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4 A Century of Locust Control in South Africa

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ABSTRACT

It is just over 100 years since the chemical control of locusts began in South Africa when sodium arsenite dust was first applied by hand to Red Locust hopper bands and roosting swarms in Natal (Anonymous, 1906). Although our knowledge of locust outbreak dynamics, insecticide technology, application techniques and intervention strategies has made great advances, locusts remain a serious problem. Outbreaks of Brown, African Migratory and Red Locust still threaten sustainable agricultural production in southern Africa. Due to insufficient early warning and limited operational capacity, Brown Locust outbreaks are only contained after emergency campaigns have been launched. Such a curative control response involves vast expenditure, high insecticide usage and increased risk of environmental contamination. This paper briefly describes the biology and outbreak dynamics of the four species of plague locust occurring in southern Africa and focuses on the Brown Locust – a species of great economic importance for the SADC Region. The status of the Brown Locust in South Africa, the advances made, the current control strategy and operational tactics are highlighted. Whether major locust upsurges can in fact be effectively managed and locust control re-inforced, will be reviewed.

INTRODUCTION

Four species of plague locust occur in southern Africa, namely the Brown Locust, *Locustana pardalina*, the Red Locust, *Nomadacris septemfasciata*, the African Migratory Locust, *Locusta migratoria migratorioides* and the Southern African Desert Locust, *Schistocerca gregaria flaviventris*. All have recently produced outbreaks within the region and have been the target of chemical control campaigns. The species each have different life histories and population outbreak dynamics, inhabit widely contrasting environments, ranging from deserts to flooded grasslands, and thus present unique problems for locust control operations.

Brown Locust

Endemic to the semi-desert Karoo areas of South Africa and southern Namibia, the Brown Locust poses by far the most serious economic problems within the region (Faure and Marais, 1937; Lea, 1958a). With its drought-resistant egg stage, short life cycle with 2–4 generations per year, high fecundity and highly gregarious behaviour, the Brown Locust regularly produces intense outbreaks (Smit, 1939; Lea, 1964, 1970). Eggs are usually laid

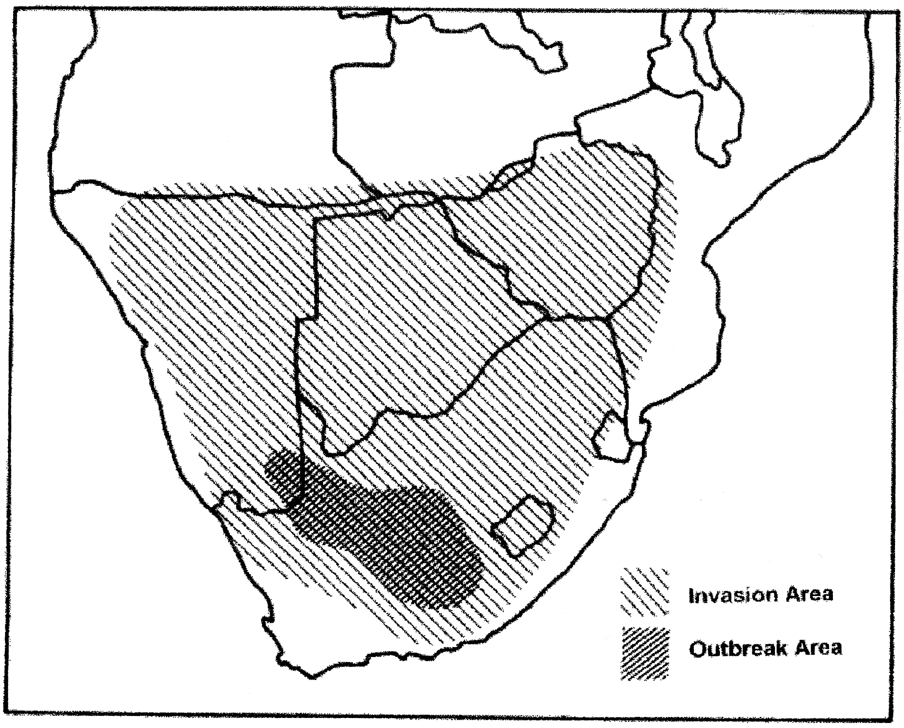

Figure 1 Outbreak and invasion area of the Brown Locust.

in dry soil and during the summer months will hatch approximately 10 days after 15–25 mm of rain has fallen (Smit, 1939). Under drought conditions, eggs enter various states of diapause and quiescence and can remain viable for up to 3 years (Matthée, 1951; Botha, 1967).

