent (min)	Nb of applications	Total time spent (min)	Total cost (€)
Cleaning	No extra costs/time spent, protocol already applied			
Monitoring (Rick sticks)	20	Weekly	1.000	0
Applying lentypou	5	Throughout the flock	1.060	1.485
Releasing predators	60	6	360	7.560
Scraping hard crusts from nests	90	6	535	0
Removing dust accumulations	45 to 90	3	225	0
Applying black soap	60	3	180	6

The product cost for predatory mites released on-farm was estimated to be €0,82 per hen or €7.560,00 in total. Lentypou+ cost €0,124 per hen or €1.149,48 (Table 13).

Total cost: €0,94 per hen

Total time: 0,36 minutes per hen

Case study 4: UK2

Table 14: Labour and costs associated with the implementation of the IPM2 strategies for the control of Poultry Red Mite (Case study: UK2)

Action	Total time spent on action	Total cost (£) (excluding labour costs)
Monitoring stick traps	12 hours and 30 mins	£0
Monitoring cardboard traps	10 hours and 30 mins	£0
Predatory mites	5 hours	£651
Lentypou+® and supplementary water additives (Hepat'or® and VolyStim®)	2 hour and 45 mins	£822
Applying soap solution	3 hours and 20 mins	£22
Total per flock	34 hours and 5 minutes	£1,495
Total per bird	40 seconds per bird	50 pence per bird

The product cost for predatory mites released on-farm was estimated to be €0,26 per hen or €775,50 in total. Lentypou+ cost €0,141 per hen or €423 in total (Table 14).

Total cost: €0,40 per hen

Total time: 0,67 minutes per hen

Case study 5: UK3

Table 15: Labour and costs associated with the implementation of the IPM2 strategies for the control of Poultry Red Mite (Case study: UK3)

Action	Total time spent on action	Total cost (excluding labour cost)
Cleaning at turnaround	No additional cleaning measures were implemented.	£0
Monitoring stick traps	11 hours and 20 minutes	£0
Monitoring cardboard traps	13 hours	£0
Releasing Predatory Mites	2 hours and 30 minutes	£1,008
Lentypou+® and supplementary water additives (Hepat'or® and VolyStim®)	3 hour and 25 minutes	£542
Applying Soap Solution	3 hours	£10
Total per flock	32 hours and 15 minutes	£1,560

The product cost for predatory mites released on-farm was estimated to be €0,40 per hen or €1.200,00 in total. Lentypou+ cost €0,097 per hen or €291 in total (Table 15).

Total cost: €0,50 per hen

Total time: 0,61 minutes per hen

Case study 6: UK4

Table 16: Labour and costs associated with the implementation of the IPM2 strategies for the control of Poultry Red Mite (Case study: UK4)

Action	Total time spent on action	Total cost (excluding labour cost)
Cleaning at turnaround	No additional cleaning measures were implemented.	£0
Monitoring stick traps	5 hours	£0
Monitoring cardboard traps	6 hours	£0
Releasing predators	2 hours	£853
Providing Lentypou+	1 hour and 10 minutes	£496
Applying soap solution	3 hours	£10
Total per flock	20 hours and 25 minutes	£1,359

The product cost for predatory mites released on-farm was estimated to be €0,34 per hen or €1.015,50 in total. Lentypou+ cost €0,088 per hen or €264 in total (Table 16).

Total cost: €0,43 per hen

Total time: 0,41 minutes per hen

Case study 7: BBr1

Table 17: Labour and costs associated with the implementation of the IPM strategy for the control of Poultry Red Mite (Case study: BBr1)

Action	Time (in minutes per application)	N° applications	Total time spent (in minutes)	Total cost (in €)
Predatory mites (Taurrus & Androlis)	60	4 releases during flock	240	1374,44 (cost Taurrus & Androlis)
Lentypou+	10	Boost of 7d, gradually lowering frequency to once a month	120	360
Monitoring: cardboard traps (farmer)	60	Weekly (flock duration 40w)	2400	

The product cost for predatory mites released on-farm was estimated to be €0,23/bird or €1.374,44 in total. Lentypou+ was estimated to cost €0,06/bird or €360 in total (Table 17). Together, this resulted in an estimated of €0,29/bird for the IPM2 products trialled on BBr1.

IPM3 (Fossil Shield + Nor-Mite)

IPM3 was trialed on three farms in France and one in the UK. The costs and time spent are approximations for each of the WP3 pilot farms.

Case study 1: FR2

Table 18: Labour and costs associated with the implementation of the IPM3 strategies for the control of Poultry Red Mite (Case study: FR2)

Action	Time spent	Nb of applications	Total time spent	Total cost (€)
Cleaning	108h (External time, estimation with 10days of working on farm) 69h (time spend by the farmer)	• Remove manure • Scraping/blowing (external staff) • 2 disinfections (1 per external staff and 1 by the farmer) • Not wet cleaning just manure pit, next to the hen house	177h (internal and internal time)	6.784€ (only external cost) 1.035€ for time cost of the farmer (15€/hour)
Monitoring Rick sticks (n=16)	45min/monitoring	Weekly	41,25h	618,75€ (15€/h for workforce of the farmer)
Applying Normite	15min/week	3*/week throughout the whole flock in drinking water + some periods daily distributed	14h	210€ (15€/h for workforce of the farmer) 0,2€/hen/round so 6601,20€ for 33.006 hens
Applying FossilShield	Depending on treatment done (local or whole barn)	16 (4 done by external workforce)	~50h (including time of external workforce)	600€ (15€/h for workforce of the farmer) 0,31€/hen/round so 10.232€ for 33.006 hens including product+labour cost application of the supplier
Remove manure from soil	15h/application	8	120h	180€ + material/electrical depreciation (15€/h for workforce of the farmer)
Removing dust accumulations	1h/week	13	13	195€ (15€/h for workforce of the farmer)
Removing eggs and eggs debris on egg belts	1h/week	13	13	195€ (15€/h for workforce of the farmer)
Remove manure from the manure belt	Automatic	3times/week before 38weeks then 4times/week	0	0

Automatic scraping under aviary system	Automatic	Daily	0	0
Emptying of the manure adjoining the building	4,5h/application	2 times	9h	135€ (15€/h for workforce of the farmer)

The product cost for Fossil Shield was estimated to be €0,20 per hen or €6.450 in total. Nor-Mite cost €0,20 per hen or €6.601,20 in total (Table 18).

Total cost: €0,40 per hen*

Total time: 0,45 minutes per hen*

*Excluding cleaning during empty period

Case study 2: FR3

Table 19: Labour and costs associated with the implementation of the IPM3 strategies for the control of Poultry Red Mite (Case study: FR3)

Action	Time spent	Nb of applications	Total time spent	Total cost (€) 15€/hour cost of the staff
Measures during empty period	180h (labour of the service supplier) 20h (labour of the farmer)	• Remove the manure (farmer) • Scraping/blowing (external company) • No wet cleaning just : Scraping of the underside of the aviary (2 scrapers under each aviary) sidewalk at the exit of the exterior access hatches + 2 ends of the interior aviary and the side walls outside • 1 desinfection *(Vetanios)*	200h (labour of the farmer and service supplier)	~2.600€ (only service supplier cost)
Monitoring Rick sticks (n=12)	1h/week	weekly	52h	780
Applying Normite	15min/week	3*/week+some periods with daily distribution	13h	7.090,40€ :195€ for hour cost and 0,23/hen/round so 6.895,40€ for 29.980 hens placed
Applying FossilShield	0,5h to 1,5h per application (farmer) 1,5 to 2 days by external	6 (including empty period and 3 applications done by external)	~32h (including time of the external)	~53€ (only farmer cost) 0,28€/hen/round so 8.394€ for 29.980 hens including cost of the product and labour cost of the supplier for application

Removing dust accumulations	30min/application	Weekly (head of the aviary)	26h	390€
Removing eggs and eggs debris on egg belts	30min/application	weekly	26h	390€
Remove manure from the manure belt	automatic	Daily (half of the barn)	0	0
Scraping of the manure belts	15-30min/application	weekly	13-26h	195-390€
Scraping the underside of the aviary (2 scrapers under each aviary)	automatic	Daily or 2-3 times/week depending on the present manure to extract	0	0
Emptying of the manure adjoining the building	1,5h/application	Every 3 months	6h	90€

The product cost for Fossil Shield was estimated to be €0,19 per hen or €5.700 in total. Nor-Mite cost €0,23 per hen or €6.895,40 in total (Table 19).

Total cost: €0,42 per hen*

Total time: 0,35 minutes per hen*

*Excluding cleaning during empty period

Case study 3: FR4

Table 20: Labour and costs associated with the implementation of the IPM3 strategies for the control of Poultry Red Mite (Case study: FR4)

Action	Time spent	Nb of applications	Total time spent	Total cost (€) 15€/hour cost of the staff
Cleaning	49h of farmer work	• Remove manure and scraping/blowing by the farmer • Partial wet cleaning without soap by the farmer : head and end of cages lines, walls and air admission • 2 disinfections (Formal pulverisation 4% by the farmer and Aseptol thermonebulisation 2% by external company	49h	1.190€ (external service supplier cost) +735€ of farmer work
Monitoring Rick sticks (n=12)	20min/week	Stop of the ricksticks monitoring at 38 weeks age of hens	18h of work on 55 weeks	270€
Applying Normite	10min/application	Stop of the normite distribution from 36 weeks age of hens	10h30 of work on 20 weeks	0,03€/hen/round so 750€ for 25.000 hens placed + 160€ of farmer work
Applying Lentypou+	10min/application	Start of the distribution from 43 weeks age of hens	6h on 28 weeks	0,158/hen/flock so 3.950€ for 25.000hens +

				100€ of farmer work
Applying FossilShield	Not by the farmer so 0h	2 times/external service supplier	0h for the farmer	0,55€/hen/round so 13.750€ for 25.000 hens including the cost of the product and the labour force of the supplier
Removing dust accumulations	1h30/application	1 time/week	82h30 On 55 weeks	1237,50€ of farmer work
Removing eggs and eggs debris on egg belts	15min/application	2times/week	27h30 On 55 weeks	412€ of farmer work
Remove manure from the manure belt	0h because automatic scraping	Daily, one line of cages/day	0h	0
Emptying of the manure adjoining the building	10min/day	1 time/day	64h On 55weeks	962,50€ of farmer work

The product cost for Fossil Shield was estimated to be €0,35 per hen or €8.800,00 in total. Nor-Mite cost €0,03 per hen or €750 in total. Lentypou+ cost €0,073 per hen or €1.825,00 in total (Table 20).

