MEMORANDUM OF UNDERSTANDING

Subject : Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action FA1404: Improving current understanding and research for sustainable control of the poultry red mite Dermanyssus gallinae (COREMI)

Delegations will find attached the Memorandum of Understanding for COST Action FA1404 as approved by the COST Committee of Senior Officials (CSO) at its 190th meeting on 14 May 2014.
MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action designated as

COST Action FA1404
IMPROVING CURRENT UNDERSTANDING AND RESEARCH FOR SUSTAINABLE CONTROL OF THE POULTRY RED MITE DERMANYSSUS GALLINAE (COREMI)

The Parties to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 4114/13 “COST Action Management” and document COST 4112/13 “Rules for Participation in and Implementation of COST Activities”, or in any new document amending or replacing them, the contents of which the Parties are fully aware of.

2. The main objective of the Action is to consolidate the existing expertise and knowledge on poultry red mite (PRM) and to generate a synergic/holistic approach to improve the health, welfare and productivity of the laying hens through more effective prevention and control of PRM.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 60 million in 2014 prices.

4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.

5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of section 2. Changes to a COST Action in the document COST 4114/13.
A. ABSTRACT AND KEYWORDS

Poultry ectoparasites are of particular concern for the European Industry. The poultry red mite (PRM), *Dermanyssus gallinae*, is the most significant pest of laying hens in Europe. A relationship between infestation and hen mortality exists and at a sub-lethal level causes significant stress to birds and a decline in egg quality and production.

The current norm of 50,000 PRM/hen, rising to 500,000 in extreme circumstances, and >80% PRM prevalence in most European countries cannot be considered acceptable, and must be reduced. This holds especially true as recent and impending legislation to improve hen welfare in this region will exacerbate the negative impact of this pest, compromising production and potentially exposing such legislation as counterintuitive in terms of overall hen health and welfare.

COREMI will look to advance and disseminate comprehensive Integrated Pest Management (IPM) for PRM by collating knowledge of mite biology, the mite-host relationship and novel control and coordinating further research work in the area. This information will be used to produce industry ‘Gold Standards’ for PRM prevention and control, tailored to individual countries and production systems. A more complete understanding of PRM impact to poultry and other sectors, including public health, will also be achieved through the Action.

**Keywords:** Poultry red mite, health, welfare, sustainability, control

B. BACKGROUND

B.1 General background

The poultry red mite *Dermanyssus gallinae* (PRM) poses a significant threat to egg-laying hens in many parts of the world, though is particularly significant in Europe (Chauve, 1998; Sparagano et al., 2009). Though all domestic fowl are at risk from PRM, infestation appears most significant in laying hens where economic costs associated with control and production losses have been estimated at €130 million per year for the EU egg industry (van Emous, 2005).

There is a relationship between PRM infestation and hen mortality, with some reports recording a tenfold increase in death rates following severe infestation (Cosoroaba, 2001). Although causal factors may vary, in extreme cases PRM numbers may be so high that hens become severely anaemic, with mortality resulting from exsanguination alone (Cosoroaba, 2001; Kilpinen et al., 2005; Wojcik et al., 2000). At a sublethal level, mite feeding may result in significant stress to hens, increased feed and water intake and decreased bird condition (Chauve, 1998; Kilpinen et al., 2005;
Mul et al., 2009), also impacting upon production by causing declines in egg quality (through shell thinning and spotting) and egg laying (Chauve, 1998; Cosoroaba, 2001). Increases in aggressive feather-pecking and cannibalistic behaviours have been reported following infestation (Chauve, 1998; Mul et al., 2009), logically supporting the view that any proposed ban on beak-trimming should be preceded by a concerted effort to improve prevention and control of PRM.

Even relatively small mite populations may have significant impact, as PRM may serve as a disease vector for numerous pathogens including *Salmonella*, *Pasteurella*, *Listeria*, *E. coli*, *Staphylococcus*, *Streptomyces*, Newcastle disease, Fowl poxvirus, St. Louis encephalitis and various other forms of encephalitis (Valiente Moro et al., 2005; Valiente Moro et al., 2009). In addition to spreading disease, infestation may limit hen immunological responses to pathogens and/or vaccination strategies. Heavy infestations are reported to reduce antibody titers to some viral vaccines, or suppress host antibody production (Kaoud, 2010; Kowalski and Sokol, 2009).

Though PRM have historically been regarded as avian-specific, increased reports of non-avian infestations suggest a possible wider threat to veterinary and medical health (George et al., 2013). The full significance of PRM to these sectors has yet to be fully ascertained and warrants urgent attention. This is especially true given the cosmopolitan distribution of PRM (also occurring in association with feral and synanthropic birds) and its significant potential as a vector of zoonotic disease. Recent review confirms increasing incidence of PRM attacks on humans (George et al., 2013), including propensity for persistent infestation when feeding on human blood alone (Pampiglione et al., 2001). Transmission of spirochetes, rickettsiae, Salmonellae, Bartonellae, Pasteurellae, Sporozoa, hemogregarines, flagellates, and filariae have all been suggested as possible through bird mites *per se* (Litwin, 1961). More recent evidence supports acquisition of *Bartonella* via *Dermanyssus spp* (Melter et al., 2012) and links attacks to Lyme disease, *Bartonella* and/or *Babesia* (George et al., 2013).