Incipient outbreaks generally arise following the end of droughts and are characterised by the dramatic increase in the density of the solitary phase adult population over wide areas of the Karoo (Smit, 1939, 1941; Lea, 1969). Hatching hoppers then aggregate and develop into thousands of small, discrete, highly gregarious hopper bands. For example, over 250,000 hopper bands and 40,000 fledging adult swarms were controlled in the massive 1985–86 upsurge. Swarming populations can then perpetuate themselves for a number of years, requiring an intense control effort, before gradually dying out during another drought cycle. The most recent outbreak cycle (1985–97) was typical of this pattern.

The outbreak and invasion area of the Brown Locust is shown in Figure 1, with the high intensity outbreak area situated in the Northern Cape Province of South Africa. Uncontrolled outbreaks in the past used to threaten agriculture throughout the entire southern African region up to the Zambezi river (Lea, 1970).

Red Locust

The recognised outbreak areas of the Red Locust occur in eight or nine relatively small, seasonally flooded, grassland areas in Central and East Africa (Gunn, 1960; Bahana and Byaruhanga, 1991). With only one generation per year the Red Locust is vulnerable to chemical control and the last major plague cycle (1927–44) ended when the first organochlorine insecticides became available (Gunn, 1960). However, recent population upsurges in southern Africa have demonstrated that outbreaks are difficult to detect in the remote and often inaccessible flooded grasslands (Brown and Price, 1997). Once adult swarms have escaped from these outbreak areas, the highly mobile swarms are difficult to track down and control in the vast invasion area. For example, swarms escaping from an intense outbreak in the Buzi river flood plain grasslands in Mozambique in 1996 flew over 2000 km through Zimbabwe, Botswana and South Africa, with swarms observed over Pretoria for the first time in 50 years.

African Migratory Locust

The Migratory Locust is widespread in grassland areas south of the Sahara and has its main outbreak area in the middle Niger flood plain in Mali where the last plague (1928–41) originated (Steedman, 1990). Over the past 30 years, numerous small-scale outbreaks have developed in various countries in southern Africa, but none of these outbreaks has been large enough to initiate a plague cycle. Outbreaks have occurred in natural grasslands, such as in the east Caprivi in Namibia, but outbreaks have been more commonly reported from cereal crop-producing areas where the adaptable locust has been able to utilise the man-made cropland environment (Farrow, 1974; Brown, 1986). For example, the green feed provided by the winter wheat crop in the Orange Free State in South Africa enhances the dry season survival and allows the locust to produce an early generation in spring which was previously not possible in the original grassland habitat (Brown, 1986). This extra generation and the high fecundity achieved in the summer maize crop enables the locust to produce localised swarming populations during autumn (Price and Brown, 1990). Populations can cause economic damage to newly planted winter wheat before dispersing and largely dying out during the cold and dry Orange Free State winter.

Southern African Desert Locust

This locust is a subspecies of the well-known plague Desert Locust from north Africa and occasionally produces small outbreaks following good rainfall in the red sand dune areas of the Kalahari desert, along the border between Namibia and South Africa. Outbreaks are generally of novelty value only, although small-scale damage has been recorded to irrigated crops along the Orange River in the past (Botha, 1969; Waloff and Pedgley, 1986).

Since the Brown Locust produces regular outbreaks and causes the most serious economic problems in the southern African region this paper will discuss the past, current and possible future control of this species.

PAST ACHIEVEMENTS

Plague Prevention

During the past 50 years, swarming populations of the Brown Locust have largely been confined to the Karoo, with only short-term invasions of neighbouring countries reported, such as in 1986. Virtually no crop damage outside the Karoo has been reported and the threat to food security within the SADC region has been averted. Although large-scale locust control campaigns have been regularly conducted in the Karoo, the actual prevention of plagues has been a success.

Outbreak Frequency

Outbreaks of the Brown Locust develop almost annually somewhere or other in the Karoo. The high outbreak frequency, measured by the number of Magisterial districts in South

Africa, Botswana and Namibia where locusts were chemically controlled each year, shows that there have only been 5 years in the past 50 when no chemical control was undertaken (Figure 2). Outbreak cycles have generally lasted 10–12 years with short drought-induced recession periods between the population upsurges.