Total cost: €0,45 per hen*

Total time: 0,50 minutes per hen*

*Excluding cleaning during empty period

Case study 4: UK1

Table 21: Labour and costs associated with the implementation of the IPM3 strategies for the control of Poultry Red Mite (Case study: UK1)

Action	Total time spent on action	Total cost (excluding labour cost)
Cleaning at turnaround	No additional cleaning measures were implemented.	£0
Monitoring stick traps	12 hours and 40 mins (20 minute per sample)	£0
Monitoring cardboard traps	10 hours (40 minute per sample)	£0
House whole application of Fossil Shield® (one application at turnaround and one when birds were 57 weeks)	Carried out by external contractor	£1,371
Local applications of Fossil Shield® instant white	40 hours and 30 minutes	£350
Providing Nor-mite	6 hours	£1,014
Applying soap solution	6 hours	£123
Total (per flock)	75 hours and 10 minutes	£2,858
Total (per bird)	30 seconds	36 pence

The product cost for Fossil Shield was estimated to be €0,254 per hen or €2.032 in total. Nor-Mite cost €0,15 per hen or €1.200 in total (Table 21).

Total cost: €0,40 per hen

Total time: 0,56 minutes per hen

Case study 5: BBr2

Table 22: Labour and costs associated with the implementation of the IPM strategy for the control of Poultry Red Mite (Case study: BBr2)

Action	Time (in minutes per application)	N° applications	Total time spent (in minutes)	Total cost (in €)
Cleaning (internally) & disinfection (externally)	9000 (per house, cleaning only)	during empty period	9000 (house 3)	7000
Silica (FS IW) treatment before placement	External	Once (during empty period)	External	1500 (product cost) + 960 for labour (external)
Local treatment during flock	NA	NA	NA	NA

The product cost for Fossil Shield Instant White for house 3 was €0,15 per bird or €1.500 in total. In this case, the application was done by an external company. The labour cost for the application was €960. In conclusion, because the treatment was done externally, the cost of the product and the application was €0,25 per bird or €2.460 in total (Table 22).

Case study 6: Poul6

Table 23: Labour and costs associated with the implementation of the IPM strategy for the control of Poultry Red Mite on pullet farms (Case study: Poul6)

Follow-up	Cleaning & disinfection: labour	Disinfectant	Acaricide	Fossil Shield Instant White	Total cost	Remarks
Pre-IPM flock	€3.000 (3 days work for 2 people)	€ 200	€600 (1 day for 1 person)	-	€ 3.800	
IPM flock	€3.000 (3 days work for 2 people)	€ 200	-	€ 6.562	€ 9.762	Application of FS IW by 2 people for 2 days cost €2620; FS IW product cost €3942)
Post-IPM flock	€3.000 (3 days work for 2 people)	€ 200	-	-	€ 3.200	

The strategy used for the IPM flock proved to be effective against PRM. However, the total cost estimated was much higher than the previous flock when the farmer used an acaricide. For the post-IPM flock however, the farmer did not need to include a treatment against PRM since the effect of the IPM treatment remained. In the future it should be investigated for how long this effect remains, in order to estimate the economic effect.

Practical implications on the short term for farmers and the poultry sector

Currently, the phytoadditives Lentypou+ and Nor-Mite are commercially available. Protocols should be discussed with the suppliers of the products to ensure an optimal use.

Predatory mites can be purchased for use on commercial farms. Care must be taken in which other products are used on-farm. For example, Exzolt or silica not only affect PRM, but also the native mites present in the hen house, including *Androlaelaps* spp and *Cheyletus* spp. It is important to seek proper advice on which products are harmless for the predatory mites and which ones are not. The supplier can train the farmers in how to use predatory mites in their hen house.

Silica is marketed in different types and brands. Natural silicas are available that can be used on organic farms. Synthetic silicas such as Fossil Shield Instant White are currently not allowed to use on organic farms in Belgium or France. Silicas are included in the biocide list.

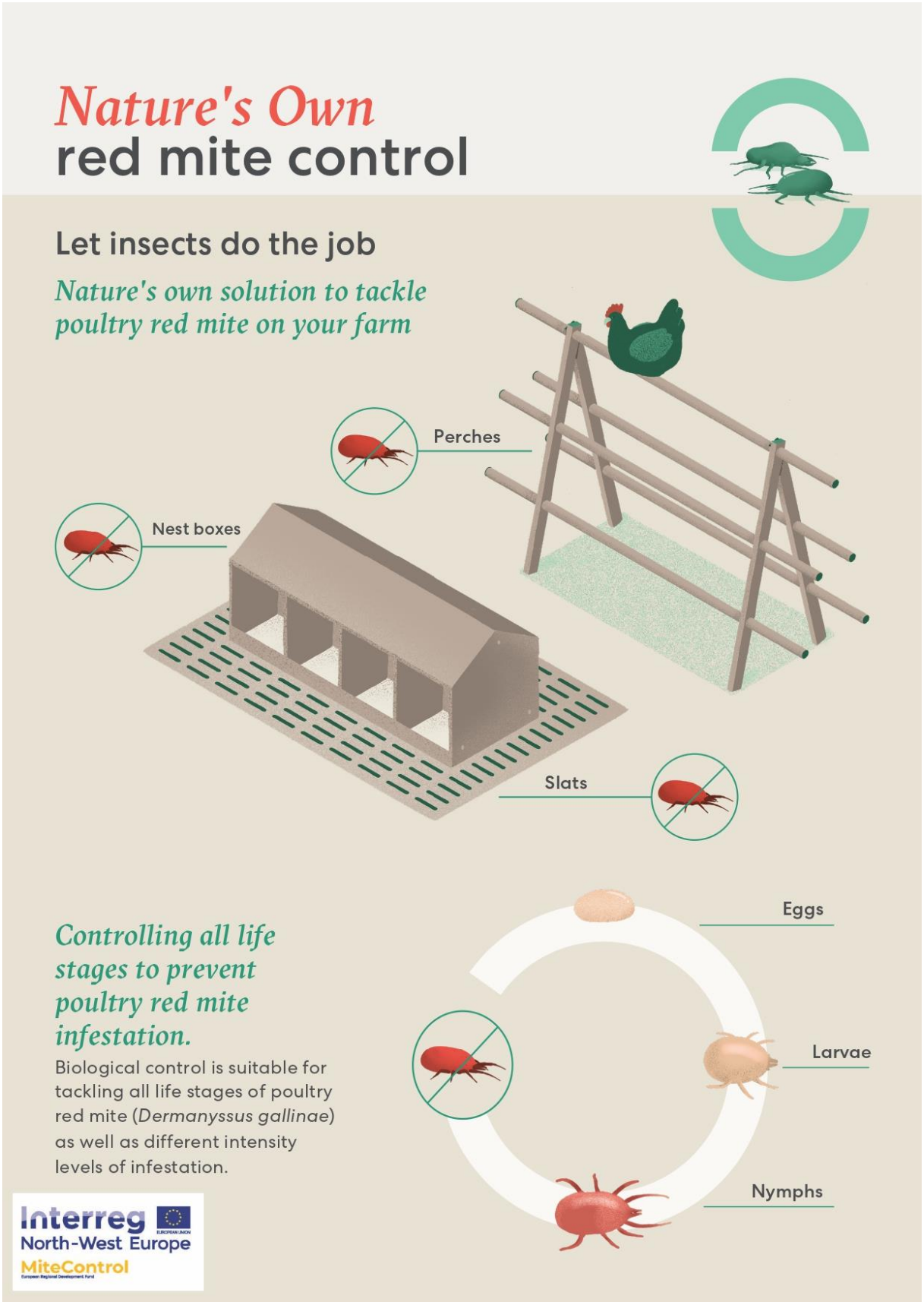
The Q perch was developed by Vencomatic and although already installed on a number of commercial farms, research to optimise the technology is still underway.

The autogenous PRM vaccine is currently not available for the use on commercial farms. More research is still being conducted by Moredun Research Institute on the formulation of the vaccine.

Although in the WP3 and WP4 trials, the combinations of the products were decided by the MiteControl partners, farmers can decide which products they would prefer to use. Of course, it should be taken into account that some products are not complementary (e.g. predatory mites and silica). Advice on the optimal use of the individual products can be given by the suppliers. Farm advisors or veterinarians can also be consulted. Not every product is well-suited for use on every farm type. The choice should be made taking into account historic PRM infestation, housing type, farming system and preferences of the farmers themselves. In case the strategy of choice does not have an effect on the PRM population in the hen house, it should be considered to use alternative non-chemical products. Product suppliers, farm advisors and veterinarians as well as the MiteControl partners can be consulted and provide guidance to the farmer where necessary.

Appendix I: Product information

Predatory mites



Why Androlis & Taurrus predators

No personal protective equipment needed, products are 100% safe for humans, birds and the environment.