Research concerning all aspects of PRM has increased in recent years as the need to better understand and manage this pest has begun to be recognised (Sparagano et al., 2014). Numerous groups from research, public health sector, industries and poultry organizations throughout Europe have interests in PRM, but these remain highly fragmented and nationally focused. As a result, though theoretically strong PRM networks have in practice the full potential of the transnational scientific community to contribute to PRM control remains unrealised. Significant potential to advance and develop knowledge that will lead to innovative tools to understand, diagnose, quantify, prevent and control PRM exists in activating and incentivising this multidisciplinary network through CA funding.
B.2 Current state of knowledge

The most recent figures suggest that PRM prevalence in EU laying hens exceeds 80% in many countries, with average prevalence being 83% (Mul et al., 2013). In the UK, between 60% and 85% of commercial egg laying facilities may be infested (Fiddes et al., 2005; Guy et al., 2004), with 100% of sampled facilities under more susceptible systems infested in certain other countries (Cencek, 2003; Sparagano et al., 2009).

Several authors have reported higher prevalence and population numbers of PRM in alternative egg production systems, such as barn and free-range (Fiddes et al., 2005; Guy et al., 2004; Hoglund et al., 1995). Trends for reduced rates in conventional cages may reflect the presence of fewer mite refugia, making conventional cages less amenable to infestation and easier to treat should infestation occur (Axtell, 1999). Nevertheless, because conventional cages can no longer be employed in the EU on animal welfare grounds, they cannot be considered as a control option. Such systems had been heavily utilised in the EU until their withdrawal in 2013 (Sparagano et al., 2009). A move away from conventional cages to systems incorporating more complex environments which appear to favour PRM is expected to exacerbate the problem of PRM, as supported by current industry assessments.

In Europe, the introduction of PRM into poultry houses is suggested to occur almost exclusively via trade routes (Oines and Brannstrom, 2011), though more work to map PRM genetics in domestic and wild birds is required to confirm this and assist in PRM prevention strategies based on optimal biosecurity measures. Once present within a poultry unit, the tendency of PRM to seek refugia and survive for extended periods without taking a blood meal presents a challenge to control efforts. Worldwide PRM has typically been controlled using synthetic acaricides, with over 35 compounds tested to this end (Chauve, 1998). At the time of writing, however, relatively few products were licensed in the EU for use against PRM, although several unlicensed (or even banned) products were still widely employed to target infestations within this region (Maurer et al., 2009; Marangi et al., 2012). Even where product choice appears non-limiting, the tendency of PRM to develop resistance to synthetic acaricides (Sparagano et al., 2014) suggests that their use is not sustainable according to current deployment methodologies that rarely seek to manage resistance.

Alternative control measures for PRM are becoming increasingly more accessible, though those in regular use remain limited (desiccants, detergents, biopesticides) with additional measures available, but typically ignored (e.g. biological control, hazard analysis). Poor uptake may result as much from a lack of direction on the effective deployment of these interventions as any inherent lack of effect on PRM, with no ‘Gold Standard’ existing to inform best practice for PRM prevention.
and management. The use of biological strategies may hold particular promise (biological control, plant-derived pesticides, entomopathogenic fungi), but remains in its infancy, requiring direction and support for its full potential to be realised.

The efficacy of many existing and emerging interventions for PRM could almost certainly be improved by use in an Integrated Pest Management (IPM) approach (Harrington et al., 2011; Sparagano et al., 2014), supported by advances in areas such as mite monitoring that are expected in the near future (Mul et al., 2013). Nevertheless, IPM remains under-utilised in the poultry sector, being largely limited to basic biosecurity, synthetic acaricides, sanitation and physically-acting substances. This is despite strong evidence from other sectors (e.g. horticulture) that IPM is highly effective against many pests. The full potential of IPM for PRM will only be realised by bringing together expertise in all of the above areas to assess which are best suited for optimal combined use; the end goal being to disseminate this information to the industry in the form of a ‘Gold Standard’ for PRM prevention and treatment. To optimise returns, inclusion of indirect control methods (such as poultry house design, resistant/tolerant hen breeds and optimal husbandry practises) should also be included in this approach (Sparagano et al, 2014).

Additional avenues for PRM control, such as vaccination and resistance breaking, are also being researched at various institutions in the EU (Sparagano et al., 2014). These methods remain further from market than those above, but may make important contributions to PRM control in the future, particularly if combined with supporting study, for example to map and genetically characterise PRM resistance at a European scale.

Despite its potential significance, no concerted attempt has yet been made to assess the wider threat posed by PRM to veterinary and medical health. Available information on this topic (see section B1) is currently derived from case studies available in the literature, with only a single minor review of this subject area being attempted to date (George et al., 2013).