Locust Control

The history of Brown Locust control during the past 100 years is summarised in Table 1.

Control strategy

Locusts have traditionally been combated at source in the Karoo before migrating swarms can escape and threaten the cereal crop-producing areas. Farmers are legally required to report the presence of locusts on their land and locust control is the responsibility of the National Department of Agriculture. Most control action is directed at late-instar hopper bands, with spot spraying of the generally small-sized (0.1–1 ha) individual bands taking place shortly after sunrise while still densely aggregated on their overnight roosts. Ultra low volume (ULV) insecticide is applied from backpacks or vehicle-mounted motorised sprayers (Brown, 1988). Roosting adult swarms, which vary in size and may be hundreds of hectares in extent, are usually sprayed from vehicles at night, which allows a longer time to complete the task. Spray aircraft are sometimes used to combat the larger targets.

Acridicides

Regular outbreaks and the relatively easy access to gregarious locust targets have made the Karoo an ideal venue to evaluate new acridicides. During the past 25 years, at least 34 products have been evaluated in laboratory bioassays and in hundreds of field trials by PPRI (Table 2), with 28 products evaluated in the past 12 years alone. Dose range-finding trials are typically undertaken against 5th instar hopper bands in a variety of Karoo habitats and are repeated at different seasons so that the minimum effective dose rate can be established over a range of application conditions (Brown, 1988).

A number of the products listed in Table 2 have now been commercially registered for locust control in South Africa under the Agricultural and Stock Remedies Act (Act 36 of 1947).

With regard to insecticide application technology, South Africa pioneered the use of insecticide baits for locust control and rapidly introduced the organochlorine insecticide BHC when it became available. The first aircraft spray trials were undertaken as early as the 1930s, when arsenic dust was simply emitted into the slip-stream of the aircraft. South Africa also developed its own stacked disc ULV sprayer, the ‘Frans Hugo’, back in the 1970s.

Locust Biology and Outbreak Dynamics

Over 150 scientific articles on the biology and control of the Brown Locust have been published. Important advances in the science of acridology have been made by a number of South African scientists. Professor Faure from Pretoria University, working with caged Brown Locusts, was the first to provide evidence for Uvarov’s theory of the phase transformation of locusts (Faure, 1932), while Matthée’s comprehensive work on egg diapause (Matthée, 1951) is still considered to be a classic study. Work on a wide range of topics, from locust biochemistry to the impact of natural enemies, have been investigated to some extent. The outbreak area has been defined and the frequency and intensity of outbreaks recorded. Smit (1939, 1960) made extensive observations on the behaviour of solitarious

