CROP PROTECTION PROGRAMME

Early warning systems and training for improved quelea bird management in eastern and southern Africa

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FINAL TECHNICAL REPORT

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Contents

1. Executive Summary

1.1. The purpose of the project was to improve forecasting and control methods for key migrant pests, with particular reference to the Red-billed Quelea *Quelea quelea,* to achieve beneficial impacts on poor communities and to train personnel involved with quelea control in forecasting and environmental impact assessment methods.

1.2. A workshop on quelea management and a training course on forecasting and environmental impact assessment of quelea control was organised and run at Machakos, Kenya, in May 2005. Both events were attended by 10 delegates from 7 countries (Ethiopia, Kenya, South Africa, Sudan, Tanzania, Uganda and Zimbabwe). The workshop agreed on research priorities for future work on quelea in four different categories (quelea management, forecasting, environmental impact assessment [EIA] and training). The training course on forecasting and EIA was an opportunity to introduce participants from eastern Africa to the achievements in southern Africa of previous CPP-funded quelea projects. A set of draft guidelines on standardised protocols for monitoring effects of quelea control on non-target organisms was adopted. These were later presented to an ICOSAMP workshop held in Pretoria, 12-16 September 2005, when they were revised.

1.3. A system for forecasting where and when Red-billed Quelea could breed in southern Africa, based on satellite-derived rainfall estimates, was extended and adapted to include eastern Africa. Forecasts from this prototype model were displayed on a web-site from October 2005 to January 2006.

1.4. The policy implications of CPP-funded research on migrant pests, 1995-2005, was reviewed. This showed that CPP-funded projects, in particular ICOSAMP, had influenced the content of the draft *SADC Policy for Managing Migrant Pests and Larger Grain Borer in the SADC region*. This document recommended: (a) continuing support for ICOSAMP and bringing it under SADC/FANR responsibility; (b) harmonizing migrant pest report forms to use the ICOSAMP format; (c) endorsement of setting up a system similar to ICOSAMP to monitor the Larger Grain Borer *Prostephanus truncatus*; (d) raising awareness on migrant pests throughout the SADC region and at NEPAD; (e) stimulating re-instatement of national migrant pest systems; (f) enhancing the role of the International Red Locust Control Organisation for Central and Southern Africa (IRLCO-CSA) by disseminating its bulletins to a wide audience; (g) building capacity on migrant pests in National Agricultural Research Stations (NARS) through training and workshops. ICOSAMP has (i) helped to refine and improve data collection, thus assisting Ministries of Agriculture to improve forecasting of outbreaks in their own country and ultimately in the SADC region; (ii) stimulated cross-border collaboration by announcing early warnings of migrant pests about to invade other countries; and (iii) stimulated inter-regional collaboration. The workshop on Quelea Management and Training Course on EIA of Quelea Bird Control held in Kenya, May 2005, endorsed the need for a system like ICOSAMP for migrant pests in the East African region. Other policy initiatives stimulated by CPP projects included (A) use of biopesticides (Red Locust and African Armyworm); (B) international (Red-billed Quelea), national (Brown Locust, African Armyworm) and community-based forecasting (African armyworm); (C) recognition of the need for environmental impact assessments of control and regional adoption of appropriate guidelines (Red-billed Quelea); (D) FAO adoption of the concept of insect growth regulator [IGR] barriers (locusts); (E) adoption a trench-digging control method (armoured bush cricket) and (F) ecologically-based monitoring approaches (Senegalese grasshopper). Outputs of the projects could also be important for the formulation of policies in relation to impending climate change.

2. Background

Migrant pests' attacks on crops are sporadic and the zones affected vary from season to season, yet when they occur the pests may consume entire crops leaving impoverished farmers without any yield to sell and no food for themselves. The Desert Locust *Schistocerca gregaria* has the potential to damage the livelihood of a tenth of the world's population and during the 1986-1989 plague donors spent $US200,000,000 (1989 prices) to protect farmers' crops and so reduce poverty. Such outbreaks can be forecasted and strategic control operations to kill the pests before they can cause extensive damage are used against locusts, quelea birds *Quelea quelea* and armyworm moths *Spodoptera exempta* in Africa and are economically justified (Cheke & Tucker 1995). Quelea can cause damage in East Africa worth US$23.9million per annum. Forecasts of migrant pest occurrences contribute to poverty reduction by reducing risk and influencing policy, both of which can contribute to improved livelihoods for the rural poor when control of migrant pests is timely and effective. However, the lack of reliable and cross border information and communications regarding migrant pest outbreaks are serious constraints to effective forecasting (summarised in the proceedings of the 1999 DFID CPP Migrant Pest Workshop, see Cheke *et al.* 2000). The CPP migrant pest cluster projects have been addressing these issues and the achievements of the quelea project to date have contributed to the objectives of the New African Partnership for Africa's Development (NEPAD) by (i) protecting the food security of the Southern African Development Community (SADC) region, (ii) establishing early warning systems to monitor a major pests of grain crops, (iii) enhancing institutional capacity to cope with migrant pests and (iv) supporting African networking in agricultural technology.

Previous CPP-funded research on quelea birds has led to (a) confirmation that the major pest of small-grained cereals in southern Africa, the Red-billed Quelea bird *Quelea quelea lathamii,* is a single inter-breeding population and so can be modelled as such (Jones *et al.* 2002, Dallimer *et al*. 2003); (b) demonstration that the spatio-temporal distribution of sites suitable for breeding by *Q. quelea* can be predicted in the short-term on the basis of satellite-derived estimates of rainfall (Cheke 2003, Venn *et al.* 2003) and disseminated in real-time at weekly intervals via a website (http://www-web.gre.ac.uk/directory/NRI/quel/Index.htm) that has been taken up and maintained within the region by the Southern African Development Community (SADC) (see http://www.sadc-fanr.org.zw/rrsu/quel/latest.htm and http://gisdata.usgs.net/sa_floods/files/region/quel/); (c) a conclusion that methods for providing long-term predictions of quelea breeding are less tractable; but (d) high numbers of quelea colonies in any year are dependent on the numbers in the previous one or more years (there being autocorrelations in the *Quelea* record at lags up to 3 years) and on rainfall in the December leading up to the breeding season; (e) confirmation that environmental impacts of quelea control are not negligible but protocols to minimise them have been recommended as part of an environmental impact assessment (EIA) (McWilliam & Cheke 2004); (f) the capacity of Ministry of Agriculture staff in Botswana to conduct EIAs and to plan quelea control campaigns has been enhanced through training courses and workshops; (g) the capacity of migrant pest workers has been enhanced regionally through workshops held in collaboration with the CPP-funded ICOSAMP project, its (website http://icosamp.ecoport.org/) and through the quelea project's website (see above) and (h) project outputs have contributed to national and regional policies on quelea bird management with particular reference to the roles of forecasting and EIA. The quelea forecasting model developed as part of the previous project is the first forecasting system for a vertebrate pest in Africa.

In addition to *Q. q..lathamii*, two other subspecies of *Q. quelea* are recognised (Fry & Keith 2004). These are the nominate race (*Q. q. quelea*) that inhabits the semi-arid region from Senegal to Chad and *Q. q. aethiopica* that occurs in Sudan, Eritrea, Ethiopia, Somalia, Kenya, Tanzania, Uganda, eastern parts of the Democratic

Republic of the Congo and Rwanda. As migrations within and between these countries will be governed by the same rainfall thresholds and patterns that have been used to model those of *Q. q. lathamii* successfully, it is now a comparatively simple task to extend the existing model to cover eastern Africa in an extension that has been requested by host countries.

The CPP sponsored a workshop on migrant pests in southern Africa in 1999 (Cheke *et al*. 2000) that led to the establishment of the ICOSAMP project, other migrant pest projects on locusts and armyworm, and a variety of policy initiatives. It is timely to review the achievements of these various initiatives to assist in defining future regional policy decisions on migrant pests. For instance, very little attention has been paid to the possible effects on migrant pest populations of environmental changes related to land use or climatic change.

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DALLIMER, M., JONES, P. J., PEMBERTON, J. M. & CHEKE R. A. (2003) Lack of genetic and plumage differentiation in the red-billed quelea *Quelea quelea* across a migratory divide in southern Africa. *Molecular Ecology* 12: 345-353.

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MCWILLIAM, A. N. & CHEKE, R. A. (2004) A review of the impacts of control operations against the red-billed quelea (*Quelea quelea*) on non-target organisms. *Environmental Conservation* 31: 130-137.

VENN, J., CHEKE, R.A. & JONES, P. J. (2003) Forecasting breeding opportunities for the red-billed quelea in southern Africa. Pp. 612-617 in Proceedings of the 2003 EUMETSAT Meteorological Satellite Conference, Weimar, Germany, 29 September - 3 October 2003. EUMETSAT, Darmstadt, Germany.

3. Project Purpose

Improved forecasting and or control methods for key migrant pests used by at least three target organizations to achieve beneficial impacts on poor communities and, as measured against baseline data, contributing to one or more of the following:

1. Strategies developed to improve forecasting and reduce the impact of migrant pests in semi-arid cropping systems, for benefit of poor people.
2. Promotion of strategies developed to improve forecasting and reduce the impact of migrant pests in semi-arid cropping systems, for benefit of poor people.

