Risk management of a major agricultural pest in Australia—plague locusts

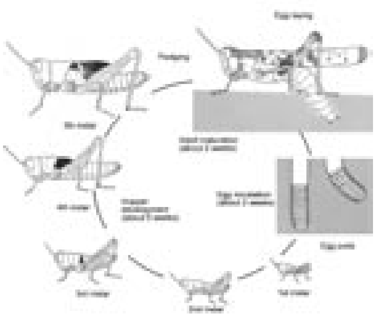
Walter Spratt outlines risk management approaches in minimising a recurrent agricultural emergency—locust plagues

Abstract

Locusts are a major pest of agriculture in Australia. The Australian Plague Locust Commission mitigates adverse impacts of locusts through considered risk management, research and the implementation of control measures. Plague locust operations must balance mission success with the potentially competing objectives of minimising adverse impacts on personal and public health and safety, the environment, the economy and trade.

Introduction

The Australian plague locust (*Chortoicetes terminifera* [Walker]) is a serious pest of agriculture in Australia. Images of widespread devastation and 'plagues' of biblical proportions are often evoked at the mention of locusts—particularly amongst the public and mass media. Primary producers, and relevant authorities, with experience of this pest, adopt a more rational attitude and take what practical steps are available to minimise locust damage.

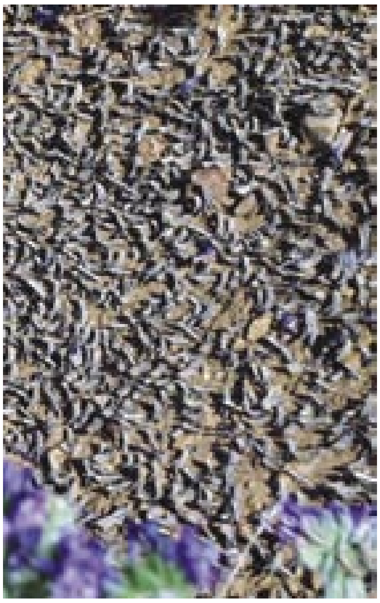


Locust life cycle

Whilst large locust outbreaks are not frequent, localised infestations (on various scales) are common enough to represent a significant economic risk to agricultural production. The potential impact on crops valued in excess of $19 billion annually (ABARE, 2004) as well as productivity losses from affected pastures and associated industries, can have serious implications for a national economy with high reliance on primary production.

The Australian plague locust is able to consume up to 30 to 50 percent of its body weight daily; can form large, very dense, and highly mobile swarms capable of long distance migration (up to 700 km in a single night—and further over multiple nights); are very well adapted to Australian conditions and are supreme opportunists that can multiply very rapidly under favourable conditions. A single swarm of mature, Australian plague locust adults, at ground densities of 4–50 locusts per square metre covering an area of 1 square kilometre, can consume between 0.8–10 tonne of vegetation per day. (Some swarms may easily exceed 50 km^2 and have densities greater than 50 per square metre). Juvenile stage densities can reach up to 12,000 per square metre—but cover much smaller areas. Considerable further losses result from damage associated with affected vegetation not totally consumed.

Lost production results not only from direct consumption, but also indirectly from damage to vegetation at a vulnerable growth stage or when simultaneously experiencing adverse environmental conditions such as hot, drying winds that can desiccate and kill damaged plants. Damage to maturing crops can reduce yields and cause grain heads to fall before, or during, harvest. Product contamination may also be an issue if locusts are present at harvest, and are included with grain to result in quality downgrades and premium reductions.



Australian plague locust nymphs in the Riverina District, NSW
[Courtesy: Judit Szabo]

The impact of a significant locust infestation on a crop is generally obvious and immediate. The effect on natural habitat, rangelands, and other pasture, is less apparent and can be grossly underestimated. Locust infestations could also threaten conservation values by

Locust bodies (and parts) can also be a significant crop contaminant during harvesting—Wentworth NSW, Spring 2000 *[Courtesy: Randy Larcombe]*

realising disproportionate effects on diminishing reserves of natural habitat. These areas are being made increasingly vulnerable by man-made changes to surrounding habitats that have disrupted the previous 'equilibrium'. Locust outbreaks may now be less of a 'natural' event and could further increase pressure on some already threatened species.