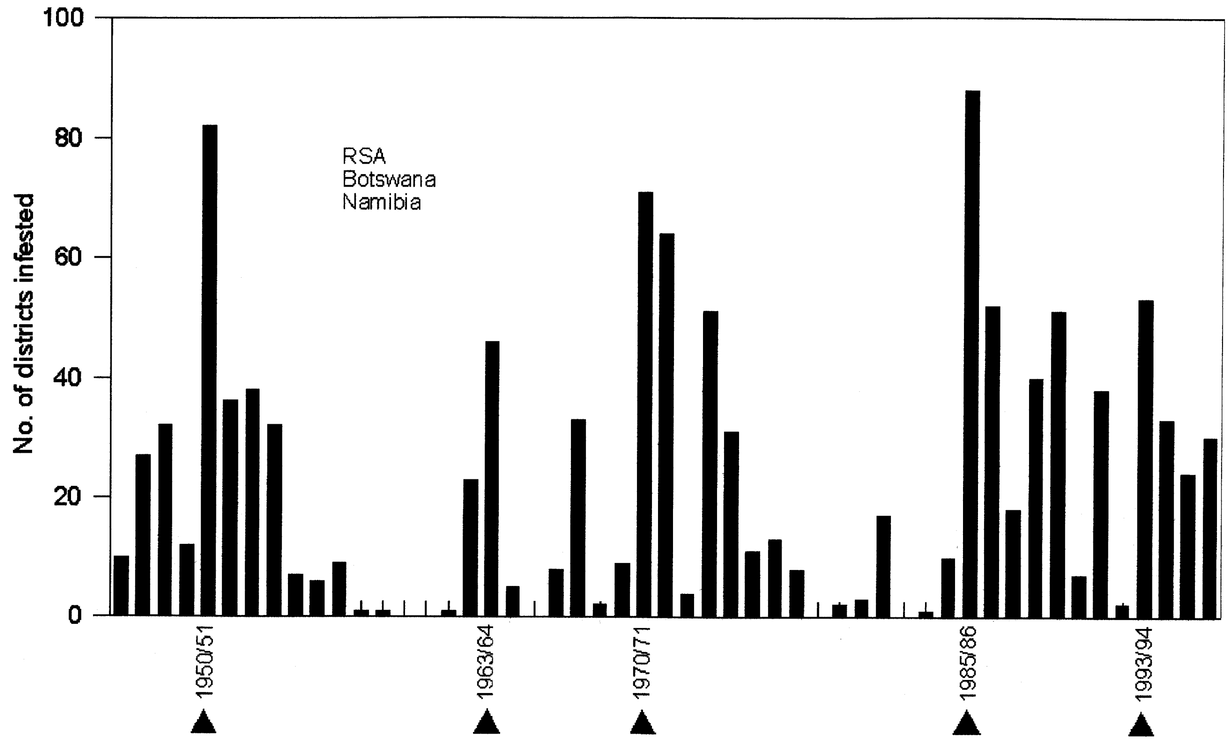

Figure 2 Frequency and intensity of Brown Locust outbreaks 1947–97 (solid bars represent the number of districts infested in the Republic of South Africa, Botswana and Namibia; triangles point to serious Brown Locust plague years).

Table 1 History of Brown Locust control in South Africa

Before 1906	Mechanical and cultural control (trampling, beating, burning pastures, digging up egg beds)
1906–34	Sodium arsenite (liquid and dusting powder)
1934–44	Sodium arsenite baits (bran bait applied by hand to hopper bands)
1945–86	Benzene hexachloride (BHC) (mainly applied as a dusting powder)
1975–94	Organophosphate insecticides (diazinon and fenitrothion applied as a ULV spray)
1990–to date	Synthetic pyrethroids (esfenvalerate and deltamethrin ULV sprays)
Future	New products continue to be registered, e.g. alpha cypermethrin, fipronil, Green Muscle

populations and the development of incipient outbreaks, while Lea (1958b, 1964) described the population dynamics and environmental factors triggering outbreaks.

Outbreak Forecasting

Regular locust population surveys undertaken at fixed sites by locust officers throughout the Karoo from the 1940s up until the mid-1960s allowed an accurate forecasting service to be provided (Smit, 1941; Lea, 1969). However, financial cutbacks have severely reduced the ability to undertake such comprehensive surveys and our ability to forecast outbreaks has deteriorated. Until 1996 there was also a good network of technical contact with neighbouring countries regarding migratory pests under the auspices of the regional Southern African Regional Commission for the Conservation and Utilisation of the Soil (SARCCUS) organisation. However, this organisation has since been disbanded and regional collaboration has consequently deteriorated.

Environmental Impact

South Africa has had a proactive history of introducing safer and more environmentally benign acridicides. Arsenic dust was phased out in the 1930s due to numerous cases of stock poisoning and was replaced by the more target-specific arsenic bait. In the 1970s, the organochlorine BHC was found to persist unduly in the Karoo environment and to have accumulated in the human population (Botha *et al.*, 1974), which led to it being phased out. The high toxicity of the organophosphate insecticides, especially the bird kills and the high number of hospital cases amongst locust officers due to cholinesterase inhibition, led to this class of insecticide being withdrawn in the mid-1990s. The environmental impacts of the synthetic pyrethroids, such as deltamethrin and esfenvalerate, as well as the insect growth regulator, diflubenzuron, have been evaluated in the Karoo. No long-term impact on non-target invertebrates was demonstrated, with most of the fauna rapidly re-colonizing spray plots within a few weeks after treatment (Stewart and Seesink, 1996; Roux, 1998).

A recent highlight has been the field evaluation and commercial registration of the locust-killing fungus, *Metarhizium anisopliae* var. *acridum* (Bateman *et al.*, 1994; Price *et al.*, 1997). This oil-based myco-insecticide, trade name Green Muscle, only kills locusts and grasshoppers and is seen as a viable, ecologically safer alternative to conventional insecticides, especially for use in National Parks and other conservation areas in the Karoo.