Effective against red mite found in poultry farming

Easy and quick to implement in your daily operation

Androlis & Taurrus
Predatory mites

Androlis & Taurrus consist of 100 % predatory mites to tackle all life stages of red mite.

Dosage
- 1 Androlis & Taurrus kit containing 1 Androlis Pro bucket (100.000 mites) and 1 Taurrus Pro bucket (400.000 mites) for 3.000 hens.

Application

Disperse the predators evenly in the nests and under the slats by hand and use the diffuser bottles for the perches and other spots where poultry red mite is found. Sachets can be used for nest boxes.

Androlis bottle & sachet
Predatory mites

Androlis sachet and bottle are complementary to the Androlis and Taurrus kit. It is set up for a gradual diffusion on the areas to be treated.

Dosage
- 1 sachet/nest roof. One box contains 60 sachets.
- 1 bottle/perch or for 200 hens.

Application

Place the Androlis sachets and bottles and repeat every 8 weeks.
The bags have an optional magnet to attach them to building structures. The bottles can be fixed using the fixing clip or tie wraps, at the level of the perches.

Appicure liquid
Feed additive

Appicure liquid is a feed additive to be used in the presence of red mite, to weaken the pests and make them more vulnerable to predators.

Dosage
- 1L to dilute in 1000 L of water for 6.000 birds. Treatment for 10 days.

In case of heavy infestation, repeat the treatment.

Application

Appicure must be mixed with poultry drinking water. It is used as a curative treatment, in combination with Androlis & Taurrus predators.

Get the best results

Preventively installing a protocol adapted to your farm makes it easier to prevent and limit infestations of red mites. Each protocol is established according to the type of breeding, the surface area of the building and/or the number of animals. These variables determine the quantity of predators to set up, the dosage and the frequency.

Total budget received from Interreg North-West Europe (2014-2020): €2,05 million of ERDF
Total project budget: €3,4 million

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Androlis Taurrus

Biological control of poultry red mites

Predators attacking all life stages of the parasite

Androlis and Taurrus are two species of mite that prey on red mites *Dermanyssus gallinae*. These two predatory mites attack the parasite during all stages of its life cycle (eggs, larvae, nymphs and adults). The predators are found in all bird nests in the wild and can occur naturally in laying hen facilities. Use Androlis and Taurrus to re-establish a natural equilibrium.

A complete and effective solution

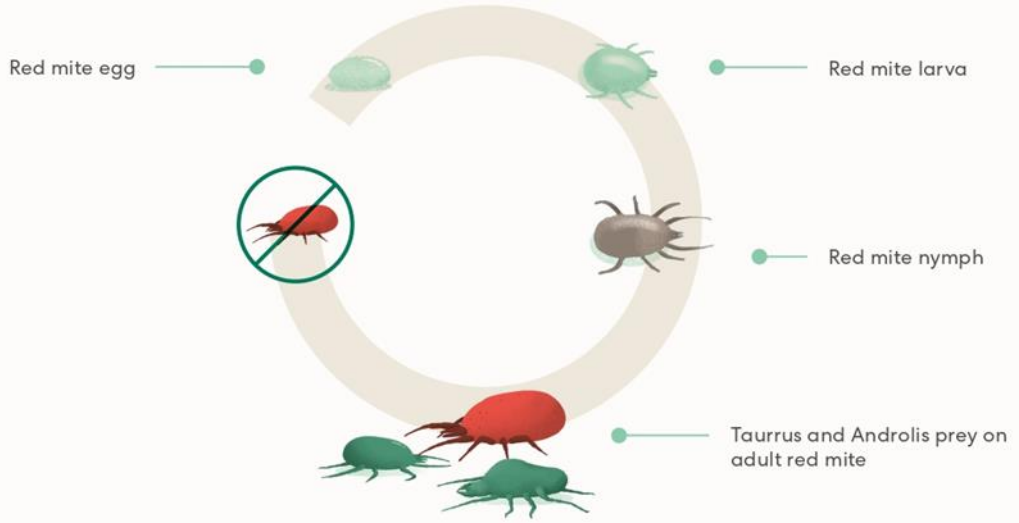
- ✓ The beneficials are harmless and pose no danger to human or animal health
- ✓ Safe to use in the presence of animals
- ✓ Effective whether used preventively or curatively
- ✓ Compatible with other treatments as part of integrated pest management

Interreg North-West Europe
MiteControl

Biological control of red mites

Red mites are a source of nuisance for chickens as well as farmers. They take advantage of periods when the hens are inactive to have a blood meal, which causes stress, nervousness, a drop in egg production, anaemia and even death. Red mites are also known to transmit numerous pathogens. They form clusters near the hens' resting areas (perches, slats and nests) and can fit themselves into the tiniest cracks and crevices in structures. Red mites can rapidly develop resistance to insecticides, adapt to extreme conditions and survive prolonged fasting. These properties make them extremely difficult to eliminate from farms.

Integrated pest management solutions combining different treatment modalities are the most effective tools for controlling red mites in the long term. Androlis and Taurrus are natural predators of red mites. They are adapted to farming conditions and live near the birds. These predators are found in all bird nests in the wild and can occur naturally on laying hen farms. Their small size and mobility enable them to hunt down these parasites in the tiniest corners of your farm.



The beneficial's characteristics

ANDROLIS
- The egg-to-egg cycle is 20-27 days
- Fertility of approximately 30 eggs/female
- Well adapted to farm environments

TAURRUS
- Life cycle of 14-20 days
- Fertility of approximately 40 eggs/female
- Able to withstand harsh conditions (extremes in temperature, fasting, low humidity)

The two predators complement each other in controlling *Dermanyssus gallinae*.

Instructions

Dosage

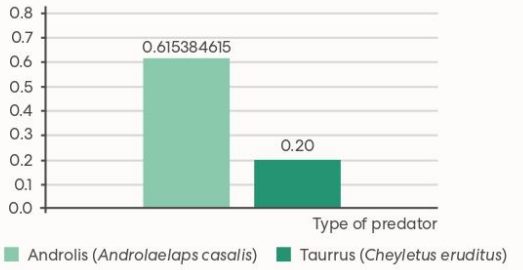
Androlis and Taurrus are available as a kit treating 1,500 hens. Each kit contains:
- One tub of Androlis PRO (100,000 predators *Androlaelaps casalis*)
- One tub of Taurrus PRO (400,000 predators *Cheyletus eruditus*)

Also available:
A bottle of Androlis (6,000-8,000 predators) for 200 hens.
A sachet for the nest roof (4,000-6,000 predators), box of 60 pre-punched sachets.

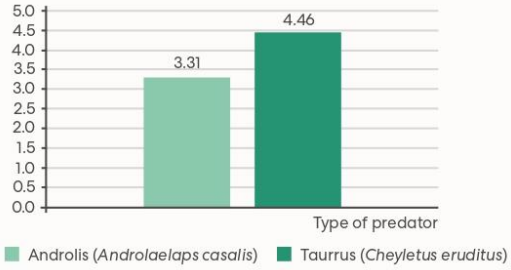
Frequency

The Androlis & Taurrus kit can be used both preventively and curatively. Initial release: use one kit for 1,500 hens, when restocking with new birds. Follow up with three to six half-releases at intervals of several weeks, using one kit for 3,000 hens. The number released can be reduced in the following years.

Predation rate of *Cheyletus eruditus* and *Androlaelaps casalis* on *Dermanyssus gallinae* in 24h



Number of *Dermanyssus gallinae* nymphs eaten in 48h by Androlis & Taurrus



Lifespan and storage

Androlis & Taurrus are live products. They must be used quickly, preferably upon receipt. The product can be stored for up to one week in a cool place away from light.

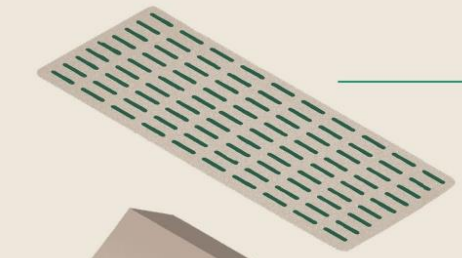
Use

- ✓ **Scatter Androlis and Taurrus in nests, under floor slats as well as in all areas where red mites can develop. Supplement the tubs with sachets and/or bottles.**
- ✓ **Place sachets on nest roofs and on building structures.**
- ✓ **Bottles can be mounted on perches using the clip.**

A complete pest-control programme

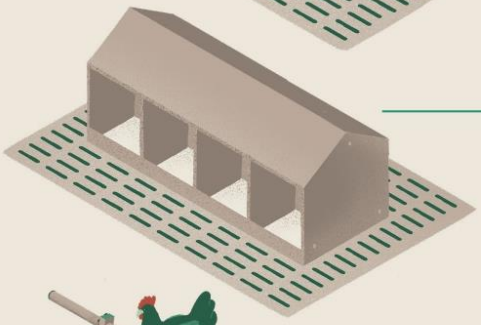
Using Androlis & Taurrus

A programme for controlling red mites is effective because the products complement each other. Each product has been developed as a response to one specific aspect of controlling farm pests.



Androlis & Taurrus kit

Androlis & Taurrus are predatory mites attacking at all the life stages of the red mite.



Androlis sachet

The Androlis sachet supplements the Androlis & Taurrus kit. It is set up for gradual dispersal in the treatment zones.

Androlis bottle

The Androlis bottle is a supplementary tool to the Androlis & Taurrus kit, set up in aviaries to disperse the predators.

Appic'ure liquid

Appic'ure liquid is a dietary supplement to be used where red mites are present, to weaken the pests and make them more vulnerable to predators.

