

APLC Research Strategy 2006-2010

1. Situation

The APLC's main strategic objective is to limit the incidence and extent to which substantial numbers of Australian plague locusts develop with the potential to cross State borders and cause significant losses to agricultural production. In responding to that charter, the APLC has to plan for and be responsive to a number of issues relating to its activities, particularly (but not exclusively) the cost, efficacy, ease of use, and the environmental and potential trade (residue) impacts of its control programs

An ongoing and focused research program is essential to addressing these issues now and into the future.

There are a number of risks that, if realised, would impact on the achievement of the research objectives. The APLC does not have, in-house, the expertise or resources (physical infra-structure and funding) to undertake all the research that is considered desirable to meet its needs. Thus, the APLC needs to engage in collaborative research with research and development organisations including industry and seek supplementary funding or in-kind assistance. The APLC is also highly dependent on research and development undertaken by industry to evaluate and develop replacement control agents. Potentially, turn-over of APLC staff with expertise in insect management, monitoring and entomology and the limited number of external funding opportunities from which the APLC may obtain support, present additional risks to the APLC in meeting its research objectives.

2. Purpose

The purpose of the research strategy is to:

Identify and prioritise research that can improve the understanding of Australian plague locust, reduce current and future risks and contribute to the longer term sustainability of locust management in Australia .

3. Objectives

Three core research areas are identified together with specific objectives to be achieved by December 2010. The three research areas are:

- Improvement in efficacy and reduction of risks associated with **control agents and application technology** addressing both immediate and future issues.
- Identification and measurement of the **environmental** and, to a lesser degree trade (residue), impact of APLC operations and integration of research results into control operations to minimise risks.
- Improved understanding of the **population dynamics and ecology** of plague locust to improve the performance and effectiveness of existing surveillance and forecasting systems, and to improve early intervention strategies and plague prevention.

Further detail on the rationale for prioritisation and specific projects are provided in Annexes 1 to 3.

3.1. Objective 1: Control agents and application technology

The strategy identifies five priority areas:

- Identification and development of alternative control agents, in terms of efficacy and safety
- The refinement of the wide track barrier spraying for locust control.
- Evaluation and refinement of current control techniques using *Metarhizium*
- the feasibility/development of a discrete barrier spraying technique using fipronil
- Improved understanding of hopper band displacement
- ground based spraying systems and equipment

3.2. Objective 2: Environmental impact

The strategy identifies six priority areas :

- A comparative evaluation of the sublethal effects of fenitrothion and fipronil on Australian native vertebrates. .
 - Within the above area of research, an increasing focus on evaluating the environmental impact of fipronil on non-target vertebrates
- Evaluate the environmental impact of fipronil on non target invertebrates
- Development of an avian risk model for evaluating and minimising environmental impact of insecticides on Australian bird species.
- Impact of fipronil on Plains-wanderer
- Environmental studies on impacts of replacement control agents
- Evaluate longer term environmental impact from previous control activities in selected areas.

3.3. Objective 3: Population dynamics and ecology

The general objective is to develop, validate, and implement improved surveillance and forecasting systems that can better identify key factors contributing to the development of significant populations, particularly at the outbreak stage, and to better predict population levels, timing, and location. Improved understanding of outbreak development is a key factor in developing an improved early control strategy to reduce the incidence of plagues and associated economic and environmental costs. In addition, biogeographical research on previous locust outbreaks and plagues in relation to weather is also seen as ongoing priority. The required research includes:

- Improved understanding of the population dynamics of plague locust including the identification of key factors and influencing multiplication rates and outbreaks
- Comparative evaluation of light trap and radar as forecasting tools
- Understanding locust movement and interchange across Australia via genetic analysis
- Analysis of the relationship between locust distribution and rainfall in the interior and development of modified survey techniques
- Effect of control activity on the size of future generations
- Biogeographical research on previous outbreaks and plagues in relation to weather

A prime consideration for the topics to be investigated is the provision of information to enhance and verify the procedures and models that comprise the *Forecasting Decision-Support System* (DSS). The Research Review Committee meeting in early August 2005, considered the DSS to be a management tool rather than a research area in its own right. That is, the *Forecasting DSS* was considered the means by which the findings of population dynamics and ecology research were put to applied use. Consequently, this Research Strategy does not contain research objectives or targets for the *Forecasting DSS per se*.