**B.3 Reasons for the Action**

The current norm of 50,000 PRM/hen, rising to 500,000 in extreme circumstances (Kilpinen et al., 2005), and >80% PRM prevalence in most of European countries (see section B2) cannot be considered acceptable, and must be reduced. This holds especially true as recent and impending legislation to improve hen welfare in this region (concerning conventional cages and beak trimming, respectively; see section B1) will exacerbate the negative impact of this pest, compromising hen health and welfare and egg production and potentially exposing such legislation as counterintuitive in terms of overall hen health and welfare. The economic burden of PRM to the
egg laying industry is already significant (see section B1) and may affect EU competitiveness in this sector further when the full effects of this legislation on infestation levels are felt. Confirming the full significance of PRM and reducing its current and future impact, primarily in poultry but also in other sectors, can only be achieved through a considered and multidisciplinary approach. COREMI (COnrol REd MIte) is needed to facilitate such an approach by optimising the latent but significant potential of the PRM research community and providing investment in its future to ensure extensive and prolonged impact.

The necessary knowledge and highly skilled personnel required to optimise PRM IPM is in short supply across EU research and poultry breeding centres, especially among the new EU member states in Eastern Europe. COREMI will generate knowledge, protocols and tools of substantial value to these groups, as well as the wider EU food and agriculture sector. COREMI, through the direct involvement of relevant members, and especially those in new entrant countries, will also facilitate exchange of knowledge and staff between laboratories and enable young European researchers to receive cross-disciplinary training and mentoring as an investment in the European intellectual capital and knowledge based bio-economy. The Action aims to technology development and transfer including ESRs and SMEs.

Results from COREMI will be disseminated to industry, EU scientists and policy makers who will be informed through peer-reviewed and Open Access scientific publications, workshops, newsletters, public information (including public engagement through scientific exhibition and fairs), briefing papers and the CA website. ‘Gold Standards’ and best practices for PRM control will be produced, based on the knowledge shared and collated through COREMI, to ensure judicious use of current control practices, minimising PRM resistance and deployment of illegal products, reducing costs and improving legislation.

To summarise the main reasons would be linked to cost reduction, improved competitiveness, human and animal health and welfare, new laws resulting in new problems. Some knowledge is present but the potential of such knowledge is not fully used.

**B.4 Complementarity with other research programmes**

No other current or planned European research programme exists having the same aims and goals as this Action. This network is unique in its nature because of the described multi-disciplinarily and multi-user approach focusing on PRM.

Nevertheless, COREMI does demonstrate links and complementary ties with some current European programmes (i.e. COST Actions FA1207 Corona virus; FA1002 Farm Animal
Proteomics and TD1303 Vectors) dealing with farm animals, avian pathogens and vectors. COREMI will complement, but in no instance duplicate, these programmes. To ensure optimum benefit is gaining from complementary programmes, representatives from the above Actions will be invited to attend COREMI meetings to allow all groups to benefit from cross-fertilisation activities and wider knowledge exchange with the possibility to co-organise Training Schools in common with the above Actions.

Other research groups working on sheep scab mites, mites infesting grain and crops for instance would be contacted to benefit from their findings, which could be transferable to PRM control methods.

C. OBJECTIVES AND BENEFITS

C.1 Aim

The overarching aim of COREMI is to generate a synergic/holistic approach to improve the health, welfare and productivity of the EU’s 350 million laying hens through more effective prevention and control of PRM. This will be achieved through cooperation and multidisciplinary networking between scientists and other stakeholders from different member states and from different disciplines, thus increasing competitiveness of the European poultry industry with respect to other leading countries. The overall objective of COREMI is to consolidate this existing expertise and knowledge to gain a better understanding of PRM and the economic and societal impacts of this pest, using this information to implement more efficient and sustainable control methods. Together, four Working Groups (WGs) will deliver the objectives below (full details of which are provided in section E2). WG 1: Developing alternative control measures; WG 2: End users (One Health)-interdisciplinary approach; WG 3: Genetic structure in a changing world; WG 4: Epidemiology, pathology, geographical mapping and surveillance tools.

C.2 Objectives

Secondary Objectives will primarily include:

1. Stimulating research, education, exchange of knowledge and experience, and training of Early-Stage Researchers (ESRs) through established and novel routes.

2. Quick implementation of innovative ideas for PRM control as a result of the multidisciplinary and country wide networking community.
3. Communication and discussion of relevant research by organising four workshops, of which at least one will be open for COST Action members and other international groups outside the consortium.

4. Creating a multi-functional website (part-secured for participants to exchange sensitive/marketable information and with an open access area for external stakeholders).

5. Knowledge management and exchange (KME) with/to the scientific community, policy makers, primary producers, poultry breeding organisations, technology industries and Small and Medium Enterprises (SMEs) (to support IP development and commercialisation of activities). COREMI will pursue a dissemination strategy targeted to bridge the gap between specialised research forums and non-specialised groups, to more closely connect science to the general public and practitioners (medical and veterinarian practitioners) on this crucial issue. Tools including the Action website and popular social media will be used to this end.