Get the best results

Setting up a preventive approach specifically for your poultry farm's needs allows you to prevent and limit red mite infestations more easily. Each programme is based on the type of farm, building surface area and number of animals. These variables determine which predators to put in place, their quantities and the frequency of application.

Total budget received from Interreg North-West Europe (2014-2020): €2,05 million of ERDF
Total project budget: €3,4 million

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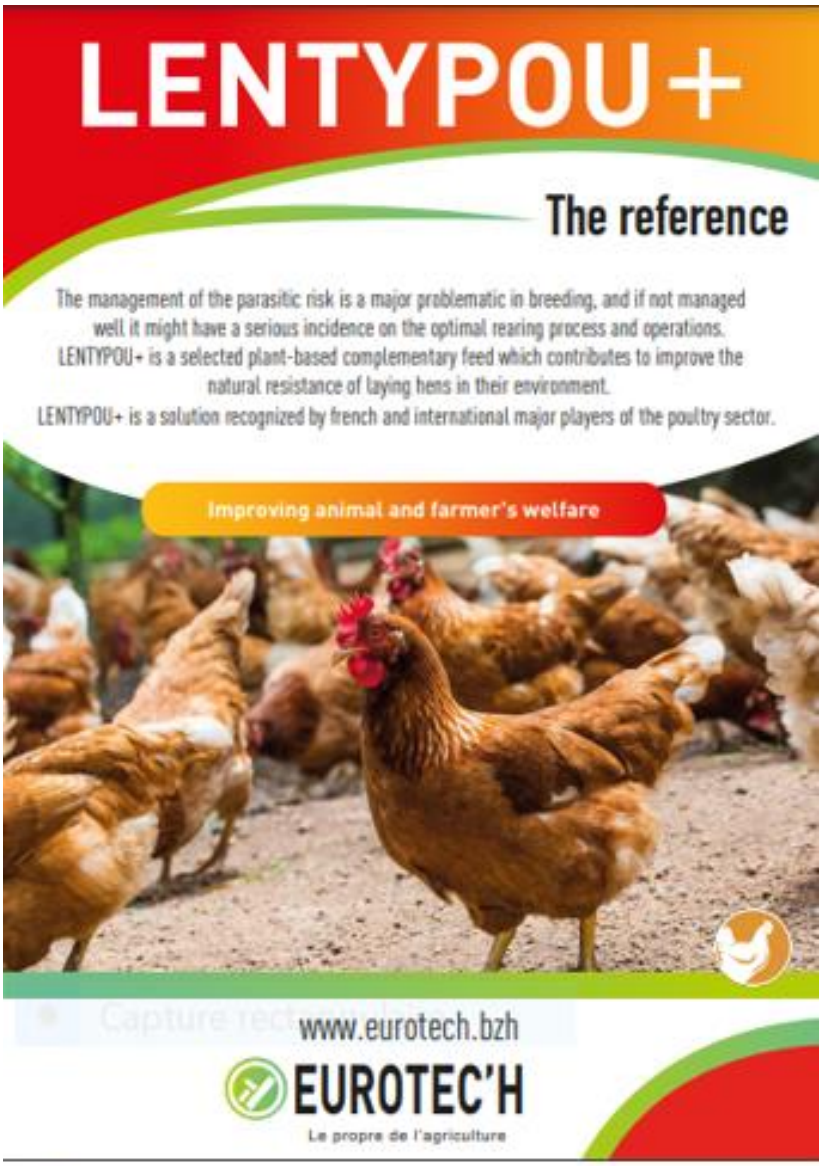
(Information and instructions for use: https://www.youtube.com/watch?v=LKgihy9R_yw)

Lentypou+



Instructions for use

Liquid product to mix with drinking water at 0,75 liter / 1 000 liter during 7 consecutive days then renew according to needs.

Before the use of LENTYPOU+, we advise to administer an hepatic draineur in order to optimize the functioning of the blood system.

Packaging, durability and storage

Presentation: yellow liquid packaged in 5L can.

Durability: 12 months from the date of manufacture

Storage: Store in a cool, dry place. Keep the can closed to prevent contamination.

Peut être utilisé en agriculture biologique en conformité avec le règlement (CE) n° 834/2007 et (CE) 889/2008. Certifié par Bureau Veritas Certification France FR-BIO-10. Cet aliment ne peut être distribué aux animaux qu'en complément d'autres matières premières issues de l'agriculture biologique.

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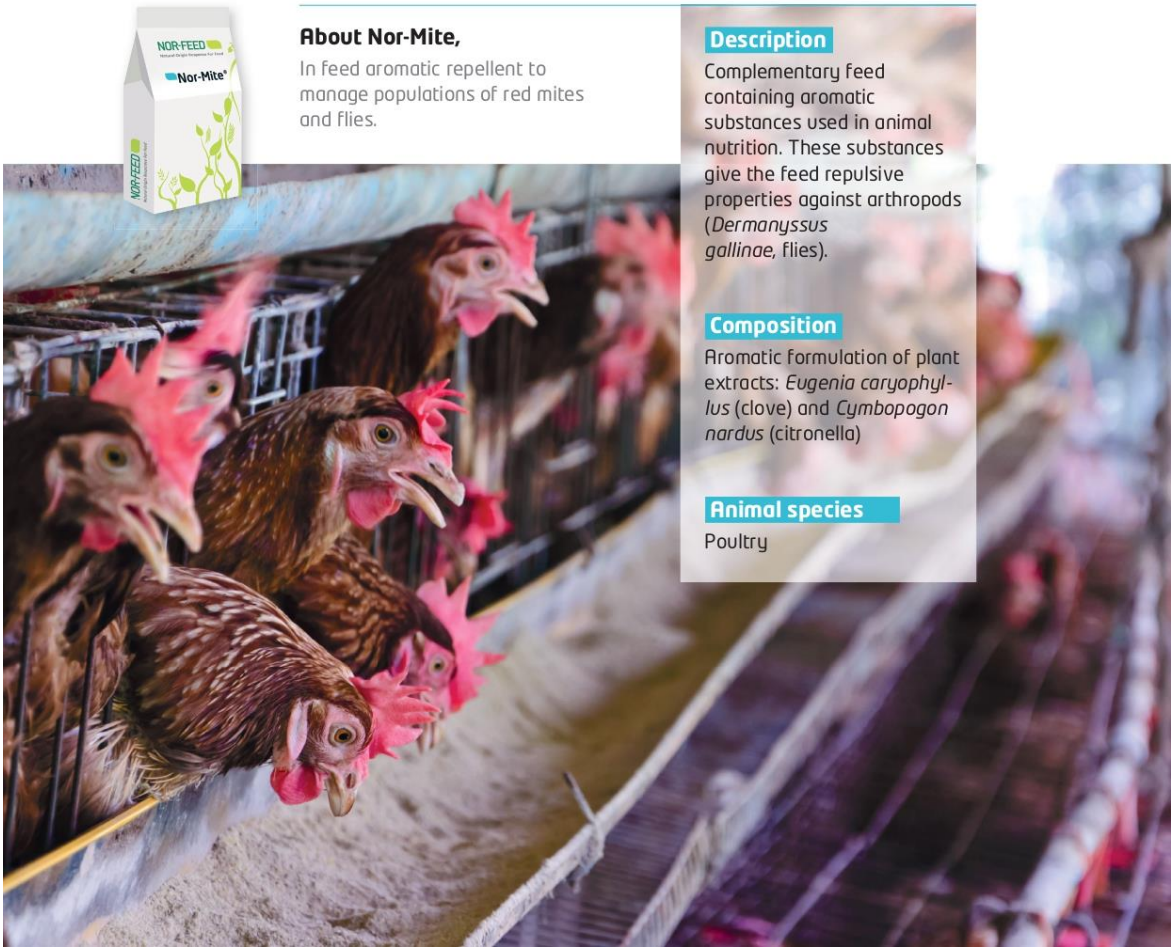
(Information and instructions for use: https://youtu.be/WFmM5FKKLaw?feature=shared)

GOOD PRACTICES

Nor-Mite®

Guidelines for good practices and use of Nor-Mite to manage red mites in farming

The level of red mite infestation in farming can be determined by different people and methods.
The "sense" of infestation is not quantifiable and can be qualified according to criteria dependent on the farmer's perception, the production period, the farm and the country.
The objective of this tool is to determine good practices in farming to manage red mites, to have a common method to monitor objectively the level of infestation and to offer an adapted use for Nor-Mite.



About Nor-Mite,
In feed aromatic repellent to manage populations of red mites and flies.

Description
Complementary feed containing aromatic substances used in animal nutrition. These substances give the feed repulsive properties against arthropods (*Dermanyssus gallinae*, flies).

Composition
Aromatic formulation of plant extracts: *Eugenia caryophyllus* (clove) and *Cymbopogon nardus* (citronella)

Animal species
Poultry

Dermanyssus gallinae

Poultry red mite, *Dermanyssus gallinae*, is one of the most common ectoparasite in poultry farms.
Costs are estimated at 130 million euros per year in the European Union.

Red mite picture: from Alan R. Walker

Their control in farming conditions is very complicated due too :

Their high prolificity

- Low fertility:
  - Coupling + blood meal = clutch
  - Average: 23 eggs/female
- But a fast growth:
  - 1 egg = 1 female ready to lay in 1-2 weeks
  - 400 % increase of *D. gallinae* population in 42 days

Their homing behavior and their herd instinct!

- Mites do not live on the hens but close to them.
- Only in contact with the host for feeding (blood meal)
  - 30 to 90 minutes
  - mainly at night.
- They hide quickly in cracks and crevices to digest blood meal, mate and lay eggs.
- They "agglutinate" and form herds.

How objectively determine the infestation level in farming?