Table 2 Acridicides screened against the Brown Locust over the past 25 years

Organochlorines	BHC gamma BHC DNOC DDT
Carbamates	bendiocarb propoxur
Organophosphates	malathion dichlorvos diazinon fenitrothion pyridafenthion phoxim chlorpyrifos
Pyrethroids	deltamethrin fenvalerate esfenvalerate alpha cypermethrin lambda cyhalothrin silafluofen tralomethrin
Combinations	deltamethrin + fenitrothion deltamethrin + pyridafenthion esfenvalerate + fenitrothion
IGRs	diflubenzuron teflubenzuron flufenoxuron
Other compounds	fipronil etofenprox
Botanicals	Neem Syringa oil
Biopesticides	*Metarhizium anisopliae* *Beauveria* sp. *Bacillus thuringiensis* entomopox virus

CURRENT SITUATION

Control Tactics

Locust control in the Karoo continues to be outbreak suppression or the 'fire brigade' approach. The periodic nature of the locust problem excludes the existence of a permanent control infrastructure and control relies on the temporary recruitment of an army of farmers and labourers during a locust outbreak. This so-called 'commando system' has proved effective over the past 50 years as there is a good network of farms, roads and communications in the Karoo. However, the system is becoming inefficient due to high transport costs, and the depressed farming situation has resulted in an increased number of absentee farmers and locked farm gates. This lack of survey and reporting from the more remote areas now means that the control organisation can become overwhelmed during a big outbreak.

The motorised mist-blower spray equipment currently used is effective, although the technology is almost obsolete and should be replaced gradually with more modern spinning disc and spinning cage equipment. Some of this controlled droplet application equipment has already been evaluated under trial conditions with favourable results.

Recurring Outbreaks

The frequency and intensity of Brown Locust outbreaks over the past 50 years, shown previously in Figure 2, suggests that more intense outbreaks occurred during the past 15 years than occurred previously, despite the extensive use of modern insecticides. There now seem to be fewer years with low locust activity and it is possible that the control action is actually preventing the outbreaks from fully gregarising, and burning themselves out, by breaking up the locust populations, as postulated by De Villiers (1987). Are we actually perpetuating a locust problem in the Karoo by preventing the locust 'pot from boiling over'?

Detailed situation maps of Brown Locust outbreaks and control actions recorded each year during the recent outbreak cycle, dating back to 1984, show that there is a definite pattern of swarm movements around the Karoo (PPRI, unpublished). Locust populations are able to utilise the various winter and summer rainfall areas in different parts of the Karoo and there is a seasonal displacement of swarms on the prevailing winds; swarms generally fly in a northerly direction during summer and then east and south-east during the autumn. The maps suggest that although hundreds of thousands of targets were energetically controlled since 1984, the campaign action actually had little effect on the basic pattern of outbreaks. Enough gregarious swarms would evidently escape control in one area of the Karoo to seed the next area where another hopper control campaign would then be waged the following generation or season. Although control action obviously greatly dampened this pattern, insufficient locusts were controlled to actually break the pattern.

The fact that a large-scale Brown Locust outbreak is almost impossible to stop by chemical means alone is supported by evidence from North Africa and Australia, where it is believed that environmental conditions play by far the greatest role in bringing locust outbreaks under control.

Monitoring and Forecasting

There has been recent progress towards developing a Brown Locust situation bulletin and outbreak early warning service, using GIS technology. However, without funding to undertake regular field surveys to obtain accurate information on the status of the locust population the computerised outbreak warning system will be of little value.

Cost of Locust Control

Controlling the Brown Locust has cost the South African taxpayer millions of Rands annually. The massive outbreak in 1985–86 cost over R50 million to control (equivalent to US$25 million at the time), while the recent outbreak in 1995–96 cost approximately R14 million (US$3.5 million). Control costs are bound to escalate in future, especially as expensive insecticides have to be imported. Also, less money is available to undertake research on the development of alternative control strategies than there used to be.

FUTURE OPTIONS

The research priority must be to develop more efficient, cost-effective and environmentally benign methods of controlling the Brown Locust. Whether this entails bolstering the current control system, or incorporating new alternative control methods into a comprehensive Integrated Pest Management (IPM) strategy, must be determined. Various options are discussed below.