6. European platform continuing its existence after the COST action period as a result of the gained insights and benefits achieved during that period.

C.3 How networking within the Action will yield the objectives?

Objectives will be achieved through innovative, transnational and multi-disciplinary knowledge sharing, with world-leading groups working to individual and shared objectives according to their expertise and experience. Key features to achieve the objectives will be:

1. Expanding upon and activating the full potential of the COREMI network to form an efficient, productive collaborative community of multidisciplinary researchers/partners.

2. Jointly developing a detailed action plan and a common research and innovation agenda for PRM.

3. Organising meetings and workshops focussed on distinct but inter-related WG topics.

4. Financing a number of Short Term Scientific Missions (STSM) for exchange of technologies, good practices and training between laboratories, poultry associations and national agencies in different member states, with priority given to ESRs. Yearly, a competitive call for STSMs supported by the Action will be held. The applications for
the STSMs will be sent to the Chair of the Evaluation Committee. The approval process will be subject to the COST rules and guidelines, and dependent on the budgetary possibilities keeping in mind fairness, equity (gender and country balance) and potential impact for each proposal.

5. Running Training Schools (TS) at leading institutes of the Action at which basic and advanced methodologies will be taught, especially for ESRs.

6. Implementing a mentoring support system for ESRs, with each being supported by a senior researcher in another COST Action country to expose such ESRs to a broader international network.

C.4 Potential impact of the Action

1. Improved general and tailored IPM for PRM, including monitoring, biosecurity, sanitation, chemical and non-chemical treatment (that incorporates resistance management) and bio-control, for the benefit of the poultry industry (see section B2/B3).

2. Improved knowledge/data/sample sharing between researchers to fully collate existing knowledge for immediate benefit (e.g. in suggesting optimal IPM), prolonged benefit (e.g. in establishing routes for data sharing to support future research), identification of knowledge gaps and optimisation of future research directions (see section B3). Provision/collation of new insights and new innovative control strategies.

3. Prioritised avenues for future effective research and synergised protocols for conducting this research to the highest standard. The potential of current knowledge would be fully implemented by the use of innovation processes in which structured barriers and opportunities for innovations are analysed.

4. A fuller understanding of the full significance of PRM, both to the poultry sector (in terms of economics and full significance) and beyond (e.g. in livestock, companion animals, birds and humans) and dissemination of this information to potential end users or high risk groups (see section B1/B3).

5. Investment in the future of the science base through mentoring, networking, STSMs and TTSs targeted to ESRs.
6. Developed collaborations with SMEs targeting new treatments and combinations of products (e.g. biologicals, repellents, abiotic powders, traps and diagnostics for infestation).

C.5 Target groups/end users

The target groups and end users are the following:

1. Researchers: The Action will consolidate research priorities and standardise procedures used when working with PRM. It will further activate a strong network for the benefit of researchers, particularly ESRs.
2. Advisors: Poultry advisors will gain easy access to new knowledge and innovative tools.
3. Policy makers/governments: KME outputs will provide useful lobbying and policy-making tools.
4. Producers: Producers will be supplied with state-of-the-science blueprints for PRM management. Related bodies such as breeding organisations and feed industries will obtain perspectives and knowledge for future decisions on production strategies.
5. Industry: A range of industry providers, including SMEs, will benefit through generation of IP and marketable new products for economic and societal gains (including breeders/ breeder companies/ pest control companies).
6. Practitioners and patients: Medical doctors and veterinarians will be able to more accurately identify dermatosis/gamasoidosis related to PRM and prescribe more efficient treatments.

All of the above groups will be directly involved in this Action, having already been invited to take part as experts.

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

The overall objective of COREMI is to consolidate existing expertise and knowledge to gain a better understanding of PRM and the economic and societal impacts of this pest, using this
information to implement more efficient and sustainable control methods. This CA will lead to better efficacy of control measures and user-led best practices. This will be achieved through four working groups (WGs); three dedicated to integrating scientific and technical knowledge from various disciplines while the 4th will ensure that end-user stakeholders (farmers, veterinarians, medical practitioners and industry) are involved in, and derive maximum benefit from, such a multi-disciplinary Action.

In this COST Action four WGs will be established to address the main objectives of COREMI through cross-links between these WGs following main questions will be addressed:

1: What are the impacts of PRM on the poultry industry and beyond? (cross-links between WGs 1 and 2)

Though figures for the economic cost of PRM to the EU poultry industry are available, the most commonly cited statistics are now a decade old (see section B1). In light of changing production practises over recent years, and high variability between other studies that have attempted to quantify the cost of PRM, a more recent and reliable economic analysis is required. Though this may not be achievable directly through COST Action funding, COREMI will (as a minimum) put in place the multi-national expertise and networks needed to achieve this in the near future, also informing on the most appropriate methodology to be used to ensure a robust and reliable analysis is undertaken.

The impact of PRM beyond the poultry sector is poorly understood (see section B1), probably as reports of attacks on non-avian hosts only rarely receive attention in the international scientific press, being more often restricted to the ‘grey literature’, if published at all. Through COREMI a better understanding of the wider significance of PRM will be gained by collating experience in this field, both across countries and between sectors.