The life cycles of native pastures are dependent on similar environmental conditions influencing locust development—this is not coincidence but an evolutionary strategy employed by this insect to synchronise its life cycle with that of its habitat. Between periods of protracted drought and possible locust outbreaks, native vegetation may only have a narrow window of opportunity in which to recover and reproduce for future pasture generation. Locust affected pasture that subsequently experiences extended drought can be severely retarded for many years and might cause corresponding reductions in stock-carrying capacity and longer-term production levels, with corresponding pressure on native fauna.

Locust ecology

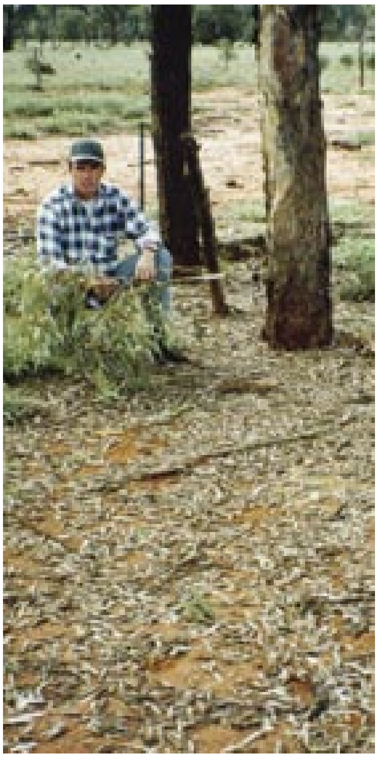
All locusts are grasshoppers, however, not all grasshoppers are locusts. Anatomically, the two are similar—the key distinguishing feature is behavioural rather than physical. Under appropriate conditions, locusts exhibit strong gregarious behaviour and a propensity to undertake significant migration, adopted as an overall evolutionary strategy to aid their survival.

Locust ecology is very closely aligned with their environment. The Australian plague locust mostly exists in low numbers as a widely distributed background population over large tracts of preferred habitat in the arid interior of mainland Australia.

In a land of extremes, periods of extended drought, localised or widespread, are commonly followed by substantial rainfall events that provide sudden and greatly improved conditions for survival and breeding. Until such events, locusts generally experience gradual, ongoing mortality—however, their environment is usually diverse enough to provide sufficient habitat, in adequate condition, to constitute a refuge for low numbers of locusts to survive and successfully reproduce subsequent generations. The mobility of winged adults enables them to actively seek out these favourable areas.

Locusts are well adapted and attuned to the Australian climate and weather systems. Their ability to migrate in association with significant moisture-bearing weather systems is well known. Their success in locating areas that have recently received sufficient rain to produce a sustainable vegetation response is almost uncanny. Low numbers of locusts within a vast area can concentrate into large, dense populations that converge into discrete areas virtually 'overnight', if meteorological conditions are suitable. This 'funnelling' phenomenon is thought to be more a function of prevailing atmospheric conditions than any deliberate act of navigation by the insects.

Severe, prolonged drought not only takes its toll on locust numbers, it can dramatically reduce populations of locust predators, parasites and pathogens.



APLC Officer inspecting successful result after treating a swarm of spur-throated locusts—Queensland (Note: APLC Officer is holding a branch broken by the weight of roosting adult locusts)

Aerial photo of a Mitchell grass plain in western Queensland infested with numerous very dense bands of Australian plague locust nymphs. The bands are visible as waves of dark, finger-like projections, eating their way across the grass plain and denuding the vegetation

Differences in 'predator'/'prey' life cycle generation periods introduces a 'lag' phase that allows locust numbers to increase dramatically before being significantly affected by these mortality factors. The ability of locusts to migrate 'en masse' also serves to avoid these natural controls—further contributing to their success as a major economic pest.

Relaxed mortality pressure combined with favourable conditions promotes rapid population increase, with each female being able to lay 30–50 eggs up to four times within a period of several weeks. The density dependent ('critical mass') trigger for gregarious, locust behaviour requires several successful breeding cycles within a single season to produce a cohesive population that behaves in a co-ordinated manner and exhibits synchronised development. This stage of population development poses the greatest risk to agriculture.