4. Targets

4.1. Control agents and application technology

- 2006: to have completed feasibility trials for an effective fipronil discrete barrier technique
- 2007: to have refined operational settings for the use of fipronil as a wide interval spray against bands and swarms
- 2008: to have refined operational techniques for the use of Green Guard against plague locust hopper bands
- 2008: to have evaluated the efficacy of Green Guard against plague locust adults
- 2008 to have developed an operational discrete barrier control technique using fipronil
- 2009: to have identified/tested potential replacement(s) for fenitrothion and fipronil
- 2009: to have identified/tested at least one additional "non insecticide" agent for aerial/ground control of locusts
- 2009 to have tested/developed improved ground control techniques and equipment.
- 2010 to have progressed research on operational techniques for use with fipronil, fenitrothion and Green Guard replacement agents

4.2. Environmental impact

- 2006: Trials to quantify the impact of Fipronil on termites completed, results analysed and implications assessed
- 2007: further trials including the environmental impact of discrete barrier spraying of fipronil on non-target invertebrates and possibly vertebrates initiated
- 2007: the avian risk model (University of Wollongong) completed and the feasibility of its extension to other taxa will have been evaluated.
- 2008 (completion of the current ARC Linkage grant) the comparative effects of fenitrothion and fipronil will be better understood and the sublethal environmental effects associated with the use of these chemicals for locust control evaluated.
 - Within this project the ecotoxicological implications associated with the use of fipronil will be quantified and the implications for APLC control assessed. Specific activities include:
 - Determining the extent and persistence of pesticide exposure on native vertebrates after locust control spraying

- Determining the long-term effects of pesticides on vertebrate abundance and diversity in experimentally sprayed test sites
- Evaluating the impact of relevant sublethal oral doses of fipronil and fenitrothion on the aerobic performance, immune function and thyroid hormone levels in vertebrates.
- Evaluating maternal transfer of fipronil and its metabolites to eggs and young in birds, mammals and lizards and the physiological impact
- 2009: Environmental impact assessment of replacement control agents initiated
- 2009: The impact of fipronil on Plains-wanderer assessed.
- 2010: evaluation of the long term impact of control activities on selected areas where past control has been undertaken completed.

4.3. Population dynamics and ecology

- 2006: literature review of Plague Locust population dynamics completed
- 2006: Analysis of 2003-04 outbreak completed
- 2007: evaluated the value of radar and light trap data for monitoring/predicting locust migration
- 2008: a model of Plague locust band movement developed
- 2008: Parameters of the existing Dymex model tested to determine reliability for prediction of populations scale
- 2010: an improved understanding of population genetics and interchange potential of populations across Australia
- 2010: improved understanding of the development of outbreaks, enhanced through opportunistic field and laboratory research on
 - Egg laying preference and survival
 - Locust fecundity and mortality

5. Review of progress

It is proposed that progress towards achieving the research strategy objectives and targets be reviewed regularly by the APLC Research Review Committee and elements and timing in the strategy adjusted as required.

Annex 1: Control agents and application technology

The current situation is that three control agents are available but there are issues that could impact on the long term availability or acceptability of each agent. Progress in identifying replacement agents will be highly dependent on industry research and development and the willingness, or otherwise, of industry to make agents available for assessment (and eventual registration in Australia). As potential replacement agents are identified there will be a need to evaluate these through desk top studies and field trials. Operational techniques, for aerial and possibly ground, application will need to be developed for those agents that are assessed by initial screening as replacements. In addition, environmental impact trials may also need to be undertaken for replacement agents. The process of initial identification, field trials, the development of operational techniques and environmental impact is likely to exceed a 5 year time frame. Trials of pesticides often involve the collection of residue data, which can be of importance from a trade (residue) perspective.