2: How to compare PRM control methods and monitoring strategies, and harmonize mite collection, identification and prevention across countries? (cross-links between WGs 1, 3 and 4)

A number of approaches have been used to collect, trap and identify PRM, some being more efficient than others. Through COREMI a standard and optimal trapping/collection/identification protocol will be devised for use by both researchers and poultry producers. This protocol will be developed based on the wide-ranging experience of COREMI partners in using different trapping/collection/identification techniques.

Management approaches for PRM are highly variable, both within and between countries, as no
‘Gold Standard’ exists to inform producers on best practices. Reports of inappropriate acaricide use (i.e. of illegal substances or approved products at less than recommended doses) are not uncommon (see section B2). This has been shown to result in residues in/on eggs and is thought to contribute to PRM acaricide resistance in some areas. Therefore, one of our most important tasks in this COST Action will be to develop systems and methodologies by which stakeholders (farmers, industry, scientific communities) can make use of the large and diverse data sources from international observations to monitor, prevent and treat PRM in a sustainable and integrated manner. ‘Gold Standards’ for these practices, tailored to production systems and regions, will be a major and lasting output from COREMI.

3: Are indicators available that can be used or developed for prediction of PRM infestations? (Cross-links between WGs 1 and 4)

Considering the rapid life cycle of PRM (potentially developing from egg to adult within a week) it is paramount that early PRM predictors are available for use at farm level to ensure that producers can respond to infestations swiftly. Efficient monitoring (see previous) would assist to this end, as would novel predictors based on actual hen responses to low level infestations. Knowledge of ‘high risk’ periods, based on farm activity, management or climatic conditions, could also benefit detection/early treatment and is currently used in other sectors (e.g. crop aphid control in the UK) to optimise pest monitoring and ensure rapid treatment. Development of monitoring devices to be easily used at farm level would assist farmers to identify the level of infestation and take adequate precautionary measures to reduce PRM population proliferation.

4: How can the targeted stakeholders use the findings? (Cross links between WGs 1, 3, 4 and WG2)

In precedence to developing networks, sample banks and priorities, methodologies and opportunities for future research on PRM, the over-riding aim of COREMI is to optimise current PRM control by consolidating existing knowledge in this area. This will be used to produce blue prints for PRM prevention and IPM that will available to producers throughout the EU to consult as a ‘Gold Standard’ for industry practice. To ensure optimal benefit, multiple versions of these blue prints will be developed to allow tailoring to different production systems and production models, with a section on resistance management included. The Action will also produce a leaflet to reach out the farming communities.

In addition to a focus on direct prevention/control of PRM, this COST Action will also consider best practise regarding indirect prevention/control through husbandry techniques, breeding programs, housing manufacturing and staff training, including this information within blue prints.
In this way, farmers can make optimal use of the results generated in this Action (and subsequent data collected using the guidelines produced in this Action) for direct and indirect PRM control. Medical and veterinary practitioners will be informed through their national associations, professional publications and participation to the COST Action’s workshops.

D.2 Scientific work plan methods and means

The scientific programme of COREMI concentrates on different but interrelated areas relating to multiple aspects of PRM. Four WGs align with the scientific programme as shown in section D1, with inter-WG links shown in section D1 above. Each WG will meet to discuss recent developments and work towards relevant objectives (section E2) best suited to their main area of interest and expertise, but with inter-WG links/meetings ensuring optimal concerted progress to best achieve the overall Action aims. The discussion areas in the 4 WGs are:

Summary of what each WG will achieve/target

WG 1: Developing alternative control measures: This WG will improve PRM control practices for the benefit of producers as well as hen health and welfare.

WG 2: End users (One Health)-interdisciplinary approach: This WG, industry led, will develop ‘Gold Standards’ for PRM control, also confirming the full potential of PRM to poultry and other sectors.

WG 3: Genetic structure in a changing world: This WG will lead on establishing links for sample exchange to create a ‘PRM sample bank’ for future use in genetic studies. This WG will also review progress and optimum methodologies and future directions for work on genetic markers and genetically-based control options.

WG 4: Epidemiology, pathology, geographical mapping and surveillance tools: This group will determine optimum PRM monitoring methods, as well as reviewing the epidemiology, clinical and histo-pathological impact of PRM in poultry systems.

For optimising the knowledge management and exchange in order to come to innovative measures and knowledge and data exchange and novel communication strategies the system...
innovation theory will be applied.

E. ORGANISATION
E.1 Coordination and organisation

Participants of COREMI have internationally recognised experience in using various innovative measuring, calibration, diagnostic and control techniques in PRM research. Many ‘senior’ participants have over a decade of experience on this topic, publishing widely in this area in the leading scientific literature and disseminating their findings across the globe through various conference presentations and industrial engagement activities (e.g. consultancy, running Work Shops, provided information to the industry press and at industry events). Most partners are applied scientists with close links to industry and are well recognised as following their research all the way through to implementation and extension. COREMI also includes numerous ESRs, all of which have shown significant potential to become leaders in their respective fields, where recognising this potential would be greatly benefitted through the Action. Numerous participants also have existing national research grants to support the critical mass of experts and knowledge needed to sustain this COST Action.