The ability of this pest to develop large populations in remote areas without necessarily posing an immediate, significant economic risk to agricultural production in the jurisdiction of origin, combined with its ability to travel large distances in short periods, represents a very real risk to agricultural production in other States and at the national level.

Organisation and strategy

The politics of this situation – an interstate risk from a migratory pest – prompted the formation of the Australian Plague Locust Commission (APLC) in 1974 to combat this pest from a national perspective at a strategic level. An agency within the Australian Government Department of Agriculture, Fisheries and Forestry, the APLC is jointly funded, in pro-rata proportions that reflect perceived respective risk, by member States with an overall matching contribution from the Australian Government.

The fundamental tenet supporting the successful management of locust outbreaks (and mitigation of related damage) at the strategic level, is early intervention. Without adequate explanation, this approach can create confusion for some stakeholders. The early intervention principle is not restricted to the tactical sense. APLC does not engage in operations deliberately intended to protect individual crops or pasture, although this may occur incidentally. Responsibility for control of this pest is tiered in a hierarchical structure beginning with affected landholders, through relevant local and State government authorities to the APLC. The APLC may initiate control operations when a situation assumes a scale and nature that may significantly endanger agriculture in more than one State, becoming a matter, potentially, of national interest.

The APLC approach is primarily proactive and intended to be preventive by disrupting the sequence of successful generations necessary, within a single season, to produce an outbreak with national ramifications. Management intervention aims to control populations by keeping their size below a prerequisite 'critical mass' thereby preventing the stimulation of density dependent behavioural triggers that can be precursors for major outbreaks.

Early intervention principles are also applied tactically within an individual breeding generation. This involves obvious immediate economic and environmental benefits. Consequently, APLC will only intervene to manage large, dense populations that pose a significant actual or potential risk to agriculture in more than one member State.

APLC operations frequently occur in isolated areas of the arid interior and remote from the main regions traditionally associated with agricultural production. Consequently operations are less visible and associated benefits often go largely unrecognised. Wright (1986) identified a conservative benefit:cost relationship in the order of 30:1 directly associated with APLC operations, although the study concentrated on the financial effects on crop production and did not examine impact on pasture or other aspects related to locusts. Success is also evident in the reduced frequency, scale and duration of outbreaks affecting agriculture since the inception of the APLC.

Risks and remedies

Pursuit of a successful outcome is not a straightforward proposition and must accommodate a number of substantial risks. There are four major risks that must be managed to ensure continued provision of net benefit of the program. These broadly fall under two main headings:

- mission failure; and
- collateral, or unintended, consequences associated with management intervention in the key areas of:
  - – health and safety;
  - – environment; and
  - – economy and trade.

Aerial photo of Mitchell grass plain in western Qld. The size of the very large band of locust nymphs on the left of the photo can be gauged by the spray plane flying approx. 10 m above the ground. Several smaller locust bands are also clearly visible on the right. The scalded areas indicate where the locust nymphs have completely denuded the vegetation. Each scalded area is how far the band of nymphs have moved in 1 day

This photo was taken by an APLC officer in a helicopter, directing the spray plane pilot onto the target and ensuring accurate placement of insecticide

Mission failure

The APLC has responsibility for managing populations of the three main Australian locust species in a geographic area of approximately 2 million square kilometres, or about 25 percent of mainland Australia.