Fenitrothion

Fenitrothion is currently the main control agent used by the APLC. It has been used for a long time, is versatile in terms of its use against both bands and swarms in a wide range of crops and pasture and is well understood. However, its range of uses across the world is decreasing. The use of fenitrothion EC used as a product for ground control has recently been reviewed by the APVMA due to OH&S concerns. It is understood that the review recommended its continued use in the short to medium term (1-5 years). APLC is a small user and if uses elsewhere in the world continue to decline, the main manufacturer (Sumitomo) may cease production. There are alternative manufacturers but the quality of their product is questionable. Therefore potential replacement products should be identified tested and operational techniques developed where appropriate.

Fipronil

Fipronil has emerged as a very useful and cost effective product, particularly for both swarm and band control using a wide interval (200-500 m) technique. Generally, the consensus of expert opinion is that the use of fipronil as a blanket treatment should be avoided. There remains uncertainty over the environmental impact of fipronil that could result in its withdrawal from the market. Fipronil is currently being reviewed by the APVMA although the main focus of this review is concerned with its use as a veterinary product, particularly for domestic pets. Therefore, as with fenitrothion, potential replacement products should be identified and operational techniques for these developed.

Fipronil discrete barrier spraying

There is scope for the APLC to explore the use of fipronil as a true barrier treatment as a further measure to reduce potentially adverse environmental impact and also to provide additional flexibility in minimising spray drift. To achieve this requires research to determine whether aerial application into wind (as opposed to cross wind) results in narrow barriers of fipronil treated vegetation.

The concept would be to develop a technique whereby narrow barriers spaced a significant distance apart would achieve effective hopper control whilst significant areas between the barriers remained free of pesticide thereby significantly reducing adverse environmental impacts. Dr Ralf Peveling, a leading (Swiss based) expert on the environmental impact of fipronil, has indicated his interest in collaborating on this work.

Metarhizium

Metarhizium is a valuable product since it enables control operations to be undertaken in areas where it is not possible to use conventional insecticides. However, there are issues about the viability of commercial production for the small and variable volumes used by the APLC. It is relatively expensive and normally available only in very restricted amounts. Questions over the efficacy of *Metarhizium* against hoppers under different, particularly cool, environmental conditions, remain. There is also need to evaluate the use of *Metarhizium* against adults since in some situations (eg organic farming areas, Plains-wanderer habitat) it would be the only alternative for swarm control.

In 2004-5 control campaign, *Metarhizium* was used for 5% of APLC control operations. It is virtually certain there will be increasing community pressure to reduce the use of conventional pesticides, particularly by aerial drift spraying, with corresponding pressure for an increased use of agents such as *Metarhizium*. Whilst not research as such, the APLC needs to develop a strategy to significantly increase the use of *Metarhizium* for band control to replace conventional insecticides.

Ground spraying

During 2004-5 a large (aggregate) area of hopper bands were treated with ground based equipment by landholders particularly in NSW. In many cases, these bands would have been too small for aerial control. Where major outbreaks and plagues develop in agricultural areas such ground control is invaluable in reducing the overall locust population at the band stage. In addition, increasing longer term pressures to reduce aerial spraying may lead to increased reliance on ground based control in the future.

There is potential for the available ground based systems, both equipment and pesticide, to be improved with research to deliver benefits to landholders and others using those systems and indirectly to the effectiveness of APLC locust control operations.

Annex 2: Environmental impact

Current status of research

Much of the initial APLC environmental research focused on the impact of fenitrothion on non target invertebrates. This research indicated that the impact of fenitrothion, whilst significant, was of limited (6-8 weeks) duration. More recently, environmental research, mainly through ARC linkage grants with the University of Wollongong (UoW) the focus of environmental research has moved to the potential adverse impacts on vertebrates, in particular native birds and small mammals.

Fipronil

Research by the APLC since the late 1990s has developed an effective operational control technique using fipronil. However, the adverse impact of fipronil in locust control operations in Madagascar mean that the APLC needs to address the use of fipronil for control operations in Australia as a priority. Such research is already underway. An initial study on the environmental impact of fipronil on termites has been undertaken and more detailed follow up studies are being undertaken. Additional work on the impact of fipronil on vertebrates (birds and small mammals) is also being undertaken in collaboration with the UoW. The results yielded by these studies will enable the APLC to better assess the impact of fipronil and to modify its control operations/techniques as appropriate.