The MC will convene through Skype or Video-conferencing at least four times per year to discuss the progress in the Action by monitoring and evaluating the achievement of objectives in each WG. Meetings of the WGs will be organised on an annual basis as two- or three-day events at different partner locations. These frequent gatherings are scheduled in order to ensure an optimal exchange of ideas, to discuss progress, to build upon acquired knowledge and to plan future activities. Joint WG meetings will enhance integration of activities from different fields, and promote interface between WGs. Some of these meetings will be held at poultry conferences to maximise the network potential and identification of new participants for future meetings.

Four `workshops will provide cross-WG sessions to promote synergy. These workshops will be well advertised in advance and COREMI will provide an open and flexible framework, allowing further partners to join. All partners will be encouraged to actively participate in COREMI, if not with data then with ideas and their respective networks. Innovations will be initiated through exchange of expertise between scientists and industry experts from different areas, leading to novel tools and ideas relevant to COREMI aims and objectives.

1. The 1st workshop will be held in month 9 and focus on WGs 1, 3 and 4. Animal physiologists, nutritionists, breeders, environmental engineers, veterinarians, animal
husbandry researchers and scientists will discuss current knowledge and experience. This workshop will identify knowledge gaps and generate a strategy, including a plan for specific bilateral/multilateral site visits. It will be the responsibility of the WG leaders to retain momentum and dialog within the WG, but also to ensure other WGs are aware of progress and when results are expected. Mentoring/coaching needs will be evaluated and mentors will be allocated to participants with priority to ESRs ensuring tighter links between countries.

2. The 2nd workshop will be held in month 18 and focus on WG2. A similar audience to the first workshop is anticipated. Alongside poultry association and industry representatives that will be invited to discuss needs and priorities from the perspective of the poultry industry, medical practitioners and veterinarians will also be invited to attend, but preliminary results will be presented, discussed, and possible refinements suggested with a view of re-examination in the following months and reporting back. Plans to disseminate to poultry associations and professionals groups (medical and veterinary practitioners) will be drawn.

3. The 3rd workshop will be held in month 30 and will focus on ESRs. Based on preliminary mentoring results, second stage plans to sustain ESR careers and future potential will be identified, as will opportunities to pursue joint research calls from Horizon 2020 (and other funders) and ensure sustainability of the consortium and the COREMI website.

4. The final Action meeting will be held in month 44, and will collate the results of all WGs. This Action meeting will be open to everybody, and will therefore be widely advertised with all targeted audiences strongly encouraged to attend. This symposium might be held as a satellite to a larger conference to promote achievements and develop further long-term collaborative work.

Although a main focus is provided for each workshop, they will not be exclusive and each WG will participate in every workshop. Thus, for example, preliminary ideas for WG 3 will be presented in the 1st workshop, and progress reports for WGs 1, 3 and 4 will be presented at the 2nd workshop. In all workshops there will be an open opportunity for presentation of posters, with COREMI offering prizes for best and runner-up presentations by ESRs. Students and ESRs will be particularly encouraged to present their on-going research and receive feedback and engage in possible
collaboration. A one-page summary of the research will also be distributed. Posters will be
displayed for the duration of the workshop, but a dedicated time-slot will be given for the
presentation and discussion of posters. Money will be allocated for young scientists, primarily post
docs, for short stays (STSMs) visiting senior researchers from the COST Action.
Between WG meetings, on-going flow of information will be supported by a COREMI share-point,
and video/phone conferences upon request to facilitate continuous information exchange and
discussions in smaller specialist groups working in specific areas. A website, with a restricted
access section, will also allow any sensitive/confidential information to be deposited in a secure
manner, also providing a platform for obtaining input on Action publications and posters. A
discussion board will also be featured to optimise knowledge transfer between COREMI
participants and the general public wishing to better understand the issues surrounding PRM and the
objectives of the Action.
The responsibility of the MC will be to:
• Monitor, review and assess the activities of the Action
• Receive reports made by the WGs
• Prepare annual scientific and budget reports for the COST Office
• Establish and coordinate Training Schools
• Promote Short Term Scientific Missions taking into account gender and country balance
• Evaluate mentoring activities
• Stimulate knowledge transfer through the website
• Information leaflets for farmers

E.2 Working Groups

The COST Action will be structured in four WGs. Activities will be coordinated by the WG leader
who will be in charge of the following:

1. Shaping the WG and its interactions so that the focus of activities stays bound to their
corresponding research topic.
2. Setting and monitoring the milestones of the WG.
3. Dissemination of the WG’s structure and achievements on the Action’s webpage.
4. Notification to the Action’s Dissemination Manager when papers in leading journals have been published.
5. Organisation of WG meetings.
6. Organisation of intra- and inter- WG STSMs in cooperation with the Action’s STSM Manager.
7. Active and proactive participation in the Steering Group (operational group under the Management Committee).