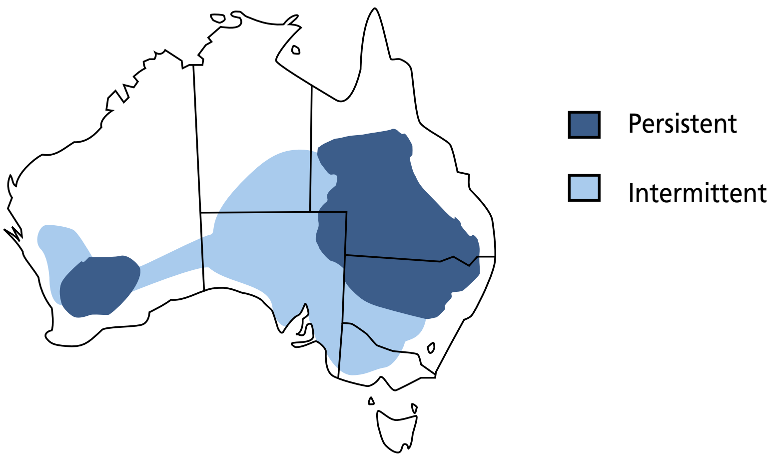
Mission failure could be defined subjectively as the degree of impact on the agricultural industry in a member State from an immigrant population. The APLC objective is to contain the population and prevent migrations of infestations that represent a significant actual, or potential, risk to agriculture in more than one member State. The APLC is a risk management program established to control significant, threatening infestations and to mitigate impact on the agricultural industry that would not otherwise fall within the capacity or province of vulnerable stakeholders. As such, APLC intervention is not intended to eliminate every locust infestation, but to substantially reduce a population and the scale of potential migration. Residual populations are still capable of inflicting a certain amount of damage that should be more readily absorbed across the broader industry, managed at the relevant local level of responsibility, or passively allowed to deteriorate naturally and revert to more normal background levels.

In order to translate early intervention principles into mission success, the APLC must maintain an appropriate rapid response capability supported by applied research and relevant infrastructure.

APLC achieves success with a staff of seventeen permanent officers stationed at three strategically located field offices supported and co-ordinated from a headquarters office in Canberra. The three field offices are virtually self-contained units with a total of eight staff capable of mounting and sustaining multiple, simultaneous control operations, with additional support from appropriate headquarters-based personnel.

Detection and monitoring are critical elements for successful early intervention. The APLC maintains an active field survey capability

Distribution of Australian plague locust in Australia



supported by comprehensive remote sensing and forecasting systems that enhance effectiveness and efficiency. Passive monitoring systems take the form of a strategically-sited network of insect light traps operated by part-time contactors plus the active cultivation of an informal reporting network of landholders plus local and State government officials. Between the active and passive systems, APLC is confident of maintaining a reliable estimate of the overall locust situation and of detecting and forecasting the development of significant events that may warrant early warning sufficiently in advance to prepare an appropriate response.

APLC staff conducting ground and aerial surveys for locust swarms near Broken Hill, NSW [Courtesy: Randy Larcombe]

The second element associated with the rapid response capability required for successful strategic and tactical intervention is that of appropriate treatment systems. The two key factors involved in management of locust infestations are time and distance. The size of areas involved and the distances of those sites from a base of operations with access to suitable infrastructure necessarily introduces the dimension of time. Time is the most critical element as it is a parameter outside APLC control. There is a range of environmental and ecological factors that combine to produce a limited window of response opportunity. This necessitates the use of aircraft—for both aerial survey and aerial treatment. Aircraft remain the most effective and efficient means of achieving the rapid response capability needed to take advantage of any 'windows', when and if they appear.

Management of unintended consequences

The nature and scale of any significant, unintended consequences have obvious and direct links to mission success. This actually represents a subset of risks that must be managed to ensure a safe and responsible outcome.

Within the scope of unintended consequences are three crucial objectives that must be satisfied in order to cultivate continued public and political support. These objectives are:

- minimising impacts on personnel and public health and safety;
- minimising impacts on the environment; and
- minimising trade and economic implications due to residue contamination.

Unless the APLC can demonstrate due diligence and responsible operation, its value (net benefit), credibility and reputation could be adversely affected. In this event, critical access to infested areas plus levels of co-operation and support could be reduced to an extent that might jeopardise overall mission success. Control mechanisms to manage these risks are not mutually exclusive and often realise synergies across all areas.

Pesticides, by their nature, pose credible risks to each of our above social, environmental and economic objectives. The adoption of integrated pest management principles aims to establish a suitable balance between effectiveness, economics and safety by employing a range of materials (with different, but complimentary, properties and modes of action) and by matching their application to suit prevailing conditions. This approach mitigates much of the identified risk whilst simultaneously increasing APLC's response flexibility and reducing operational vulnerability by spreading reliance of pesticide supply over multiple providers.