4. Research Activities & Outputs

Activities and Outputs

Output 1. *Workshop on quelea management and training course on forecasting and environmental impact assessment of quelea control*.

Activities in support of this output were:

A 1.1. Materials for workshop and training course prepared, April 2005.

A 1.2. Workshop on research needs for quelea birds in eastern Africa (1 day) and training course (4 days) on EIA of quelea bird control held at Nairobi, May 2005.

A 1.3. Workshop proceedings and EIA protocols disseminated.

Output 2. *Extended and improved Quelea forecasting model to include eastern Africa.*

Activities in support of this output were:

A 2.1. The existing quelea forecasting model expanded to include the East African distribution of *Quelea quelea aethiopica*.

A 2.2. The existing quelea forecasting model improved to include access to more environmental variables to refine interpretations of probabilities of breeding.

A 2.3. Recommendations for optimal replacement systems for current Meteosat downloads.

Output 3. *Review of policy implications of DFID CPP-funded research on migrant pests, 1995-2005.*

Activities in support of this output were:

A 3.1. Information on priorities for quelea bird management in Africa sought from stakeholders.

A 3.2. Achievements of CPP-sponsored projects on migrant pests in southern Africa for the period 1995-2005 collated and reviewed.

A 3.3. Policy initiatives to enhance agricultural productivity by migrant pest management recommended in consultation with ICOSAMP project leader during visit to Pretoria, November 2005.

A 3.4. Report on review completed and suitable versions submitted for (a) publication in a peer-reviewed journal and (b) a popular account in a development publication.

All of the above activities were successfully accomplished with the exception of A2.2. and the report from A3.4. has not yet been submitted for publication although a related popular article is in press (Cheke 2006).

Additional activities included (i) attendance at the ICOSAMP Workshop on Migrant Pest Identification and Control Management, 11-17 September 2005, where papers on quelea and EIA were presented; (ii) a re-analysis of the numbers of quelea colonies reported per year in relation to rainfall which has established correlations between the rainfall in December, January and February and colony abundance (Todd *et al.* 2006 in prep.) and (iii) DNA studies of the *Plasmodium* blood parasites of *Quelea q. lathamii* (Fleischer *et al.* 2005).

REPORT ON ACTIVITIES

4.1. OUTPUT 1.

Report on Workshop on quelea management and training course on forecasting and environmental impact assessment of quelea control

Workshop and Training Course Arrangements

4.1.1. The meeting was held at the Garden Hotel, Machakos. Venue choice, local arrangements and local travel had been organised by J. M. O. Ndege (DLCO-EA) who also contacted DLCO-EA member states requesting them to nominate their delegates. In the event, these came from Ethiopia, Kenya, Sudan, Tanzania (2, one from the north [Arusha] and one from Dar-es-Salaam) and Uganda, in addition to the invitees from South Africa and Zimbabwe (see Table 4.1. 5). All international travel had been organised by NRI and paid for in advance and accommodation and allowances were also paid by NRI using the CPP budget. The programme for the meeting is given in Table 4.1. 1, from which it can be seen that the first day and part of the last day constituted the workshop with the remaining time occupied with the training course.

Workshop on Quelea Management

4.1.2. The meeting was opened by James M. Gatimu, Operations Coordinator of DLCO-EA deputising for Mr Peter Odiyo, the Director. He read a welcome address written by Mr Odiyo who was unable to attend himself. The address explained that member states were responsible for monitoring quelea populations in their countries but that DLCO-EA was responsible for the control. EIA work was important as the National Environment Management Authorities (NEMA) in Kenya and Uganda have, since 2004, required EIAs of any new spray operations requested by commercial farmers. Mr Odiyo thanked DFID for their sponsorship of the meeting that will “improve the capacity of the national technical staff.”

4.1.3. R. A. Cheke then described the results of work conducted in southern Africa on (a) quelea taxonomy that demonstrated from morphological and DNA studies that birds occurring throughout the region from Angola to Mozambique were indistinguishable and thus constituted a single interbreeding population; (b) climatological studies that led to the development and implementation of (c) a forecasting system based on satellite-derived rainfall estimates; (d) a desk study and (e) practical work on the assessment of the environmental impacts (EIA) of quelea control by spraying and explosives and (f) research on environmentally friendly control options. Next, Margaret Kieser gave a presentation on the role and functions of ICOSAMP and its web-based dissemination systems. Each delegate was then asked to summarise the quelea problems in their countries.

Eritrea

Although there was no delegate from Eritrea, Mr Tesfayohannes of the DLCO-EA, an Eritrean national, reported that quelea birds attacked sorghum in the west in an area centred on Gojul during September to November and damaged millet in the east near Ghelealo from December to January. The birds do not breed in the country but invade from neighbouring states (Sudan and Ethiopia). There has been a gradual increase in quelea numbers since 1991. Some ground-based spray operations were mounted but were difficult because of the black cotton soil. Most control was aerial and conducted by DLCO-EA aircraft. .

Ethiopia

Mr Assefa reported that Ethiopia’s annual losses to quelea birds of sorghum alone ranged from 27,000 to 40,000 metric tonnes (51% of the expected yield). To combat the pests, aerial spraying with pesticides began in 1978 leading to the deaths of 20,000,000 birds per annum. No research on quelea has taken place in Ethiopia since 1981, there are no collaborations or regional information exchange systems, no forecasting systems, no databases, no EIA data and there is a “shortage of trained manpower in the field of bird pest management.” Suggestions for work on these topics were proposed to enhance the efficiency of the National Bird Control Unit (NBCU) acting in liaison with DLCO-EA. .

Kenya

Mr Kithae reported that in Kenya quelea are controlled in and near cropped lands. Changes in food safety demands and declining budgets required appraisal and improvement of control methods. There was poor information flow from affected areas to the HQ, a lack of trained technical staff and limited information available on quelea management. Suggested solutions included training of field staff and farmers, strategic research, an integrated pest management approach, means to harvest the birds, population models and strengthened links with stakeholders (municipalities, local governments, farmers and environmentalists). Some control of roosts was conducted with explosives. .

Sudan

Mrs Musa reported that in Sudan sorghum, millet and sunflowers were attacked. Overall seasonal losses due to quelea depredation are estimated to be around 2% of total yield. Aerial application of fenthion is the principal large-scale method of control. In 2004 breeding colonies of quelea were reported from many different States (Gedarif, Kasala, Gizera, Blue Nile, White Nile, South Kordofan, West Kordofan, South Darfur and Upper Nile). One hundred and nine sites, covering a total of 14780 ha, were controlled using 95 flying hours with kill rates >90%. Previous seasons' control involved 35024, 22034, 30316 and 36656 ha in 2003, 2002, 2001 and 2000, respectively. Mobilization of survey and ground-control teams is difficult due to muddy roads as a result of the heavy clay soil in the breeding areas. In order to overcome these difficulties tractors are used for transport, in the absence of heavy duty trucks. Sudan does not use explosives for control.

Tanzania

Dr Magoma reported that Tanzanian Government policies to encourage farming of millet and sorghum in place of maize are being undermined by quelea damage since quelea birds do not attack maize. Potential damage to cereals was estimated to be 100,000 tons in the Tarangire and Manyara areas in 2004. Sixty percent of cereal production areas are threatened annually. The potentially vulnerable cereal crop production is 2,656,000 metric tones, valued at TShs 198.7 billion (1 US $ = Tshs 1090). In 1979 loss of cereals valued at US $ 2.4 million was recorded, in 1997/98, 23 % of paddy rice was lost at the Lower Moshi irrigation Scheme (1125 ha) and in 2001, 700 ha and 40 ha of wheat at Basuto and Mulbadaw recorded 100% losses, respectively. Sunflower crops are also attacked. Quelea harvesting can be achieved with one individual capable of destroying 500 nest/ha in *Acacia* at a cost of US $ 30.00 per ha. Required improvements that were suggested included local community participation, ecologically sound control methods including harvesting, regional monitoring and building the capacity in monitoring and forecasting. There was some evidence that quelea were changing their habits and breeding in new areas, a phenomenon that required investigation.

Uganda

Mr Mafabi reported that in Uganda quelea are declared as being in epidemic proportions if the local districts cannot cope with them. Quelea had been controlled in the Tilda rice scheme during 2000. Small farmers attempted control also, by scaring, trapping and illegal use of pesticide-dipped seeds. Given the lack of trained personnel in Uganda and slow information flow systems, regional training programmes were needed.

Zimbabwe

Dr Chikwenhere reported that in Zimbabwe the important crops prone to bird damage are winter wheat, barley and small grains (sorghum and millets). Control has taken place since the 1950s with about 500 million quelea birds being killed between 1974 and 1989. The management of quelea control had been the responsibility of the Problem Bird Control Unit (PBCU) within the Department of National Parks and Wildlife. The PBCU still undertook the operations when pesticides were available, but the budget was now under the management of the Ministry of Agriculture. In addition to spraying, conducted with the aid of two recently repaired aircraft, trapping with bird lime and harvesting of nestlings were also practiced.