Different methods can be used in order to monitor the infestation level.
The method chosen by Nor-Feed, inspired by the work of Lise Roy & Chiron et al. (2015), consists of fixing an adhesive tape around a rod of the farming equipment.
After 15 days, the tape is collected, its observation permits to determine the infestation level of the farm house and to adapt the prevention protocol.

Three infestation levels, three types of prevention with Nor-Mite

Which is the infestation level?		Observation in farm
Severe infestation Presence of mite herds		Mites everywhere, visible or in agglutinated herds
Moderate infestation Some mites visible		Mites visible in the cracks and crevices
Low infestation No mites visible		No mites visible

PS: **the liquid version of Nor-Mite** can be used for low to moderate infestations during 7 consecutive days, then 3 days per week.

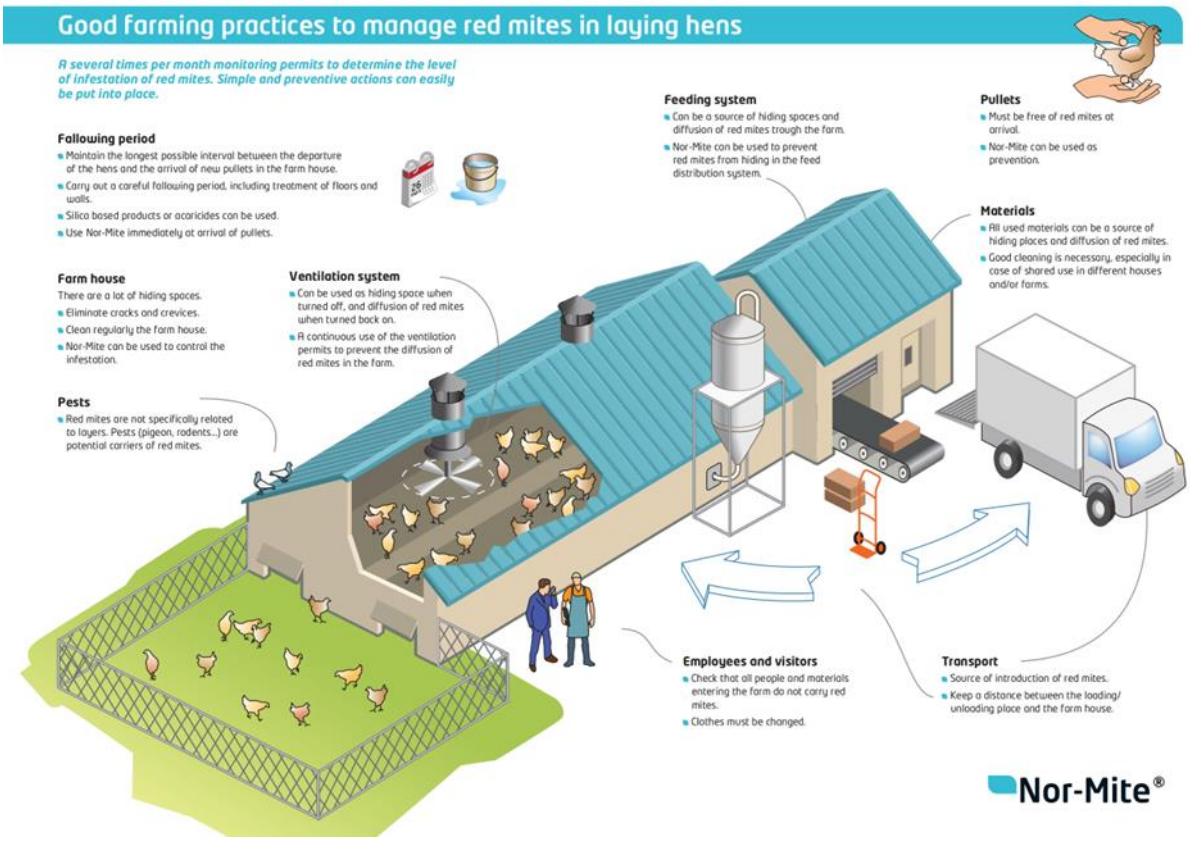
**Recommended to use Nor-Mite at least 3 days before transferring to laying farm*

The Nor-Mite is used throughout the flock to maintain the infestation level as low as possible.

Illustration : antelo.fr - Photo de couverture : Fotolia

NOR-FEED
Botanicals • You know why

PLANTS AND PLANT EXTRACTS IN ANIMAL FEED
Angers Technopole - 3 Rue Amedeo Avogadro - 49070 Beaucouzé, France
Tel : +33 (0)2 41 93 74 56 www.norfeed.net

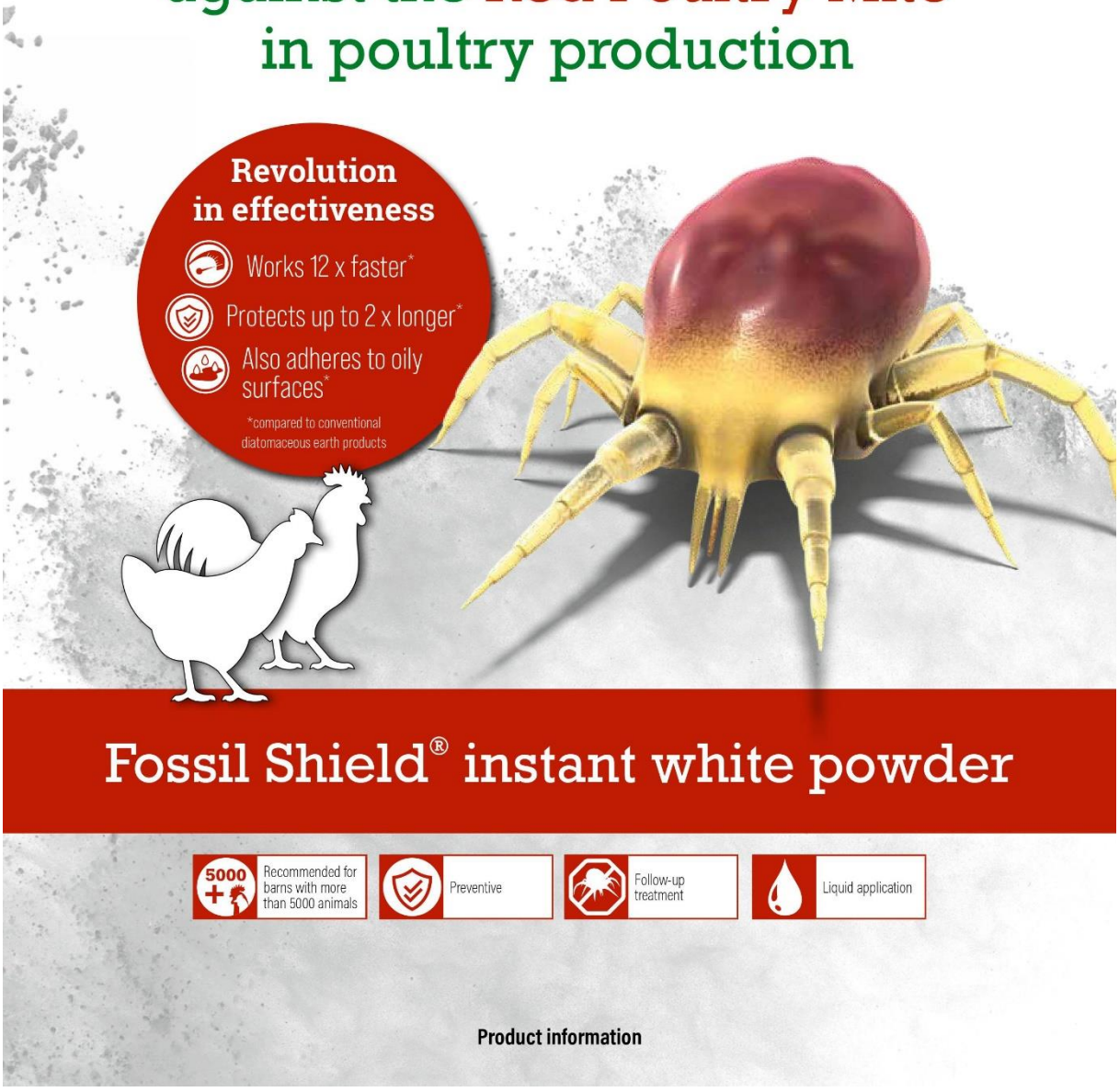


(Information: https://www.youtube.com/watch?v=eB6_9opLYsA)

FOSSIL SHIELD®

protects against red mites

Professional protection against the Red Poultry Mite in poultry production



Approximately 80 percent of poultry farms are affected by the red poultry mite.

The red poultry mite (Dermanyssus gallinae)

The red poultry mite belongs to the arachnids and can grow to a length of up to 1 millimetre. It is found in almost every poultry population. In case of heavy infestation or lack of hosts, the mites also pose a serious problem for humans. The mites are grey, but turn grey-brown after feeding. The eggs of the red poultry mite are pale, almost transparent and about 0.4 millimetres in size.

Poultry farmers fear these bloodsuckers, because the tiny ectoparasites are hardly visible to the naked eye and difficult to control. For example, the red poultry mite has been observed to travel up to 30 metres to find new hosts. The red poultry mite is nocturnal and retreats into narrow crevices and cracks and open colonies during the day.

Profile - the red poultry mite

Latin: Dermanyssus gallinae

Size: 0.5-1 mm

Colour: grey to red (red colour after feeding)

Development period: 7-9 days depending on temperature and humidity.

Activity: Although the red poultry mite is nocturnal, it can also be found on the chickens during the day if infestation is heavy.

Mite eggs: The female lays about 20 eggs every 2-3 days (a female can produce up to two million offspring within 12 weeks).