A relevant case is APLC's investment in the development, and subsequent operational use, of the biological control agent *Metarhizium anisopliae* (var *acridum*)[1]. Although slower to take effect, and not yet as cost effective as conventional chemical pesticides, its implementation is fully accepted and endorsed by all leading organic production certification agencies in Australia. This strategic initiative facilitates continued access to areas of critical locust habitat that were threatened with operational exclusion following their conversion to certified organic production in order to take advantage of niche export markets.

The economics and efficacy characteristics of this biological

1 Not registered at time of writing.

APLC contracted spray aircraft operating 'smoke' generator to assist determination of application drift risk [Courtesy: Randy Larcombe]

control agent currently restrict its operational use to areas that would otherwise be closed to conventional chemical pesticide application operations, e.g. organic production or environmentally sensitive areas. This agent requires no produce withholding period before marketing as there are no associated residue issues, although some environmental concerns remain regarding potential impact on non-target grasshoppers.

Continued use of conventional chemical pesticides, containing active ingredients of varying toxicity, remains a potentially hazardous activity, with obvious implications for personnel, public and environmental health and safety as well as for export trade markets conscious of chemical residues. Residue-related trade incidents have had substantial implications for Australia's primary production export markets, and can damage Australia's reputation for clean, green production (SafeMeat, 2004). For example residues of chemicals exceeding designated limits for beef have cost Australia many millions of dollars (Hill, D. J. 1996).

The APLC seeks to manage risks of this nature by development and implementation of a range of control mechanisms. Some involve ongoing research into improved methods and materials to minimise non-target effects. Research into application methods has resulted in the successful adoption of greatly reduced application rates (in the order of 30 percent or greater) with direct, corresponding benefits to human and environmental health and safety, in addition to significant budgetary savings.

Pre-emptive research also aims to identify any significant non-target impact that might result from locust management operations. The objective is to identify, and incorporate, significant areas of concern into strategic and tactical considerations at the earliest opportunity, and attempt to formulate appropriate countermeasures to satisfy stakeholders without compromising mission success.

Conclusion

A diverse and dynamic operating environment constantly confronts the APLC with new challenges and increasing constraints. In order to remain valid and sustainable, the APLC continually scans its environment to detect trends that might present credible risks or opportunities.

The APLC is constrained to function within the legislative frameworks of the respective States within which it conducts operations. Legislation is closely aligned to, and generally reflects, socio-economic and cultural norms that are constantly evolving. The organisation is proactive and quick to identify, evaluate and implement promising new risk management strategies to contribute to the pursuit of 'best practice'.

The importance of this aspect of risk management should not be underestimated. The impact of adverse incidents, anywhere in the field of locust management, can have a dramatic and disproportionate effect that could conceivably threaten the viability of its important role in agricultural protection.

Risk management involves an intricate mix of interrelated factors and considerations that must be planned, and prepared for, in advance of any requirement. Agricultural risks, including locust plagues, are no less complex but can be managed successfully if approached in a rigorous, systematic and comprehensive manner.

References

Australian Bureau of Agricultural and Resource Economics, 2004. Australian Commodities Forecasts and Issues, Vol. 11, No. 1, March quarter 2004.

Hill, D. J.,1996, Chemical Residues in the Australian Beef Industry: Assessing the Economic Impacts of the Chlorfluazuron Incident on Returns to Cattle Producers, Thesis—Master of Economics, University of New England.

SafeMeat, 2004, Plague locusts, Wingless Grasshoppers and Livestock Residues (Brochure).

Wright, D. E., 1986, Economic Assessment of Actual and Potential Damage to Crops Caused by the 1984 Locust Plague in South-eastern Australia, Journal of Environmental Management, Vol. 23, pp. 293–308.

Author
Walter Spratt is Operations Manager with the Australian Plague Locust Commission. He commenced as a Field Officer during the 1984 spring plague and has been based at Broken Hill (NSW), Longreach (QLD) and Canberra (ACT). He has been directly involved with conducting and coordinating numerous locust management operations over the past 20 years.