DLCO-EA

Mr Ndege reported that DLCO-EA involvement with quelea control began in 1970 on a repayment basis but in 1979 the organisation was mandated to control the birds.

In addition to fenthion, cyanophos was now registered for use in Tanzania, it had been used in Kenya and was about to be registered in Ethiopia. In addition to control, DLCO-EA conducted research and ran training courses and workshops.

4.1.4. Recommendations

Following extensive discussion, the following recommendations were adopted by the workshop, recognising needs under four headings:

QUELEA MANAGEMENT
4.1.4.1. RESEARCH ON DOSAGE RATES*
4.1.4.2. DAMAGE ASSESSMENT
4.1.4.3. MASS CAPTURE METHODS AND PROMOTION OF USE OF QUELEA FOR FOOD
4.1.4.4. PROMOTION OF NON-CHEMICAL CONTROL METHODS
4.1.4.5. TESTING AND IMPROVEMENTS OF GROUND-SPRAYING METHODS AND EQUIPMENT MAINTENANCE
4.1.4.6. DEVELOPMENT OF NEW AVICIDES
4.1.4.7. DATABASE ON QUELEA IN THE DLCO-EA REGION
4.1.4.8. AVAILABILITY OF ACETYLCHOLINESTERASE TESTING KITS FOR ROUTINE MONITORING OF THE HEALTH OF SPRAY PERSONNEL AND ATROPINE SULPHATE FOR EMERGENCY USE IN CASE OF POISONING

FORECASTING
FORECASTING SYSTEMS INCLUDING:
4.1.4.9. AN INFORMATION EXCHANGE SYSTEM SIMILAR TO ICOSAMP
4.1.4.10. WEATHER MONITORING e.g. THE WORLDSPACE RADIO SYSTEM
4.1.4.11. POPULATION STUDIES INCLUDING MODELLING
4.1.4.12. RESEARCH ON MIGRATIONS WITHIN THE DLCO-EA REGION WITH SPECIAL EMPHASIS ON ORIGINS OF POPULATIONS OCCURRING IN SOUTHERN ETHIOPIA AND UGANDA

ENVIRONMENTAL IMPACT ASSESSMENT
4.1.4.13. EIA DATA COLLECTION ON FENTHION, CYANOPHOS AND EXPLOSIONS

TRAINING
4.1.4.14. INTER-COUNTRY AND REGIONAL COLLABORATION AND TRAINING ON CONTROL AND MONITORING EXPERIENCE AND EXPERTISE SHARING
4.1.4.15. TRAINING ON GROUND-SPRAYING METHODS AND EQUIPMENT MAINTENANCE
4.1.4.16. SEMINAR FOR INFORMING DIRECTORS OF DEPARTMENTS RESPONSIBLE FOR QUELEA CONTROL e.g. AGRICULTURAL DEPARTMENTS

*The requirement for research on dosage rates was raised since Sudan controlled their birds successfully at rates of 1 l/ha (occasionally only 05.l/ha), DLCO-EA usually used 2-4 l/ha but South Africa reported use of dosages ranging from 7 l/ha up to as high as 14 l/ha.

The workshop also endorsed protocols for EIA procedures (n.b. these were later revised at the ICOSAMP meeting in September 2005, see below and Table 4.1. 6).

4.1.5. Training Course on Environmental Impact Assessment of Quelea Bird Control

4.1.5.1. Trainees were provided with copies of DFID-funded publications (a) Grant, I.F. & Tingle, C.D. (eds.) (2002) *Ecological Monitoring Methods for the Assessment of Pesticide Impact in the Tropics. Handbook and Methods Sheets*, Natural Resources Institute, Chatham UK, as the basic text for methods of monitoring non-target invertebrates, birds and reptiles, in conjunction with field-work; (b) Allan, R. G. (1997) *The Grain-eating Birds of Sub-Saharan Africa. Identification, Biology* *and Management*. Natural Resources Institute, Chatham, UK; (c) Cheke, R. A., Rosenberg, L. J. & Kieser, M. E. (eds.) (2000) *Proceedings of a Workshop on Research Priorities for Migrant Pests of Agriculture in Southern Africa*, Plant Protection Research Institute, Pretoria, South Africa, 24-26 March 1999. Natural Resources Institute, Chatham, UK; (d) McWilliam, A. N. & Cheke, R. A. (2004) A review of the impacts of control operations against the Red-billed Quelea (*Quelea quelea*) on non-target organisms. *Environmental Conservation* 31: 130-137; (e) a video on quelea birds and (f) a CD with all of the workshop and training course presentations, and associated documents, on it. At the start, the delegates were given a questionnaire on their experience and abilities (Table 4.1. 2). After completion of the course they were asked to complete a course evaluation form (Table 4.1. 3) that included questions on their assessments of how they had benefited from the course. A signed certificate of attendance was given to all participants with their names added to the template used (Table 4.1. 4).

4.1.5.2. The course went well with all trainees participating actively and enthusiastically. Nine out of a maximum of 10 possible post-course questionnaires (Table 4.1. 3) were completed. Most responses were favourable but more practical work was identified as a priority for future courses. In response to question 7, the answers were as follows: (a) not at all **0**; (b) a little **0**; (c) a lot **2**; (d) substantially **4**; (e) enormously **3**. In response to question 8, the answers were as follows: (a) not at all **0**; (b) a little **0**; (c) a lot **1**; (d) substantially **6**; (e) enormously **2**.

4.1.5.3. After the meeting, J. Ndege was to report on it to the pre-Council meeting of DLCO-EA, being held in Kisumu the following week, and a report would also be given to the full Council meeting with Ministers attending later in the year. The reports would include mention of the draft recommendations and protocols. It is to be hoped that they will form the basis for adoption as regional policy within the DLCO-EA zone and that they could also be proposed for adoption by SADC countries, perhaps via ICOSAMP. .

4.1.5.4. The delegates recognised the value of the ICOSAMP scheme for southern Africa and were keen to see such a system set-up devoted to eastern Africa, or a scheme that encompassed both regions simultaneously, thus promoting southern-eastern linkages. Similar views were expressed regarding the forecasting model, work on quelea bird harvesting and EIA practices. Thus the achievements of the CPP migrant pest projects in southern Africa are suitable for uptake by another region and an organisation to which members states' national governments buy into (DLCO-EA) is available to facilitate such uptake.

4.1.6. Dissemination of Workshop proceedings and EIA protocols disseminated

4.1.6.1. A CD with all the workshop and training course presentations (Microsoft Powerpoint files etc.) and associated documents on it was given to all participants (See para. 4.1.5.1).

4.1.6.2. Results of previous CPP-funded research on the biology, forecasting, control and environmental impacts of Quelea bird control and the Draft Guidelines for *Standardised protocols for monitoring effects of quelea control on non-target organisms* were presented at an ICOSAMP meeting held at the Plant Protection Research Institute, Pretoria, South Africa, from 11 to 17 September 2005. The results of work conducted in southern Africa were presented on (a) quelea taxonomy that demonstrated from morphological and DNA studies that birds occurring throughout the region from Angola to Mozambique were indistinguishable and thus constituted a single interbreeding population; (b) climatological studies that led to the development and implementation of (c) a forecasting system based on satellite-derived rainfall estimates; (d) a desk study and (e) practical work on the assessment of the environmental impacts (EIA) of quelea control by spraying and explosives and (f) research on environmentally friendly control options. There was a session during which the draft guidelines were explained. Following extensive discussions and contributions from member states of SADC, the guidelines adopted in Kenya during May 2005 were improved. The final agreed version appears as Table 4.1. 6.

4.1.6.3. After the ICOSAMP workshop all delegates were given CDs with the proceedings of the meeting on it, including the Guidelines.

4.2. OUTPUT 2.
Extended and improved Quelea forecasting model to include eastern Africa.

4 2.1. Quelea forecasting model for East Africa.

The existing quelea forecasting model developed for southern Africa (see FTRs for R6823, R7967 & R8314) was expanded to include the East African distribution of *Quelea quelea aethiopica*. This subspecies occurs from northern Tanzania to the Horn of Africa and is thus governed by different rainfall regimes than those affecting the southern African subspecies *Q .q. lathamii.* .

The new East African model was developed as a separate system. Cold Cloud Duration (CCD) data were collected for the appropriate region and, using the same algorithms as those which drive the southern African system, output was created in time to publish forecasts on the internet from the week ending 9 October 2005 until the week ending 15 January 2006. See http://www-web.gre.ac.uk/directory/NRI/quel/EAfrica/. An example of the output of this prototype system is presented as Fig. 4.2.1.

4 2.2. The existing quelea forecasting model.

The existing quelea forecasting model for southern Africa was run successfully by the Remote Sensing Unit of SADC from 11 September 2005 until 18 December 2005. The SADC team succeeded in downloading Meteosat Second Generation data (from satellite Meteosat 8) as well as Meteosat First Generation data (Meteosat 7) as a back-up. Unfortunately, both of their downloading systems failed in mid-December 2005 and they were unable to obtain the necessary CCD data to continue running the model for six weeks after 18 December. By then, financial constraints meant that the NRI systems had been converted to collect only data for the East African model and so NRI was also unable to supply back-up data. Fortunately, the data were secured from elsewhere and the SADC system was able to re-start by 31 January 2006. See http://gisdata.usgs.net/sa_floods/files/region/quel/index.htm.