Spot Application

The current spot application of insecticide to roosting locust targets can be very effective and has a relatively low environmental impact, although too few targets may be located to stop the outbreak process. How effective is the current commando system and what proportion of locust targets are actually controlled? Scouting for targets could possibly be improved by using micro-light aircraft to monitor remote areas or where access to farms is currently difficult. The search for targets could also be concentrated in specific areas highlighted by an effective locust early warning system.

Blanket Spraying

The aerial spraying of blocks of land infested by locusts is the main technique used during most locust control campaigns around the world. However, the discrete nature of Brown Locust hopper bands would possibly result in the wasteful and environmentally damaging spraying of large areas with no locusts. Blanket treatment against the Brown Locust could, however, be used as a control tactic once a certain threshold number of targets has been reported.

Target-Specific Locust Control

The repeated application of conventional insecticides for locust control in the unique Karoo biome is a cause for concern and there is an increasing demand for more environmentally acceptable methods of controlling locusts, especially in ecologically sensitive areas. Although conventional insecticides are likely to remain the mainstay of locust control for some time, there is an urgent need to develop an IPM strategy for Brown Locust control, which can accommodate alternative control methods, for use in specific areas where a reduced environmental impact is required. Products such as the Green Muscle myco-insecticide and various insect growth regulators have already been evaluated against the Brown Locust and are commercially available.

Other target-specific control options, such as entomopox viruses, botanicals and insecticide baits, require more evaluation. Poison baits were extensively used in the Karoo in the 1930s before being phased out when BHC became available. However, a recent re-evaluation of baiting, using small doses of modern stomach-acting insecticides incorporated into a wheat bran carrier, showed that baiting was an effective and highly target-specific method of hopper band control (Price and Brown, 1997). However, the logistics of bait storage and transport could present problems.

Insecticide Barrier Treatments

The technique of spraying persistent organochlorine insecticides, such as dieldrin, on to narrow strips of vegetation as a barrier against hopper bands was extensively used in Central and North Africa in the past against the Red Locust and the Desert Locust, but was never used against the Brown Locust. However, a new generation of insecticides, with good persistence on vegetation but without the bio-accumulation problems associated with the organochlorines, is now available. Promising candidates include fipronil and some of the insect growth regulators.

The efficacy of barrier treatments against the fast-marching Brown Locust bands in the Karoo, with its sparse vegetation cover, needs to be evaluated. Treatment thresholds also need to be established since barrier spraying, if not judiciously applied, can result in the wasteful spraying of many square kilometres of habitat where there are few locusts. Barriers can also only be used against hopper bands and provide no control of adult swarms.

Target Adults Only

Abandoning the current hopper band control strategy and concentrating the control effort against the fledgling swarms once they aggregate is a tactic that has long been advocated as a more effective use of resources in the Karoo (Cilliers *et al.*, 1964). However, this strategy may require a large number of aircraft to be readily available as the 'window' of opportunity for control is short before swarms start to migrate out of the Karoo. The control of hundreds of swarms once outside the Karoo would cause huge logistical problems.

Direct Crop Protection

Before synthetic insecticides became available the uncontrolled migration of swarming populations from the Karoo led to a long recession period between outbreaks (Lea, 1970). Swarming activity outside the Karoo also soon died out as the locusts were outside their optimum breeding habitat. Due to the escalating costs of locust control, the economic option of suspending locust control in the remote outbreak areas and only concentrating on direct crop protection instead is an idea that has been considered as a cost-effective option in other locust affected regions (Herok and Krall, 1995). However, it is unlikely that this strategy will be adopted in southern Africa due to the national responsibilities regarding migrant pest control and the political sensitivity regarding food security within the region.

CONCLUSION

Despite over 100 years of systematic locust control campaigns in the Karoo, the Brown Locust still has the ability to produce outbreaks that can overwhelm the control capacity. Even though the modern insecticides currently applied are highly effective, the control strategy is still basically how it was 50 years ago. Perhaps Brown Locust outbreaks have been controlled as efficiently as possible and attempts to improve the current system or to implement alternative control methods will not be cost-effective. However, the future aim must be to strive for effective, environmentally benign and cheaper ways of managing locust populations. Whether this is possible is what time and the results of more focused research can tell us.

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