More recently, the APLC has been approached by NSW Department of Environment and Conservation (DEC) regarding the possibility of conducting collaborative research on the impact of fipronil on Plains wanderer. Unfortunately, it is not possible to incorporate such research into the current ARC project with the UoW. However, a small well defined cooperative research project between the NSWDEC and the University of Wollongong, with input from the APLC, on the impact of fipronil on Plains-wanderer could have potential benefits for the APLC in the medium term.

Annex 3: Population dynamics and ecology

Current status of research

Since the establishment of the APLC most research has focussed on operational priorities such as the development of survey and spraying techniques, using remote sensing, locust behaviour etc. The APLC has undertaken limited research on plague locust population dynamics. In addition, very little research has been undertaken on plague locust population dynamics by CSIRO since the late 1980s. Our understanding of the population dynamics of plague locust has therefore not progressed in any substantial way. This is seen as a significant weakness in APLC research that needs to be addressed. Improved understanding of outbreak development is essential for a successful preventive control locust program and to underpin the rationale for the APLC's operations. Research on population dynamics will require both field and some laboratory study and a long term commitment will be required both by the APLC and collaborating partners. There will also be a need to take full advantage of opportunities for field research when locust populations are detected in the interior.

The major goal of the research is to improve our understanding of population dynamics and, through this, to be able to improve our predictions on the scale of population development and possibly enable improved risk assessments of individual populations in terms of the decision to control or not. Significant progress in this area will depend to a large degree on the availability of external resources and expertise through ARC grants.

Population dynamics research

Given the complex nature of the issue, collaborative research will be essential. Professor Stephen Simpson's group at the University of Sydney has indicated a strong interest in collaborating with the APLC in a number of areas. They have particular expertise in population genetics, phase change and locust feeding behaviours and nutrient-intake strategies. In combination with the APLC's operational expertise and applied ecology, significant advances in understanding should be possible as a result of this interaction.

In terms of developing a model of plague locust population dynamics, it is envisaged that data from the literature review, and longer term the capture of new population dynamics data, would enable enhancements to be made to the current Dymex model.

Review of existing literature

A review of the available literature is seen as an essential initial step. It will consider the state of knowledge concerning locust mortality factors (biotic, including intra- and inter-specific, and abiotic, e.g. climatic factors), locust fecundity and the role of migration and behaviour in population fluctuations. The main aim of this review will be the identification of key knowledge-gaps.

Radar studies

The current ARC linkage project with the University of New South Wales on the use of radar will yield results shortly. Initial indications are that plague locust night migration is a more frequent "regular" occurrence than previously anticipated. Given that migration is regarded as a key factor in population dynamics the results of the current study are likely to have implications for APLC control strategy and possibly monitoring.

Biogeographical studies

Biogeographical studies of previous locust outbreaks and migration have proven a useful research tool in the past. Currently the APLC is undertaking an analysis of the 2003-04 outbreak and there is interest from a university in examining the relationship between seasonal rainfall/drought sequences and locust population levels at the “macro” level.

Other areas of potential investigations

The following suggestions were not discussed by the Research Review Committee in August 2005 but are potentially valuable avenues of research.

- investigate population regulation of Australian plague locust by micro-organisms (in particular known entomopathogenic bacteria, fungi and other pathological agents that occur on the surfaces of plants in habitats where locusts are endemic) with a view to identifying new biological control agents and ways of altering their numbers without the need for laboratory culturing and multiplication
- investigate role of chemically-mediated behaviours in Australian plague locust, e.g. selection of oviposition sites and aggregation of females
- investigate immune-response mechanisms in Australian plague locust with the ultimate view being to identify agent(s) that may make them susceptible to epizootics

The APLC would not have the in-house resources to undertake the above types of research and hence external funding would be required and it is envisaged that APLC involvement in resource terms would be low. It is suggested that the inclusion of these topics be considered at a future meeting of the Research Review Committee.