Attempts to improve the model output by adding probabilities to the output maps were incomplete at the time the problem with the SADC system occurred and so were not pursued.

4.2.3. Recommendations for optimal replacement systems for current Meteosat downloads.

The Quelea forecasting system has been reliant on obtaining CCD data from the first generation of Meteosat satellites, but these were to be phased out on 31 December 2005 and be replaced by Meteosat second Generation systems (MSG). This to continue from 2006 onwards it became essential to obtain new equipment to download the appropriate data. In the event, the demise of the first generation system has been delayed but MSG is now functioning. Following enquiries regarding the most appropriate downloading systems to recommend for the future, and given financial constraints, a system supplied by Timestep Weather Satellite Receiving systems (see http://www.time-step.com/) was purchased. This was commissioned in January 2006 and is currently being tested and evaluated. The Timestep recommended system includes:

- SkyStar II USB version receiver.
- Triax 88cm dish (*recommended by Eumetsat)*
- TechniSat SatFinder LevelMeter, high quality moving coil meter
- Timestep *DB1 lite* software for display

4.3. OUTPUT 3.
Review of policy implications of DFID CPP-funded research on migrant pests, 1995-2005.

4.3.1. *Achievements of CPP-sponsored projects on migrant pests in southern Africa for the period 1995-2005*

MIGRANT PEST PROJECTS 1995-2006
The achievements of DFID-sponsored projects on migrant pests up to 1999 have already been reviewed (Cheke 2000), but that review did not emphasise their impacts on policy. During the 1995-2006 period, the CPP commissioned 24 projects in its migrant pest cluster. These are listed below and their policy implications, if any, will be discussed under the classifications of (a) African Armyworm; (b) Brown Locust; (c) Red Locust; (d) Desert Locust; (e) Senegalese Grasshopper; (f) Red-billed Quelea; (g) Information systems; (h) projects on Armoured Bush Crickets (i) miscellaneous topics and (j) climate change. Finally a section on migrant pest databases is presented.

4.3.1.2. Projects on African Armyworm
R6746 1996-2000 *Entomopathogenic Baculoviruses for control of the African Armyworm,* Spodoptera exempta*, in Tanzania*
R6762 1996-1999 *Decision tools to aid armyworm surveillance and outbreak prediction*
R7954 2001-2004 *Novel technologies for the control of the African armyworm* Spodoptera exempta *on smallholder cereals in East Africa developed, evaluated and promoted*
R7966 2001-2004 *Identifying the factors causing outbreaks of armyworm as part of improved monitoring and forecasting systems*
R8407 2005-2006 *Economic evaluation and international implementation of community-based forecasting of armyworm*
R8408 2005-2006 *Novel controls for armyworm in East Africa adopted / demonstrated / disseminated – national / regional organizations*

The development of decision tools for armyworm forecasting (R6762, R7966) showed that moth outbreaks could be forecasted as being of no risk, low, medium or high risk on the basis of rainfall patterns. Thus a policy of using forecasting technology was adopted by the Tanzanian Pest Control Services for its national programmes, but it was further refined to be based within communities. The initiative of community-based forecasting (R8407, R8408) represents a significant change in how migrant pests are forecasted from a prevailing view that migrant pests, by their nature, are international and so forecasting them can only be tackled by centralised organisations. However, community-based forecasting (CBF) of armyworm was developed and implemented in Tanzania and the project work showed that forecasting at a village level can be both feasible and complementary to the national service. Indeed the national service in Tanzania has taken a lead in setting-up and running the community forecasting pilot studies (Mushobozi, 2004). Community-based forecasting, though clearly lacking the bigger perspective of the national operation, has key advantages. A greater sense of ownership of the process increased the likelihood that farmers will act on forecasts and a major constraint that the national forecast sometimes failed to reach the people who needed it, has been overcome. In the first community forecasting pilot, carried out in 5 villages in Kilosa district during the 2001/2002 season, the Tanzanian government supplied insecticide spraying equipment for the participating villages and they agreed to pay the local costs for a second pilot study. There are now 20 villages in 4 Districts of Tanzania implementing CBF of armyworm. Community-based forecasting has been largely self-sustaining having continued in all villages with only a small external input of pheromone lures and evaluation visits. In addition, 5 villages in Machakos District, Kenya started CBF in 2005 with USAID funding, and a pilot study was also carried out in Ethiopia. District authorities have benefited through institution-building and the links between community forecaster, village government, extension staff and district office have been strengthened. Actions have changed as farmers report monitoring their crops for armyworm and taking early control measures, with the effect that armyworm damage has been reduced with higher yields and improvements in peoples' livelihoods as consequences.

The number of villages reached was a small proportion of the number which might benefit, but demand for CBF has been expressed by groups and individuals from villages and districts who have heard about the pilot schemes but have not so far participated. Thus, there is potential for up-scaling to provide more villages the opportunity to develop CBF. CBF is sustainable by using a forecasting pack , which was produced in both Kiswahili and English to accompany training (Day *et al.* 2002).

Given the success of the forecasting methods, it is necessary to control the outbreaks that do occur in as environmentally safe a means as possible. Projects on the use of alternative pesticides (R6746, R7954, R8408) showed that *Spodoptera exempta* nuclear polyhedrosis virus (SpexNPV) was a successful agent but it takes longer (5 days) to be effective compared with synthetic insecticides (1 day). SpexNPV was shown to be effective when used with different application methods, from knapsack sprayers on small plots to aerial application over large areas, and was thus suitable for local control or strategic large scale control. The projects confirmed that it is a viable strategy in Tanzania to produce SpexNPV for armyworm control by spraying naturally-occurring armyworm outbreaks with an inoculating dose of SpexNPV and then harvesting the diseased larvae. The system for harvesting infected field populations still requires to be optimized but the strategy promises to enable Tanzania to control armyworm at a cost of 3-5 US$/ha in place of the current 16.5 US$. On the recommendation of the Tanzanian Plant protection advisory committee the government of Tanzania has adopted the use of SpexNPV as national policy.

4.3.1.3. Projects on Brown Locust

R7779 2000-2003 *Forecasting outbreaks of the brown locust in southern Africa*

Project R7779 (ZA0407) had no regional policy impact and little national impact. This was because although the research that would have allowed the development of a Brown Locust Information Support System (BLISS) was completed, a follow-on project that could have developed the system was not funded. However, the research has led to a proposal by the Plant Protection Research Institute (PPRI) to the South African National Department of Agriculture for the setting-up of a management and control centre to revise the national strategy for Brown Locust control in the light of the project's findings. These included a redefinition of the pest's outbreak area, which has shifted SW since the 1950s as it has become drier in the East and wetter in the West. The project showed that during the within-season development of a plague / large outbreak, only a small percentage of the total area may be suitable for breeding at any one time. As a result, throughout the season, the locusts are forced to make successive migrations to clumped resources scattered throughout the Karoo area in order to concentrate and breed. These findings have a policy implication regarding the time for which control resources need to be acquired before a plague / large outbreak and on the mobilisation of control teams during the breeding season.

4.3.1.4. Projects on Red Locust

R7818 2000-2003 *Development of biologically-based control strategies for environmentally sustainable control of red locust in Central and Southern Africa*

Outputs from project R7818 convinced the International Red Locust Control Organisation for Central and Southern Africa (IRLCO-CSA) and the Tanzanian and Zambian Governments that control with *Metarhizium* was the way forward for treatments against Red Locust in environmentally sensitive areas, although care with managing the danger of affecting non-target grasshopper populations in the wet season was needed. This consideration was minor in comparison with the potential damage that conventional pesticides could inflict on the non-target fauna, in line with the recommendations on *Metarhizium* to FAO by the pesticides referee panel. The project also enhanced Namibian, Tanzanian and Zambian national recognition of the importance of biodiversity and the conservation status of ecologically sensitive areas such as wetlands, where the impacts of locust control measures need to be reduced. The project outputs were of lesser importance for South African policies as Red Locusts do not present a major problem there and *Metarhizium* is inefficient against Brown Locusts because of temperature constraints.

4.3.1.5. Projects on Desert Locust

R6809 1997-1998 *Statistical analyses of locust movements and their determinants*
R6822 1996-1999 *Identification of the factors which lead to changes in desert locust populations at the beginning and end of recession periods.*

These projects did not lead to policy changes except insofar as they influenced how FAO uses databases such as SWARMS and RAMSES for desert locust forecasting, thereby enabling control operations to be planned and targeted with greater accuracy and enhancing the ability of national control units to increase or decrease their survey and control resources in response to forecasted locust population developments.