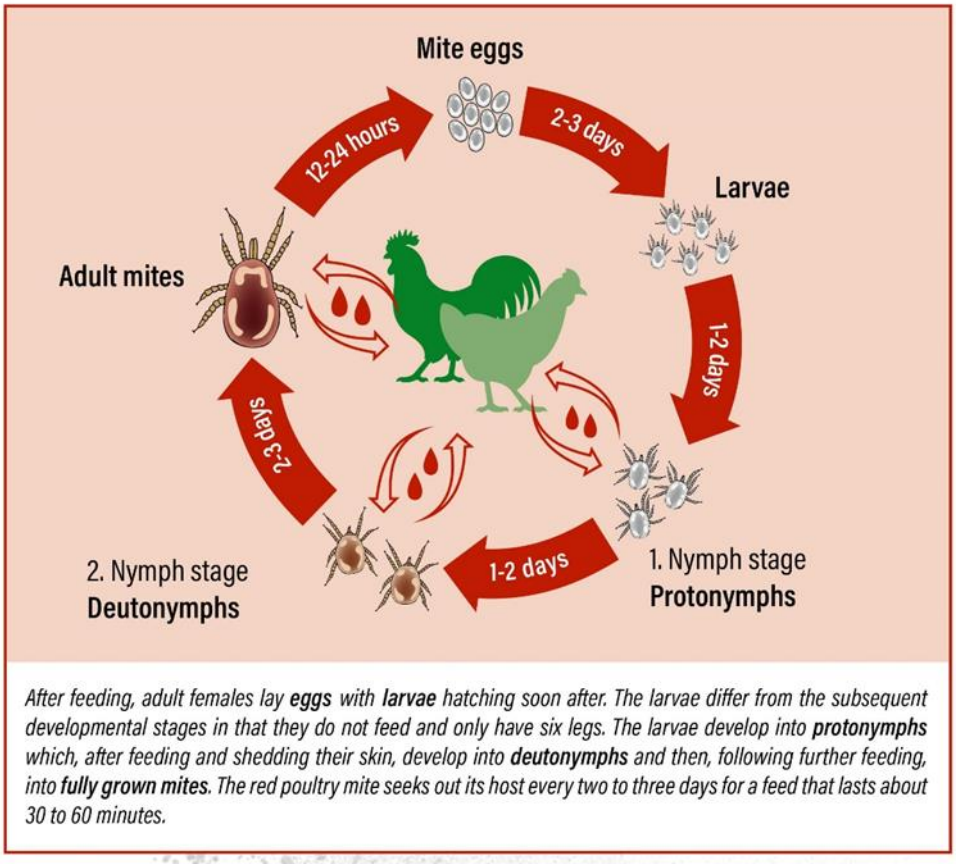
Temperature sensitivity: Active from 10°C, below which it lapses into torpor (survival times of up to 18 months are possible under these conditions). Mite eggs are also very resistant to cold. Temperatures below minus 20°C and above 50°C kill the mites.

Lifespan: approx. 8 weeks (whereby they can survive starvation periods of up to 34 weeks.

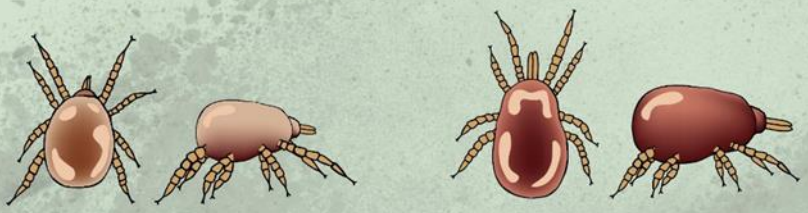
Eggs *Larvae* *Protonymphs*

Mites can travel up to 30 metres.

Life cycle of the red poultry mite



*After feeding, adult females lay **eggs** with **larvae** hatching soon after. The larvae differ from the subsequent developmental stages in that they do not feed and only have six legs. The larvae develop into **protonymphs** which, after feeding and shedding their skin, develop into **deutonymphs** and then, following further feeding, into **fully grown mites**. The red poultry mite seeks out its host every two to three days for a feed that lasts about 30 to 60 minutes.*



Deutonymphs *Adult mites*

3

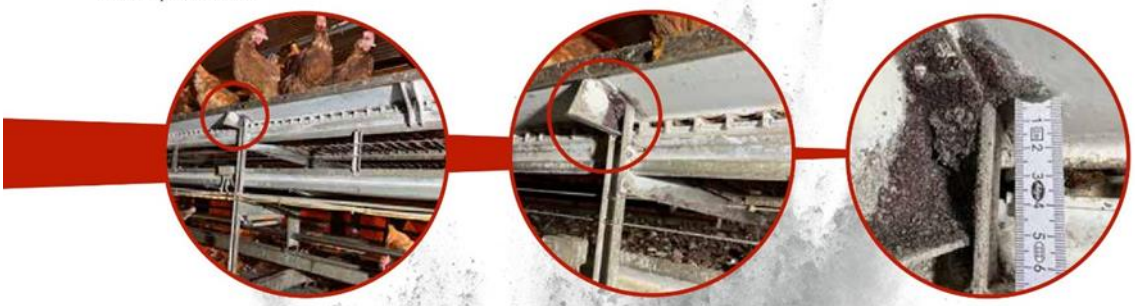
The damage caused by the red poultry mite is estimated at 11 million Euros per annum.

The red poultry mite causes great economic damage.

- anaemia
- increased stress
- a weakened immune system
- behavioural disorders
- reduced laying performance
- weight loss
- increased feed consumption
- transmission of pathogens such as diphtheria, avian cholera, etc.
- inferior breeding results
- aggressiveness all the way to cannibalism
- anaemic death
- loss of quality due to soiled eggs

Commercially available diatomaceous earth coating – 3 months after stabling

The images show a facility coated with a conventional diatomaceous earth product. Significant mite infestation is already apparent after three months. This requires immediate action! We recommend speedy treatment with our FOSSIL SHIELD® products, which are very effective in highly humid areas due to their water-repellent properties and which are therefore ideally suited not only for prophylactic treatments, but also, as in this case, for follow-up treatments.



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What measures are available against the red poultry mite?

PHYSICAL MEANS

Synthetic silica: The silica particles absorb the protective wax layer and the mite becomes dessicated. Advantages: Also effective in high humidity and ideal for long-term prophylaxis.

Diatomaceous earth products: The diatomaceous earth particles chafe the mite's carapace, and low humidity dessicates it. Not effective in environments with high humidity.

Heat treatment: In unoccupied barns with professional techniques or scorching.

BIOLOGICAL MEANS

Predatory mites: Successful application depends on many factors (including humidity, temperature, sites must not be pre-treated or treated in parallel). The predatory mites must not belong to any bloodsucking species. There are no reproducible positive results from practice.

Essential oils: No measurable positive results from practice.

CHEMICAL MEANS

Disinfection: Chemical agents may only be applied in unoccupied barns in strict compliance with all safety measures.

Drinking trough supplements: Drinking trough supplements with veterinary approval have a good curative effect against all bloodsucking stages. Optimal in combination with a prophylactic silicate coating.

Mechanism of action FOSSIL SHIELD®

How does FOSSIL SHIELD® work?

FOSSIL Shield® products with synthetic amorphous silicon dioxide as the active ingredient have a **purely physical effect**.

Effect

The mechanism of action sets in as soon as the parasites come into contact with the product and dust themselves with the silica. The evaporation-inhibiting protective layer of the parasitic insects is absorbed and the mites dessicate within a few hours.

FOSSIL SHIELD®'s active ingredient is synthetic, amorphous silicon dioxide (CAS: 68909-20-6 (Nano)). The active ingredient is hydrophobic (water-repellent) and remains fully effective even in environments with higher humidity.

Natural diatomaceous earth is hydrophilic (water-attracting), which means that the active ingredient becomes saturated in higher humidity and then only has a limited effect on the red poultry mite.

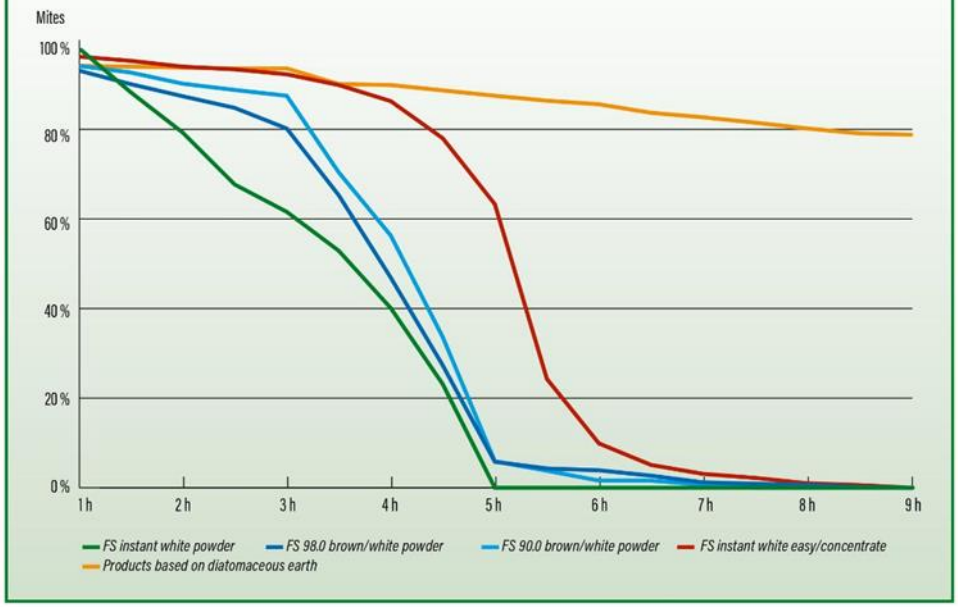
It is thanks to this circumstance that, compared to diatomaceous earth, FOSSIL SHIELD® products with a very low percentage of active ingredient are more effective on the red poultry mite.