The structure of the COST Action is based on four WGs:

**WG 1: Developing alternative control measures:**
Ob 1: Collate available information on PRM biology, ecology, physiology and mite-host relationship identifying knowledge gaps to optimise PRM IPM strategies.
Ob 2: Evaluate the potential of novel biological and non-biological strategies and house design that can be directly or indirectly used against PRM.
Ob 3: Identify avenues for work into protective antigens and immune-responses to PRM in hens.
Ob 4: Identify economic thresholds and optimal IPM strategies for immediate and future use to offer farmers better informed PRM management.

**WG 2: End users (One Health)-interdisciplinary approach:**
Ob 1: Produce guidelines for prevention (leaflets), surveillance and control (chemical/non-chemical) of PRM produced within the framework of existing Hazard Analysis and Critical Control Points (HACCP) procedures.
Ob 2: Review the economic and social impact of PRM, and foster further study on PRM in non-avian hosts with medical and veterinary practitioners.

**WG 3: Genetic structure in a changing world:**
Ob 1: Forge links to facilitate sample exchange and allow a ‘PRM sample bank’ to be developed for future use, for example to investigate PRM genetics between countries, host types (e.g. wild and domesticated birds; humans) and production systems (e.g. with regard to varying acaricide use).
Ob 2: Review progress on genetic markers for PRM and assess optimum directions in this field for further study.
Ob 3: Review progress from other sectors on ‘resistance breaking’ and other genetically-based control options (e.g. sterile males, Trojan females) and assess scope for use against PRM.
**WG 4: Epidemiology, pathology, geographical mapping and surveillance tools**

Ob 1: Review the epidemiology, clinical and histopathological impact of PRM in poultry. Taking into consideration different poultry systems (organic, free range, aviaries, cages, barns).

Ob 2: Review the potential of spatial mapping tools to monitor and predict mite proliferation, also considering how this may be effected by and correlate with global warming.

Ob 3: Produce data from countries without any information

As noted in section E1, there will be a COREMI share-point, video/phone conferences and WG-meetings between the four larger Action workshops to facilitate information flow and discussions in smaller specialist groups working in specific areas.

MC members will participate in the different WGs based on their specialities and interests. Each WG will have a leader and a deputy leader to guide progress in their WG and ensure that WG objectives are met. WG leaders will report on progress of WG objectives and deliverables to the MC.

**E.3 Liaison and interaction with other research programmes**

In B4 the complementarity of COREMI with other COST Actions (TD1303, FA1002, FA1207) is given. Through its partners COREMI will also be able to integrate with other non-PRM networks and learned societies that its participants are involved in for broader benefit and impact.

Identification of such networks will be done at the first COREMI meeting to expand the potential participants and interact well beyond the COST Action membership.

In developing COREMI, the Action has already made contact with numerous leading associations and research networks that will be of use in the capacity above. Among them are the British Egg Marketing Board-BEMB and the British Egg Industry Council-BEIC (UK), the European Union of Wholesale with Eggs, Egg products, Poultry and game-EUWEP (European Association) and the Organizacion interprofesional del huevo y sus productos-Inprovo (Spain), that have already sent letters of support.

Although COREMI is organised in the Domain of *Food & Agriculture*, it will promote cross-cutting linkages with *Environment*, bringing together stakeholders from different fields. This Action does not aim at funding the research work in the participating institutes/countries, but will greatly enhance on-going and future research and ensure maximum exploitation of the novel data generated.
E.4 Gender balance and involvement of early-stage researchers

This COST Action will respect an appropriate gender balance in all its activities and the MC will place this as a high priority and standard item on all of its MC agendas. The Action will also be committed to considerable involvement of ESRs. This item will also be placed as a high priority and standard item on all MC agendas. Whenever possible the Lead and Deputy lead for each of the four WGs will be from a different gender. Of the proposed seven MC members, 3 are female, and 4 are male.

Involvement of ESRs will be established by supporting visits of ESRs to high-profile labs and groups with internationally recognised expertise in the area of interest of this Action. One member of the MC will be specifically assigned to the task of monitoring the involvement of ESRs. The MC will also put in place a mentoring scheme that will link ESRs with a more senior researcher from another participating country to develop their international exposure.

F. TIMETABLE

The COST Action will run for a total of four years. The timetable and milestones are given in Table F. The Action will be initiated at the first MC meeting in the beginning of Year 1, where WGs will be formed and WG Coordinators elected.