4.3.1.6. Projects on Senegalese Grasshopper

R5304 1990-1996 Oedaleus *diapause studies*
R6788 1997-2000 *Development of an outbreak forecasting tool for the Senegalese grasshopper,* Oedaleus senegalensis*, using satellite and ecological data.*

These projects improved understanding of the diapause mechanisms and conditions leading to outbreaks of this important Sahelian pest. They have impacted on control policies in the Sahelian countries. For instance *O. senegalensis* was not the cause of much damage during 2005 in Niger and this was attributed to poor mid-season reasons and so the Plant Protection Department was unconcerned by the pest at harvest time, knowing that it would not pose a problem. They were also monitoring sites where the grasshoppers were known to have laid in previous seasons, basing their activities on improved understanding of the pest's ecology as a result of the project's research on egg-pod predation and forecasting methods and its training activities in egg-pod prospection methods.

4.3.1.7. Projects on Red-billed Quelea

R6823 1996-1999 *Models of Quelea movements and improved control strategies*
R7967 2001-2003 *Forecasting movements and breeding of the Red-billed Quelea bird in southern Africa and improved control strategies*
R8314 2003-2005 *Quelea birds in southern Africa: protocols for environmental assessment of control and models for breeding forecasts*
R8426 2005-2006 *Early warning systems and training for improved quelea bird management in eastern and southern Africa*

The policy implications of the quelea projects (R6823, R7967, R8314 and R8426) concern forecasting and Environmental Impact Assessment (EIA). The ICOSAMP website has been used to disseminate outputs from the quelea forecasting model developed by the CPP projects and the *Guidelines for standardised protocols for monitoring effects of quelea control on non-target organisms* proposed as part of the project were approved by representatives of SADC countries attending an ICOSAMP workshop in Pretoria, 11-17 September 2005. An earlier version of these guidelines had also been approved by representatives of East African countries at a workshop on quelea management held in Kenya, 14-22 May 2005. This has also led to a proposal for EIA work on quelea from the Tanzanian Government. Environmental Impact Assessment (EIA) is now a requirement for any undertaking in Tanzania that affects the environment under Section 81 (1) of the Environmental Management Act No. 20 of 2004 which came into effect in July 2005. Aerial spraying, including against quelea, requires an EIA to be conducted as stipulated under Schedule 3 of the Act. Similarly, the National Environment Management Authorities (NEMA) in Kenya and Uganda have, since 2004, required EIAs of any new spray operations requested by commercial farmers.

4.3.1.8. Projects on Information systems

R7890 2001-2003 *Establishment of an information core for southern African migrant pests (ICOSAMP)*
R8315 2003-2005 *Establishment of satellite ICOSAMP systems and improved migrant pest reporting network*

Projects R7890, R8315 and R???? (ZA0698) involved the setting-up, expansion and dissemination of an information core for southern African migrant pests (ICOSAMP). ICOSAMP has had a major impact both on regional (at SADC and NEPAD) and national policies. The SADC-FANR Crop Development Unit commissioned consultants (S. Z. Sithole, W. Mwaikambo and M. T. C. Tarimo) to draft a Policy for Managing Migrant Pests and Larger Grain Borer in the SADC region that was presented to delegates at the SADC-FANR technical meeting held in Lesotho (29-30 November 2004). The meeting recommended various revisions. The draft was again discussed at the SADC-FANR technical meeting held in Maputo, Mozambique (14-15 November 2005) but has yet to be formally adopted. Section 11.4 of the draft document states the following for ICOSAMP: "SADC member states are thankful for the existence of ICOSAMP and the role it is playing in providing information on the activities of migrant pests as an early warning system. The role of ICOSAMP is pivotal to the management of migrant pests but as a donor funded project it will come to an end one day and when that happens SADC FANR is encouraged to ensure that services currently offered by the regional project continue. Discussion with ICOSAMP management made the mission to come up with the following:

- SADC FANR is encouraged to come up with a mechanism for ensuring that the role of ICOSAMP continues in the region even if it means relocating the project to the SADC secretariat.
- A regional scientist should be identified to understudy the current manager of ICOSAMP.
- A home for the ICOSAMP activities should be identified and preferably it should come under a SADC Plant Protection Desk (PPD) or SAPPO/SAMPCO to be established at the SADC Secretariat under the Crops Development Unit.
- The PPD would also be responsible for regional plant protection matters including SPS, food safety and pesticide management issues.
- Subject to availability of funds, the renewal of ICOSAMP project should be approved by the region."

Under Policy Recommendations, regional level policies recommended included the following: (a) "Continue supporting the efforts of ICOSAMP and facilitate its approval and extension. Investigate the possibility of bringing it under FANR responsibility." (b) "Harmonization of migrant pest forms for use during monitoring, reporting and control operations; adopting the format of ICOSAMP."

Other policy initiatives stemming from ICOSAMP include (a) SADC-FANR endorsing the idea of setting up a similar system to monitor the Larger Grain Borer (LGB) *Prostephanus truncatus*; (b) raising awareness on migrant pests throughout the SADC region; (c) stimulating re-instatement of national migrant pest systems e.g. re-start of Lesotho's armyworm monitoring system; (d) raising awareness on migrant pests at NEPAD; (e) enhancing the role of the International Red Locust Control Organisation for Central and Southern Africa (IRLCO-CSA) by disseminating its bulletins to a wider audience than the IRLCO-CSA membership; (f) building capacity on migrant pests in NARS through training and workshops: all collaborators have stated that new country-specific systems provided by ICOSAMP will help them to refine and improve data collection, thus assisting their Ministries of Agriculture to improve forecasting of outbreaks in their own country and ultimately in the SADC region; (g) stimulating cross-border collaboration by announcing early warnings of migrant pests about to invade other countries e.g. reports of Brown Locusts in Namibia led South Africa to conduct surveys in likely areas where the pests might occur in South Africa; (h) stimulating inter-regional collaboration: the CPP-funded Workshop on Quelea Management and Training Course on Environmental Impact Assessment of Quelea Bird Control held at Machakos, Kenya, 14-22 May 2005, endorsed the need for a system like ICOSAMP for migrant pests in the East African region.

4.3.1.9. Projects on Armoured Bush Cricket

R7428 1999-2002 *Biology and control of Armoured Bush Crickets in Southern Africa*
R8253 2002-2003 *Biology and control of Armoured Bush Crickets in Southern Africa*

The outputs of projects R7428 and R8253 included recommendations for the adoption of a control procedure involving the digging of trenches around infested fields and adding pesticide-laced baits to the trenches. There has been uptake of this technology as parts of national policy for control of armoured bush crickets in Botswana, Namibia, Zambia and Zimbabwe.

4.3.1.10. Projects on miscellaneous topics

R5270 1987-1996 *Production of microbial agents for insect pests*

R5306 1989-1996 *Preparation of an East African Grasshopper Taxonomic Handbook*
R5746CB 1992-1996 *Use of acylurea insect growth regulators for migratory pest control*
R7065 1998-2000 *Modelling the performance of barriers of insect growth regulator for locust and grasshopper control to maximise their efficiency and minimise their environmental effects.*

Project R5270 showed that the use of tissue culture methods for producing microbial pesticides using viruses is only economic for producing small batches of virus e.g. cloned lines, for research purposes and thus not an option for mass production of viruses for pest. Project R7065 led to the FAO group dealing with locust control (ECLO) to take up the concept of insect growth regulator (IGR) barriers and added diflubenzuron to their list of products considered for locust control.

4. 3.1.11. Data-bases

ICOSAMP maintains data-bases on dates, locations, densities, control data, a gazetteer and other topics on African Armyworm *Spodoptera exempta,* Red Locusts *Nomadacris septemfasciata*, Brown Locusts *Locustana pardalina*, African Migratory Locusts *Locusta migratoria*, the southern African Desert Locust *Schistocerca gregaria flaviventris* and Red-billed Quelea *Quelea quelea* reported within the SADC region from 2001 to the present. To date, it holds 2922 records with 889 on armyworm, 855 on locusts and 1178 on quelea. It also stores all its bulletins and maps, which are available on-line. A back-up of the data-set is sent to ECOPORT. In addition to the centrally maintained system, there are separate ICOSAMP data-bases that are country-specific and maintained in each of the 12 countries involved. A customised data-base using ICOSAMP software is being created for armyworm in Tanzania.

An electronic database of all quelea breeding records in southern Africa from 1836 to 1972 was collated using Microsoft Access software by project R6823 (Venn *et al.* 1999). The data-base includes data from Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe. The most useful information is available only from the early 1950s, detailing precisely located colonies where the dates of egg-laying are known but the data-base also contains details of dry-season roosts, control operations, and reported crop damage. The information was retrieved from the code used to create an earlier computerised version (on magnetic tapes but now lost) based on the *Quelea quelea* Questionnaires (see below). A folder with the coded output is held, together with the hard-copy version of the original paper archives (known as the COPR Quelea Bird Archive), at NRI but the archives are about to be lodged with the Sub-Department of Ornithology of the Natural History Museum at the Walter Rothschild Zoological Museum at Tring, Hertfordshire. The archive contains records of Quelea distribution, biology and control covering the period from around the 1900s to the 1970s collected during a 1970s project led by the late Dr Peter Ward. Information extracted from published and unpublished sources are stored in N-boxes as numbered documents. The number format is originating country or organisation and a sequential number e.g. Uganda 1 to 20. Documents also have a unique Archive Number (1-968). There are document and archive number lists and an alphabetical author index. There is also a subject index to the documents. Geographically based information was extracted onto 2 x 80 column cards called *Quelea quelea* Questionnaires for computer mapping. Topics on the questionnaire cards are: archive number; questionnaire number; report reliability; location; date; population size (area) sample number; activity; vegetation at roost or collony; ringing & recovery details; damage; control measures; control results.