The carriers in FOSSIL SHIELD® products are for the most part silica of natural origin and are used exclusively for the even distribution of the active ingredient and therefore for application and active ingredient efficiency.

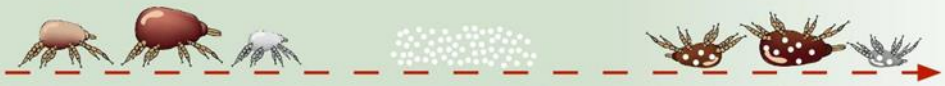
5

FOSSIL SHIELD® products take effect in just a few hours.

Fully effective in a few hours!



Compared to diatomaceous earth products, which usually take several days to control the red poultry mite, FOSSIL SHIELD® products only need a few hours. FOSSIL SHIELD® products are characterised by their fast and sustainable efficacy.



The mites come into contact with FOSSIL SHIELD® products on their way to the host animal and become dessicated.

FOSSIL SHIELD® products cause a physical absorption of lipids on the epicuticle of the mites. The wax layer that protects the mites from dessication is destroyed upon contact. The mites dehydrate and become dessicated. FOSSIL SHIELD® products have a long efficacy curve, which has the advantage that even parasites that hatch from the eggs weeks later are effectively killed.

Synthetic silicate products by FOSSIL SHIELD® are 100% amorphous.

The advantages of FOSSIL SHIELD® products

PRODUCT

- Works in just a few hours
- Maximum yield and efficiency
- In conformance with the EU biocide directive
- No build-up of resistance
- Perfectly effective at high humidity

ANIMAL

- Prevents disease transmission
- Combats feather-plucking
- Reduced feed intake due to intact plumage
- Consistent laying performance due to less stress
- No blood on the eggs
- More pleasant working conditions for the barn staff

Control strategy in 3 steps

1. THOROUGH CLEANING

Thorough cleaning of the barns and equipment is the basis for effective control. It is important to cover as many of the mites' hiding places as possible. This may require the partial dismantling of the fixtures. The use of cleaning agents with a high pH value significantly improves the cleaning effect and is also a basic prerequisite for effective disinfection.

2. EFFECTIVE DISINFECTION

When choosing a disinfectant, consider the pathogens it must be effective against. Always disinfect against bacteria, viruses and fungi! Simultaneous disinfection using an antiparasitic agent such as **Complexsteril 2K plus** against against coccidia, worm and mite eggs is highly recommended.

3. COATING

After disinfection and drying, the sites are coated with FOSSIL SHIELD® products in liquid form or for post-treatment in the occupied barn with liquid or powder products. The products contain synthetic amorphous silicon dioxide as the active ingredient.

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FOSSIL SHIELD® Product overview for professionals

Product	Description	Application	Type of treatment	Form	Spreading technology	Suitability	Container sizes
FOSSIL SHIELD® instant white powder	Water-dilutable suspension concentrate	High yielding and very effective biocidal product, can be suspended 1:8 in water.	• Preventive • Follow-up treatment	Liquid	• Paint-sprayers • Pumps/hoses • Pressure containers	All holding systems with wood, plastic and metal parts.	10 kg 
FOSSIL SHIELD® instant white ultra	Ready-to-use suspension	Ready-to-use product.	• Preventive • Follow-up treatment	Liquid	• Paint-sprayers • Pumps/hoses • Pressure containers	All holding systems with wood, plastic and metal parts.	25 l 
FOSSIL SHIELD® instant white easy	Ready-to-use suspension	Simply shake and apply.	• Preventive • Follow-up treatment	Liquid	• Pump sprayer • Backpack sprayer • Paint-sprayers • Pumps/hoses • Pressure containers	All holding systems with wood, plastic and metal parts.	25 l 
FOSSIL SHIELD® instant white concentrate	Water-dilutable suspension concentrate	Dilute concentrate 1:1 with water.	• Preventive • Follow-up treatment	Liquid	• Pump sprayer • Backpack sprayer • Paint-sprayers • Pumps/hoses • Pressure containers	All holding systems with wood, plastic and metal parts.	30 l 
FOSSIL SHIELD® 90.0 brown powder	Powdery electrostatic product which can be used for powder treatment and specific follow-up-treatment.	Ready-to-use product.	• Preventive • Follow-up treatment	Powder	• Electrostatic machine • Atomiser pistol • Battery-operated Backpack atomiser	Applied with professional electrostatic machines and the advantage that system parts, which would remain uncoated with conventional application methods, can also be coated.	12,5 kg 
FOSSIL SHIELD® 90.0 white powder	Powdery electrostatic product which can be used for powder treatment and specific follow-up-treatment.	Ready-to-use product.	• Preventive • Follow-up treatment	Powder	• Electrostatic machine • Atomiser pistol • Battery-operated Backpack atomiser	Applied with professional electrostatic machines and the advantage that system parts, which would remain uncoated with conventional application methods, can also be coated.	12,5 kg 
FOSSIL SHIELD® 98.0 brown powder	Powdery dusting product which can be used for powder treatment and specific follow-up-treatment.	Ready-to-use product.	• Preventive • Follow-up treatment	Powder	• Atomiser bottle • Bobby powder atomiser • Atomiser pistol • Battery-operated Backpack atomiser	For dusting in all enclosure systems with wooden and metal fixtures for hobby and professional use.	15 kg 
FOSSIL SHIELD® 98.0 white powder	Powder product, can be mixed with water as needed.	Can be used as powder or diluted with water (see information on product label).	• Preventive • Follow-up treatment	Powder / Liquid	• Bobby powder atomiser • Atomiser pistol/bottle • Battery-operated Backpack atomiser • Pump sprayer • Backpack sprayer • Paint-sprayers • Pumps/hoses • Pressure containers	For dusting in all enclosure systems with wooden and metal fixtures for hobby and professional use.	15 kg 
FOSSIL SHIELD® Duo Des Kok	2-component disinfectant *Please check your national regulations to determine if the product is approved.*	Mix components A and B at 1:1 ratio	• Pre-treatment	Liquid	• Backpack sprayer • Paint-sprayers • Pumps/hoses • Pressure containers	For disinfection of all barn facilities.	**C 1** 10 l  **C 2** 10 l 

FOSSIL SHIELD®

protects against red mites

Fossil Shield® instant white powder

5000+ Recommended for barns with more than 5000 animals

Preventive

Follow-up treatment

Liquid application

Spreading technology

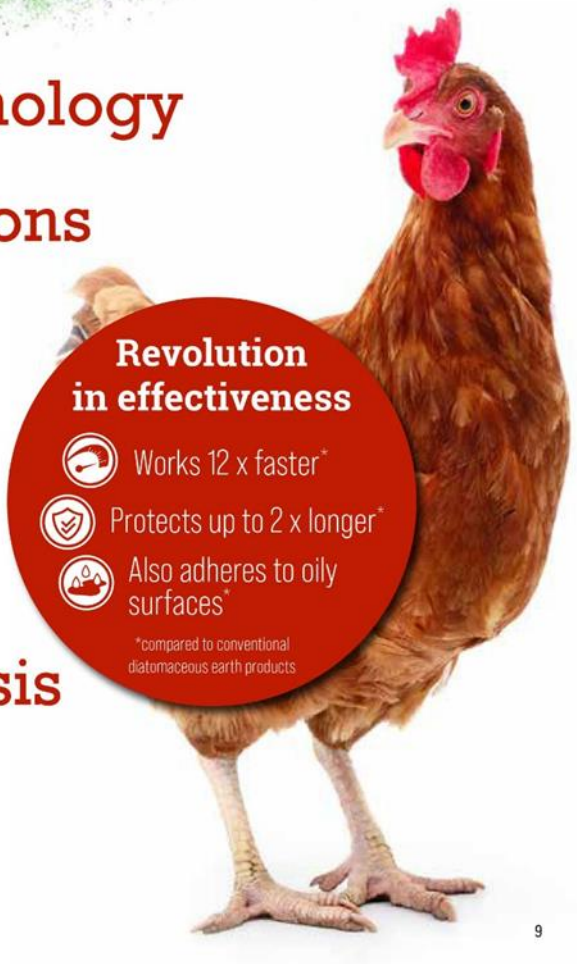
Mixing instructions

Application

Advantages

Product sheet

Chemical analysis



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Spreading technique for FOSSIL SHIELD® instant white powder

Mixing technology
210 litre mixing tank, drill,
agitator (Collomix DLX 152 M)

Item no. MT1

40 litre pressure vessel sprayer
max. 5 bar, with 10 m hose and spray lance
Accessories:
1 x 25 m hose NW 9
1 spray lance with full-cone nozzle
1 mixer 160 mm

Item no. MT40

150 litre pressure vessel sprayer
Standard equipment:
air accumulator tanks, spray mast with 12 flat-jet nozzles, mixing tank with hoses, transfer pump, filter, compressor, KS-Tools kit, mixing machine with mixer 160 mm, cable reel 25 m / 230 V, 2 x 25 m hose ID 9, 2 spray lances with full-cone nozzles, spare nozzles and GEKA connections ¾", 1", 1 ¼"

Item no. MT150-S

Optional accessories:
Tanker with 150 litre tank +
compressor with HONDA motor

10

Mixing instructions

1

Prepare a 210 l tank, agitator and 10 kg FOSSIL SHIELD® instant white powder. Wear personal protective equipment.

2

Prepare 80 litres of clear water.

3

Tear the bag open at the top seam.