Table F: Timetable, Milestones (M) and Deliverables (D) for the CA-PRM Action

<table>
<thead>
<tr>
<th>Description</th>
<th>Year 1-1</th>
<th>Year 1-2</th>
<th>Year 2-1</th>
<th>Year 2-2</th>
<th>Year 3-1</th>
<th>Year 3-2</th>
<th>Year 4-1</th>
<th>Year 4-2</th>
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<td>D1 Kick off meeting during first workshop</td>
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<td>X</td>
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<td>D3 Action webpage operational</td>
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<td>D8 Competitive call STSMs held</td>
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<td>D9 Workshop 1 held</td>
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<tr>
<td>M1</td>
<td>Optimum PRM IPM protocols drafted for blue print development (WG1)</td>
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<tr>
<td>M2</td>
<td>Impact of PRM on the poultry industry and beyond (WG2)</td>
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<td>M3</td>
<td>Initial protocols for harmonized methodologies developed (WGs 1, 3 and 4)</td>
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<td>First indicators of genomic/proteomic candidates for future control (WG3)</td>
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<td>Workshop 3 held</td>
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<td>M5</td>
<td>Economic, welfare importance and human impact of PRM (WG1)</td>
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<td>Benefit for producers when PRM is controlled (WG2)</td>
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</table>
G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: BE, CH, DE, DK, EL, ES, FI, FR, IT, NL, NO, RS, SE, SK, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 60 Million € for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

H. DISSEMINATION PLAN

H.1 Who?

The targeted audiences of this COST Action can be categorised as:
- Partners in the COST Action
- International researchers (e.g., animal breeders, animal nutritionists, system biologists, environmental engineers, poultry associations) working on poultry production and mitigation strategies
- ESRs working on aspects of: poultry, arthropods, agriculture, genomics/proteomics, pest control and mitigation strategies
- Technology Platforms: ETP Food for Life and FABRE
- Advisors working for farmers to improve farm management and genetics
- Policy makers that have an interest in reducing the economic impact from PRM and comparable pests
- Industry that will have an incentive to incorporate mitigation strategies to actively participate in increasing poultry production and reducing treatment costs and animal/production losses
- The general public and practitioners, who will be targeted to raise public awareness of the broader significance of PRM and reduce the societal impact of this pest
- Pharmaceutical companies (agro-biochemical and biocontrol)

H.2 What?

The COST Action will use the following tools for dissemination:
- For COREMI partners conferences, events, press released by partner institutions, general and
specialised workshops and meetings will be organised, as will e-mail networks, an Action share-
point, and web resources to securely store and share reports (and other relevant documents)
featuring on-going work in the COST Action
- For other researchers and the industry there will be an area of the website where details of
(and links to) scientific and popular publications, international conferences, events and non-
confidential reports will be available. The website will also provide links to relevant websites, such
as the one from the European Veterinary Parasitology College (http:www.eurovetpar.org).
- For policy makers and advisors there will be an area of the website containing relevant details
of (and links to) useful material including flyers and abstracts describing the work done in the
COST Action
- For the general public there will be an area of the website featuring updated information on
the activity and impact of the work generated in the COST Action. Some public engagement
activities such as Science Festivals will be discussed by the MC.

Social media (initially targeting Twitter and Facebook then Linked In discussion groups while the
CA membership is growing) will be used for all targeted audiences to maximise dissemination of
results and awareness of the work.

H.3 How?

The Management Committee will be responsible for ensuring appropriate running of COREMI and
dissemination of results, checking the progress of the Action at each of its meetings, and updating
the dissemination plan during the course of the Action. They will set up an Action specific website,
while the WG leaders will be responsible for keeping it updated as Editors. The Management
Committee will receive proposals for the use of funding and select annual activities, decide subjects
of training courses, and compile annual COST reports.

One website will be created, but with two primary ‘areas’ – one that is password protected for
members of the COST Action, and one that is open to other parties. In the confidential area on-
going work and files will be stored and exchanged and data will be uploaded for sharing and
potential further processing, e.g. in undergraduate/postgraduate student projects. In the open area of
the website activities, events and publications will be described, and advisors, non-participating
researchers and the general public can subscribe to the homepage. Also, open positions at
institutions within the COST Action network will be presented here; e.g., PhD fellowships or post
doc positions.

Two email-lists will be generated; one email list for members of the COST Action and another
email list for people or organizations that subscribe to webpage updates and newsletters.
COREMI will establish four workshops. These workshops will be announced well in advance and be open to anyone who would like to participate. The last workshop will be held in relation to other scientific conferences to attract as many people as possible and in collaboration with conference organisers to maximise attendance and impact.
STSMs and researcher exchanges per year will be supported by COREMI. These will be used as a tool for internal dissemination, and seminars will have to be given during these short visits.
Everybody in the consortium can apply for these travel grants, by sharing their idea and aim with the MC. The MC will then decide on whether or not the visit will be financially supported with a travel grant, with priority given to applications from ESRs.
Training Schools: one Training School per year will be organized for ESRs. The topics of the four Training Schools will be:
1) Career development and publishing
2) Identifying and applying for funding opportunities
3) Establishing, maintaining and optimising networks
4) Industry, entrepreneurship, IP and patenting

The above topics would not only help to support career development of ESRs, but also permit exchange of practical information, skills and contacts between Training School participants, organisers and guest speakers.
With a number of COREMI’s participants being Editors of leading periodicals, the work conducted in this COST Action will be submitted for publication in a special issue of a peer reviewed journal or a Book related to PRM. This will highlight the major findings of the network during the Action period. A COREMI Editorial board could be put in place to help such dissemination.