An EXCEL file containing data on quelea records in southern Africa up-dated to include information up to 2005 is currently held at NRI with a back-up copy lodged with ICOSAMP. The quelea breeding forecasts produced by this project and its predecessors are archived on the internet at http://www-web.gre.ac.uk/directory/NRI/quel/Index.htm.

The COPR locust archives (paper records) have already been transferred to the Natural History Museum, with funding from DFID. The archives are currently held at the Museum's Wandsworth store (contact Julie Harvey, telephone 020 7942 5241 email: j.harvey@nhm.ac.uk). The Locust Archive contains records that a predecessor of the Natural Resources Institute was authorised to hold, map and archive on behalf of locust affected countries at the 1931 and 1932 Locust Conferences. In 1978 this task passed to FAO. The main holding is the reports of locust sightings and their control from the earliest records until the 1980s. The bulk of the material is from the1920s to 1980s. These data with the associated weather records were used to analyse and forecast locust developments, plan and formulate anti-locust campaigns and policies. The archive also contains reference material produced by and used in studying the population dynamics and geographical distribution of locusts and to formulate control policies.

This unique collection is unmatched in the world. Locust reports are stored alphabetically by originating country or organization. Associated maps are stored by geographical region.

The archive contains original material covering the following topics:

(a) reports of locust sightings and control campaigns from affected countries;

(b) registers and indexes of affected country reports and of published source of locust distribution and catalogues of archived maps;

(c) locust officers' field reports and diaries;

(d) monthly maps of Desert Locust infestations plotted onto topographical maps (1:1-1:5 million) and summarized onto smaller scale maps.

(e) similar maps of other locust species (Red, Migratory and Tree Locusts);

(f) monthly rainfall, temperature maps and daily synoptic charts for Africa and southwest Asia;

(g) monthly Desert Locust situation reports and forecasts, 1943-1973 sent to affected countries and subsequently received from FAO

There are over 200ft of desert locust sighting records. Physically the records comprise a series of open ended box files which contain manila envelopes inside which are folders containing a variety of loose paper. Many of the individual papers date back to the 1920s and 1930s and are extremely brittle and ragged at the edges. They also contain staples or pins which are rusting. The associated indexes are mainly housed in metal cabinets. The indexes to published records are shelved in folders. The maps of locust sightings, rainfall and synoptic charts for the Desert Locust area are stored in metal plan presses; most are horizontal presses some smaller scale maps are in upright presses. Other locust material, reference documents and published daily weather maps, climate statistics are filed, stored or shelved as appropriate.

Films of locusts and locust swarms taken during this period were officially handed to the National Film and Television Archive in 1996. The Anti-Locust Research Institute's specimen collection of Locust and other migratory pests from Africa and southwest Asia were officially handed over to the Natural History Museum in the mid 1990s.

A companion data-base on African armyworm comprising 3 filing cabinets of records/reports, indexes, maps, and photographic records relating to armyworm outbreaks and moth trap counts in eastern and southern Africa from about 1967 until 2002 has been lodged with Dr Ken Wilson, Department of Biological Sciences, Lancaster University, Lancaster LA1 4YQ, United Kingdom, Tel/Fax area codes: 01524 (UK); +44 1524 (Int), Direct: 593349 (Office), 593406 (Lab), Email:

ken.wilson@lancaster.ac.uk; Webpage: http://biol.lancs.ac.uk/erg/ecology.htm). Dr Wilson has suggested (pers. comm. to RAC, 3 February 2006) that it might be appropriate for this material to be transferred to the NHM in due course as well. Armyworm data from East Africa derived from this archive were collated into a DOS-based electronic system known as WORMBASE. This was distributed to most armyworm-affected countries including Malawi, Zambia and Zimbabwe and, provided computers with DOS still function in the various countries, the data should still be accessible. A limited attempt was made to convert WORMBASE to a WINDOWS-based system running in Microsoft ACCESS in which project R7966 developed an ACCESS system for Tanzania. This was capable of displaying all the data relevant for a particular week and location (district) such that the forecaster could make the forecast by viewing rainfall, satellite and moth catch data all at once. The Tanzanian armyworm archive is now being transferred into ACCESS using software developed under the ICOSAMP project.

4. 3.1.12. Migrant pests and climate change

All migrant pests are dependent on rainfall and will thus be likely to increase or decrease in their severity regarding crop damage as the climate changes. It is now generally accepted that anthropogenic factors are causing the generation of "greenhouse gases" such as carbon dioxide, which are leading to global warming. The effects of climate change on the ecology of southern Africa are predicted to lead to increased frequencies of drought and greater variability in rainfall patterns. There has already been a 20% decline in summer rainfall over southern Africa between 1950 and 1999, but it is not only the quantity but also the timing and spatial distribution of rainfall that will affect migrant pests. Given that the CPP-funded projects on migrant pests have made considerable progress in establishing the rainfall patterns responsible for outbreaks of armyworm, quelea and locusts, their results will be useful for assisting policy decisions in relation to predictions of different climate change scenarios.

4.3.1.13. Policy initiatives to enhance agricultural productivity by migrant pest management.

The above review has shown that migrant pest policy initiatives have been achieved in the Africa with respect to (A) Establishment of regional information and forecasting systems; (B) use of biopesticides (Red Locust and African Armyworm); (C) international (Red-billed Quelea), national (Brown Locust, African Armyworm) and community-based forecasting (African armyworm); (D) recognition of the need for environmental impact assessments of control and regional adoption of appropriate guidelines (Red-billed Quelea); (E) FAO adoption of the concept of insect growth regulator [IGR] barriers (locusts); (F) adoption a trench-digging control method (armoured bush cricket) and (G) ecologically-based monitoring approaches (Senegalese grasshopper). Other policy initiatives to enhance agricultural productivity to be considered regionally include: (H) formulation of policies in relation to effects of impending climate change on migrant pests and how they could affect changing agricultural scenarios; (I) policies on intra-regional and inter-regional collaboration; (J) policies on early-warning systems and (K) policies on risk management.

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6. Dissemination Outputs

Publications

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FLEISCHER, R. C., REED, J. L., BEADELL, J., DURRANT, K., JONES, P. J., DALLIMER, M., CHEKE, R.A. & MCWILLIAM, A. N. (2005) Prevalence and phylogeography of avian blood parasite lineages in *Quelea quelea.* Abstract of poster presented at 123rd. meeting of the American Ornithologists' Union, University of California, Santa Barbara, U.S.A., 23-27 August 2005.

Papers in advanced stages of preparation:

Todd, M., Kniveton, D., Cheke, R. A., Venn, J. F., & Jones, P. J. (to be submitted in early 2006) Variability of annual breeding records of the red-billed quelea bird *Quelea quelea lathamii* in southern Africa and relationships with climatic data. *Journal of Applied Ecology*

Venn, J. F., Cheke, R. A. & Jones, P. J. (to be submitted in early 2006) Forecasting breeding opportunities for the Red-billed Quelea *Quelea quelea* in southern Africa. *Journal of Applied Ecology*

Internal reports

Cheke, R. A. (2005) Back-to-office-report: Visit to Kenya 14 May 2005 to 22 May 2005 to facilitate Workshop on Quelea Management and run Training Course on Environmental Impact Assessment of Quelea Bird Control. Unpublished report to CPP.

Cheke, R. A. (2005) Back-to-office-report: Visit to South Africa 11-17 September 2005 to participate in Workshop on Migrant Pest Identification and Control Management. Unpublished report to CPP.

Cheke, R. A. (2005) Back-to-office-report: Visit to South Africa 19-26 November 2005 to gather information on impact on policies of CPP migrant pest projects. Unpublished report to CPP.

Other Dissemination of Results
Model outputs on website (http://www-eb.gre.ac.uk/directory/NRI/quel/Index.htm)

Listing and reference to key datasets generated:
See section 4. 3.1.11.

7. Contribution of Outputs to developmental impact

As migrant pest control is the responsibility of governments in nearly all circumstances, outputs on migrant pests benefit the poor via their influence on national, international and regional forecasting and control organisations rather than through direct uptake by farmers. It is thus not possible to enumerate the numbers of farmers affected other than by quoting the totality of farmers potentially affected by locusts, armyworms and quelea birds. The numbers actually affected vary from year to year. However, the sensitisation and technology transfer concerning environmental impact assessment and forecasting of quelea birds reached representatives of 4 regional organisations (SADC, DLCO-EA, IRLCO-CSA and ICOSAMP) and 16 countries (Angola, Botswana, Democratic Republic of the Congo, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe). In addition, NEPAD was briefed on the work of the project and of ICOSAMP. The increased environmental awareness of plant protection staff in the SADC and East African regions will lead to (a) fewer decisions to control e.g. where concentrations of non-targets such as storks are present or where the local population will undertake their own control by harvesting quelea colonies; (b) more efficient control and more concern to avoid non-target fatalities and pollution; (c) reduced pollution and (d) enhanced capacity in scientific methods. The quelea forecasting model will lead to better decision-making regarding control with respect to targeting and timing of control actions and with preparedness for control operations and hence more efficient control and reduced crop loss.