4

Hold the opened bag under water and carefully pour the powder into the barrel.
Avoid dust!
Close the mixing drum with the special lid supplied and start mixing.

5

Clearly visible: the product becomes darker during mixing and absorbs water.

6

Stir in product thoroughly for approx. 2-3 minutes and then allow to swell for approx. 5-15 minutes (do not stir during this time).

Note: Avoid dust – only operate agitator when submerged in powder

7

After swelling, the mixture becomes pulp-like when mixed further.

8

Stir the rough mixture until the surface is smooth and shiny.

Attention! Stir briefly before each transfer and longer standing time.

FOSSIL SHIELD®
instant white powder

APPLICATION:

For prevention 44 g biocidal product /m² (corresponds to 396 g application suspension/m², in case of infestation 80 - 85 g biocidal product /m² (corresponds to 720 - 765 g application suspension/m²). One treatment before stabling. Follow-up treatment if required, max. 5 times per laying period (14 - 24 months).

RECOMMENDED LOCATIONS FOR COATING AS SUSPENSION:

1. All parts of the facility, in particular all joints and other mite hideouts.
2. A 20-cm surrounding strip within the housing at a height of approx. 1 m with account taken of doors, windows, vents, etc.
3. Incl. walls and ceilings, in case of heavy infestation.

SUITABILITY OF CAGE, AVIARY AND OTHER CAGE-FREE SYSTEMS:

Holding systems with wood, plastic and metal parts are especially suitable.

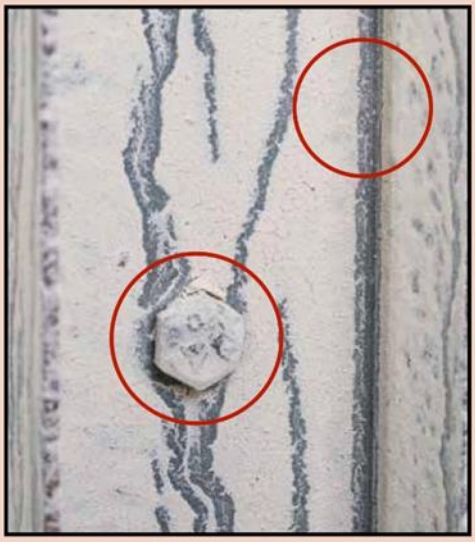
BENEFICIAL FEATURES:

No waiting periods, removable with water, dust-resistant and efficient application. Adequate protection from mite infestation throughout the laying period can be achieved by carrying out a thorough coating treatment procedure in the empty, cleaned and disinfected housing (possibly with re-treatment).

The surface of FOSSIL SHIELD® instant white powder resembles a rough mountain landscape. Mites have to travel much longer distances on their way to the host animal. Due to longer contact, the effect on the mite is significantly stronger.

Surface of a conventional diatomaceous earth product, offering significantly flatter and smoother structures. This means shorter residence times for the mites on the surface and therefore an inferior effect.

FOSSIL SHIELD® instant white powder creates a particularly thick build-up at the mites' preferred colony sites and offers the animals little refuge.

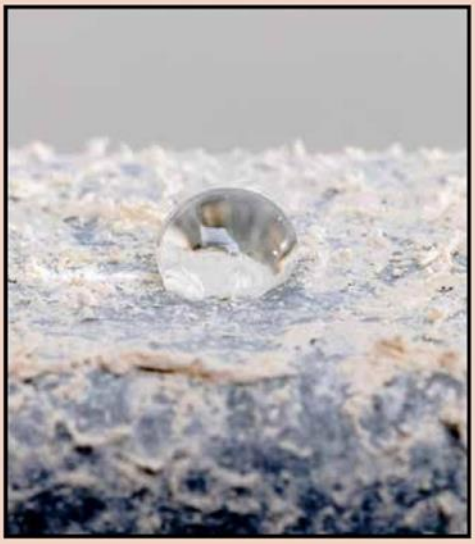


Due to falling drops of water, conventional diatomaceous earth products often create courses of water, which provide the mites with numerous hideouts and routes to get to their host animals.

FOSSIL SHIELD® instant white powder creates a particularly thick build-up at the mites' preferred hideouts and offers the animals little refuge.

In contrast, conventional diatomaceous earth products often create small courses of water, which provide the mites with numerous hideouts and routes to get to their host animals.

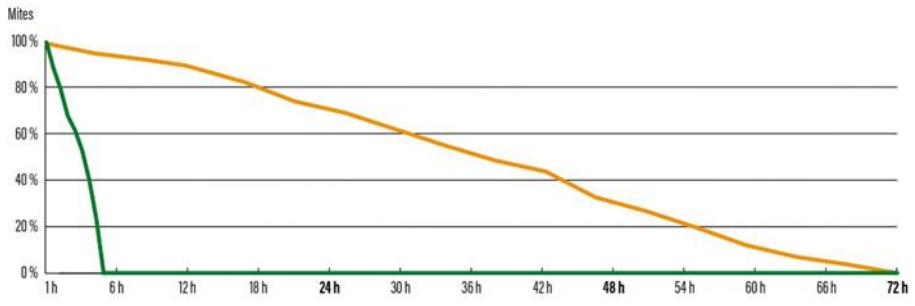
FOSSIL SHIELD® instant white powder – Advantages



FOSSIL SHIELD® instant white powder is hydrophobic. As a result, the product works very well and quickly even in environments with high humidities.

With conventional diatomaceous earth products, moisture penetrates the material. In highly humid environments, this means a very much reduced efficacy against the red poultry mite.

Efficacy curve of FOSSIL SHIELD® instant white powder in comparison to conventional diatomaceous earth products.



FOSSIL SHIELD® instant white powder is effective against the red poultry mite in just a few hours, compared to up to three days with conventional diatomaceous earth products.

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instant white powder

Biocidal product as agent for controlling red poultry mites

For commercial use only

www.fossil-shield.de

10 kg e net

Profi EN

FOSSIL SHIELD® instant white powder is a biocidal product (wettable powder WP) that can be suspended in water (for professional users). It forms a strongly adhesive, chalking protective coating against red fowl mite suitable for any type of poultry farming.

Active ingredient: Synthetic, amorphous silicon dioxide (as a nanomaterial, consisting of aggregates and agglomerates); CAS: 68909-20-6 (Nano); active ingredient content: 72 g / 1000 g

Dose and mixture instructions for professional application (to be strictly complied with): Add contents of 10 kg bag to at most 80 l of potable water and stir thoroughly; leave to stand for about 5 min. and then stir for 1 min. Repeat the stirring process 1 or 2 times. Finely sieve (max. mesh width: 0.4 mm) the suspension through the pump pressure line when ready. The suspension has to be stirred prior to each refilling of the spray equipment. Partial removal is possible. Mixing technology: approx. 200 l container, min. 750 watt mixing/drilling machine with HF agitator at 400-600 r/min, e.g. Collomix DLX 152M

Application method and equipment: Use mobile vertical spray equipment or pressure-vessel hose spray equipment of up to 150 m in length from Bein. Alternatively, spray equipment from e.g. Birchmeier, Ammer or Gloria or diaphragm pumps powered by compressed air. **Do not use centrifugal pumps or pumps with pressure control valves!**

Application:
- Preventative: 44 g biocidal product /m² (corresponds to 396 g application suspension/m²)
- For mite infestation: 80 - 85 g biocidal product/m² (corresponds to 720 - 765 g application suspension/m²)

Frequency:
- One treatment before stabling in empty barn, after cleaning and disinfecting the barn.
- Follow-up treatment if required, max. 8 times per laying period (14 - 24 months).

Recommended locations for suspension-based coatings:
1. All parts of the facility, in particular all joints and other mite hideouts.
2. A 20 cm surrounding strip within the housing at a height of approx. 1 m with account taken of doors, windows, vents, etc.
3. Incl. walls and ceilings, in case of heavy infestation.
4. Ensure even coating.

Suitability of cage, aviary and other cage-free systems: Holding systems with wood, plastic and metal parts are especially suitable.

Beneficial features: Removable with water, dust-resistant and efficient application. Adequate protection from mite infestation throughout the laying period can be achieved by carrying out a thorough coating treatment procedure in the empty, cleaned and disinfected housing (possibly with re-treatment).

Safety instructions:
- Safety sheet available upon request
- To avoid risks to human health and the environment, comply with the instructions for use
- Keep product out of reach of children
- Wear an RPE10 (FFP2) mask when mixing and RPE4 (FFP1) protective clothing, gloves and mask during application
- Use electrostatically-dissipative climbing aids
- Only use product for intended purpose
- Do not expose persons or animals to product
- **It is imperative to ensure proper ventilation before, during and after application of product**

First aid measures: If inhaled, ensure fresh are and consult a doctor for any complaints. After contact with the skin or eyes, carefully rinse with plenty of water. Take off all contaminated clothing. Consult a doctor if irritation (redness) persists. If swallowed, rinse mouth immediately, drink water and consult a doctor.

Storage: Store under frost-free, dark and dry conditions. Can be stored unopened for up to 3 years after date of manufacture.

Disposal: Dispose of empty contents/container in accordance with local/regional/national/international regulations. Small product quantities can be rinsed away with lots of water, while larger quantities should be disposed of in special waste, not in waste water.

UFI: GJ13-E0Q3-200C-47SM

Emergency telephone (can be reached 24/7):
GBK GmbH +49 (0) 6132-84463

Use biocides safely. Always read the label and product information before use.

Batch:

Date of manufacture:

FOSSIL SHIELD®
protects against red mites

Manufacturer: **Bein GmbH** Siedlungsstraße 6-8 · D-36132 Eiterfeld · Germany
Telephone: +49 (0) 66 72 - 92 33 0 · Email: info@bein-gmbh.de · www.fossil-shield.de

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