There is potential for wide scale impact by further involving the East African region and for establishing links with the West African region. East African country representatives endorsed the idea of expanding ICOSAMP and quelea forecasting into their region, and there is also potential for uptake of quelea forecasting and EIA work in West Africa, affected by the nominate subspecies *Quelea quelea quelea*.

Follow-up work to establish and validate the East African forecasting system and link it with DLCO-EA control operations would be worthwhile. The EIA guidelines and further research on environmentally safe measures for quelea control (e.g. harvesting) and on impact mitigation could be up-scaled throughout sub-Saharan Africa.

8. Acknowledgements

We are grateful to the Crop Protection Programme of DFID for supporting this project and its predecessors. Joseph Ndege and DLCO-EA are thanked for their major roles in the organisation of the workshop in Machakos. M. E. Kieser provided invaluable support and assistance on behalf of ICOSAMP at the Kenya Workshop and during RAC's two visits to South Africa in 2005. The project is also indebted to all other collaborators and participants at the two workshops (on Quelea in Kenya and on ICOSAMP in South Africa) for their enthusiasm and commitment. Dr J. F. Venn wrote the software for the model developments. Dr J. Holt provided information and advice on armyworm. Dr J. I. Magor and H. McEvoy-Marshall supplied information on the locust and quelea archives.

Figure 4.2.1. Output form the East African model for the week ending 4 December 2005, showing areas where breeding would be possible in countries including Kenya, Uganda, Sudan, Tanzania and the Democratic Republic of Congo.

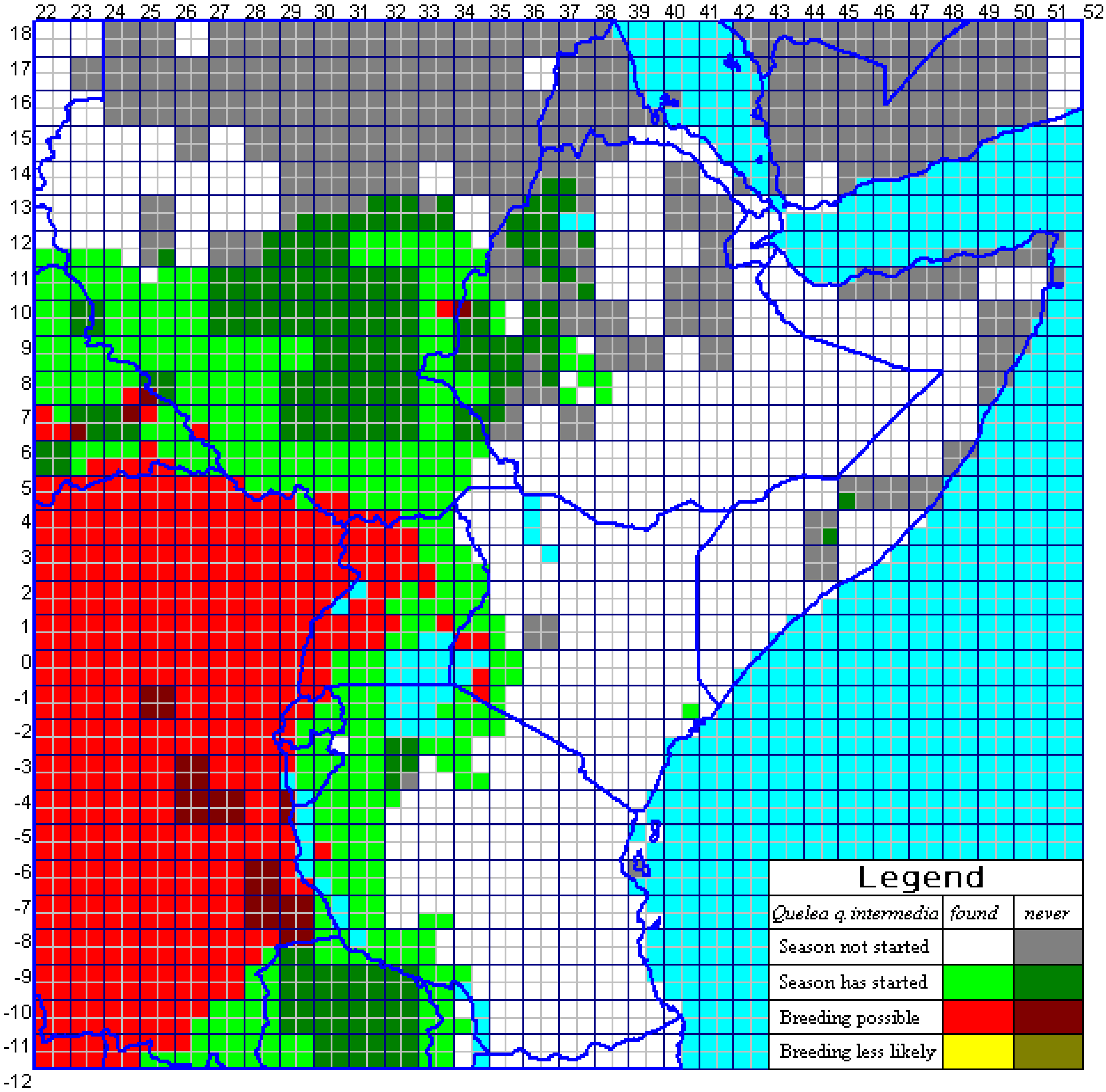

TABLE 4.1. 1.

WORKSHOP ON QUELEA MANAGEMENT AND TRAINING COURSE ON FORECASTING AND ENVIRONMENTAL IMPACT ASSESSMENT OF QUELEA CONTROL.

16 – 20 May 2005. The Garden Hotel, Machakos, Kenya

Programme

Sunday 15 May
Delegates arrive and travel to venue

Monday 16 May

WORKSHOP ON QUELEA MANAGEMENT

0900 Introduction.
Recent work on quelea management in southern Africa

1030 Coffee break

1130 The Information Core for Southern African Migrant Pests (ICOSAMP) project. Presentation by M.E.Kieser

1230-1400 Lunch break

1400-1600 Country reports by each delegate
Eritrea, Ethiopia, Kenya, Sudan, Tanzania, Uganda, Zimbabwe, DLCO-EA

Discussion on problems, needs and possible improvements to current means of controlling breeding colonies and roosts.

Tuesday 17 May

TRAINING COURSE ON FORECASTING AND ENVIRONMENTAL IMPACT ASSESSMENT OF QUELEA CONTROL

0900 Introduction
Aims of the Course
Introduction to EIA and Toxicology

1100 Coffee break

1130 Video (1 Hour)

1230-1400 Lunch break

1400-1600 Introduction to the Ecological Monitoring Methods Manual
Planning and programme design
Study Design: Sampling, randomisation, pseudo-replication and data analysis

Wednesday 18 May
0900 Survey methods: terrestrial invertebrates
Survey methods: vertebrates
Birds, amphibians and reptiles
Recording environmental parameters
Introduction to the afternoon’s practical sessions

1400-1600 Practical
Vegetative cover and shade
Residue Sampling
Vertebrates:
Visual encounter surveying: amphibians and reptiles
Complete species inventories: amphibians and reptiles
Quadrat and transect block micro-habitat sampling
Birds: Timed point counts and Transect counts

Thursday 19 May

0800 Safety

1015 Coffee break

1100-1130 Acetylcholinesterase kits and recent EIA results

1230-1400 Lunch break

1400-1600 Models, Rainfall & Forecasting

Friday 20 May

0800 Quelea EIA (Discussion of published paper on Quelea EIA)
Protocols for EIA of Quelea control operations

1100-1230 Information on priorities for quelea bird management in Africa. Delegates views

1230-1400 Lunch break

1400 Delegates disperse to Nairobi

Saturday 21 May

Delegates depart

Table 4.1. 2

Environmental Impact Assessment Training Course

Please rate your knowledge and experience of the following topics as either:

A: *EXCELLENT*; B: *VERY GOOD*; C: *GOOD*; D: *POOR*: E: *NIL*

1. ENVIRONMENTAL IMPACT ASSESSMENT IN GENERAL

2. ENVIRONMENTAL IMPACT ASSESSMENT OF QUELEA BIRDS

3. CONTROL OPERATIONS

4. CONTROL OF QUELEA BIRDS WITH QUELETOX

5. CONTROL OF QUELEA BIRDS WITH EXPLOSIVES

6. IDENTIFICATION OF MAMMALS

7. IDENTIFICATION OF BIRDS

8. IDENTIFICATION OF INSECTS

9. ANIMAL POPULATION MONITORING

10. VEGETATION SURVEYS

11. DO YOU HAVE ACCESS TO A COMPUTER WITH INTERNET ACCESS (A) DAILY (B) OFTEN (C) OCCASIONALLY (D) NEVER?

12. DO YOU HAVE ACCESS TO A COMPUTER WITHOUT INTERNET ACCESS (A) DAILY (B) OFTEN (C) OCCASIONALLY (D) NEVER?

Table 4.1. 3.

UNIVERSITY OF GREENWICH AT Medway

Natural Resources Institute

Course Evaluation Form

Course title: FORECASTING AND ENVIRONMENTAL IMPACT ASSESSMENT OF QUELEA CONTROL **Course Leader**: Robert A. Cheke	Instructions: Using the headings as a guide, please comment on the course. It would help us if you could include positive points as well as negative points or areas for improvement. Please continue over the page if necessary.
1. Facilities (i.e. teaching room, accommodation)	
2. General communication (ease of contacting and speaking to lecturers, general presentation of course material etc)	
3. Organisation of course	
4. Intellectual challenge of the course	
5. Visual aids	
6. Overall quality of course and any additional comments	
7. After the course has your understanding of Environmental Impact assessment improved (a) not at all; (b) a little; (c) a lot; (d) substantially or (e) enormously?	
8. After completing the course has your confidence in being able to conduct an Environmental Impact assessment of Quelea bird control been enhanced (a) not at all; (b) a little; (c) a lot; (d) very substantially or (e) enormously.	

Table 4.1. 4

Certificate of attendance at the meeting

DFID Department for International Development

CPP

Natural Resources Institute

CERTIFICATE OF ATTENDANCE

I hereby certify that
attended the

Workshop on Quelea Management and a Training Course on the Forecasting and Environmental Impact Assessment of Quelea control

held at the Garden Hotel, Machakos, Kenya from 16 to 21 May 2005.

Professor Robert A. Cheke
Workshop Convenor and Course Facilitator

Machakos, 20 May 2005

Table 4.1. 5. List of delegates and their contact details

ADDRESSES OF PARTICIPANTS TO QUELEA MANAGEMENT & TRAINING COURSE ON FORECASTING & ENVIRONMENTAL IMPACT ASSESSMENT OF QUELEA CONTROL,

GARDEN HOTEL, MACHAKOS, KENYA
16 - 20TH MAY 2005

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MOSES MUWANIKA MAFABI SENIOR AGRICULTURAL INSPECTOR (VERTEBRATE TAXONOMY)	CROP PROTECTION DEPARTMENT P.O. BOX 102 ENTEBBE TEL: 256 41 322 610 CELL PHONE: 256 71 528 574 EMAIL: mmmafabi@yahoo.co.uk
RICHARD N. MAGOMA PRINCIPAL AGRICULTURAL OFFICER	MINISTRY OF AGRICULTURE & FOOD SECURITY (PLANT HEALTH SERVICES) P.O. BOX 9071 DAR ES SALAAM TEL: 255 2 286 5642 FAX: 255 2 286 5642 EMAIL: rnmagoma@yahoo.co.uk

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FATIMA MOHAMED ELAMIN MUSA HEAD OF VERTEBRATE PEST SECTION	VERTEBRATE PEST SECTION PLANT PROTECTION DIRECTORATE MINISTRY OF AGRICULTURE & FOREST P.O. BOX 14 KHARTOUM NORTH TEL: 091 825 6422
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Table 4.1. 6.
Standardised protocols for monitoring effects of quelea control on non-target organisms. **REVISED AFTER DISCUSSION AT ICOSAMP MEETING, PRETORIA, 12-16 September 2005.**

RECOMMENDED MONITORING PROTOCOLS

1. Control decision
A decision by the delegated authority to undertake control operations against a particular colony or roost should not be taken lightly. If the birds are not threatening any crop (e.g. they are only feeding on grass seeds and/or insects), then there is little justification for control. Spraying should preferably not take place where habitation, livestock, bee-hives, water or environmentally sensitive areas (e.g. areas of conservation concern) could be affected. In such circumstances the possible use of explosions or other alternative methods could be considered.

2. Safety
Personnel must not enter after explosions until instructed that it is safe to do so and preferably avoid sprayed zones for three days. Before entering a recently sprayed zone, personnel should wear protective clothing (overalls, masks, goggles, rubber boots, nitrile rubber gloves), although. First aid training should be provided and emergency kits including atropine sulphate available. Checks should be made on procedures adopted for removal and safe disposal of contaminated pesticide containers. Warnings must be issued to people to ensure that they and their livestock are absent from the target site well before any explosion or spraying operation.

3. EIA decision
A decision on which of the methods listed below or of any other suitable alternative techniques will be used, must be made at the outset. This will depend upon available man-power, their expertise, time constraints and resource considerations.

4. Habitat description, vegetation survey and monitoring procedure. A map with GPS coordinates and description of the affected area should be made as detailed as possible in relation to time and labour constraints. A digital photographic record should be kept of habitat and sampling sites. A decision should be made whether to compare untreated sites with ecologically equivalent treated areas or to do before and after investigations at the same site.

5. Sampling soil for levels of pesticides (to be repeated before and after control applications and at intervals after control, if possible, or involving comparison of uncontrolled sites with ecologically equivalent treated areas)
5.1. Sampling. Select about five widely spaced sampling sites per contaminated area (both before and after control) and collect at least 4 random soil samples at each of the five sites. Samples to consist of 100-1000g from the top 0-20cm of soil and to be placed in clean cloth bags for air drying. Number and label each sample and record location of each sample with GPS. Procedures can be modified to accommodate laboratory requirements.

5.2. Preserving. Air-dry the soil in the bags in shade to reduce the moisture content until the samples are dry and friable. As close as possible to the time of analysis, remove stones and vegetation and pass each sample through a 2-4mm sieve as an aid to homogenisation. Take two sub-samples of 100g from the mixture, store in labelled aluminium containers or foil for analysis. If using the latter, double wrap the foil and label the external layer with sample details. A separate check-list detailing all the samples should be sent with the samples to the analytical laboratory. Maintain samples deep-frozen as cold as possible (-20) until analysis. All sampling equipment should be washed with 50/50 solution of hexane-acetone or dichloromethane.

6. Vegetation sampling
6.1. Sampling. Select at least three widely spaced sampling sites per contaminated area (both before and after control) and mark 3 randomly chosen sample points at each site with numbered stakes. Take position of sites with GPS. Collect vegetation before spraying, immediately after spraying, on days 1,

3, 7, 14 and if possible on day 28 post-spray. Leaves, branches and grass samples need to be collected separately. Samples to consist of 100g randomly cut from the top 10cm of cover (or appropriate alternative in tall vegetation or after ground-spraying operations) at the three sample points in each of the three sites. Place immediately in labelled aluminium foil. Deliberately contaminate one of the three unsprayed samples collected from each site with a known amount of the pesticide being used to determine percentage recovery of the pesticide following storage.
6.2. Preserving. Specimens should be kept cool until analysis.

7. Assessment of changes in insect populations

7.1. Sweep-netting. Mark out 5 x 100 m transects spaced equally at least 100m apart within the centre of control and experimental plots, then take 20 'standard' sweeps at roughly 5m intervals for each transect. This should be performed by the same worker on all occasions to reduce bias in sweep rates and capture efficiencies. The contents of the nets should be transferred to strong, sealed polythene bags at the end of each transect. Insects should then be sorted from debris and preserved in 70% alcohol for subsequent counting and identification. To detect short term effects, pre-spray sampling needs to be carried out on a minimum of three separate days before pesticide application and at least on days 1, 3, 7 after spraying and preferably on days 10 and 14 as well. Monthly sampling over an annual cycle would be required to make an assessment of long-term impact of a one-off control operation.

7.2. Malaise Traps. Place a minimum of 3 malaise traps (to assess within treatment variability) at least 100m apart within the middle of both treated and control blocks. Orientation should be at right angles to the prevailing wind. The collection bottle can be half filled with 5% formalin as a killing and preserving agent, to which is added a drop of detergent and some glycerol to reduce surface tension and evaporation respectively. Catches should be collected and containers recharged every 24 hours, preferably in the early morning, and insects transferred to 70% alcohol for later identification in a laboratory.

7.3. Pitfall traps. Using random numbers or stratified sampling, select 20-50 points for positioning pitfall traps at least 35m apart. Dig a hole in the ground with a trowel or spade and sink a portion of a plastic drainpipe such that it stands vertically and so that the top is just below the soil surface and firm it into place well. Mark the outside of the trap container with the site number and trap number and the date. Slip the trap container into the drainpipe and half fill with preserving fluid. Smooth the soil around the lip of the trap so that there is a slight slope down to the trap and that there are no obstructions (e.g. the lip of the trap, etc.) impeding the invertebrates from falling into the trap. Cover with a shade board. Mark the position of the trap with a marker flag placed nearby or note a nearby landmark (termite mound, bush, tree, etc.). The trapping period must be the same for all sample sites.

8. Assessments of changes in bird populations

8.1. Transects conducted on foot. Use timed bird counts and transect methods before and after spraying, with timed counts interspersed along a series of at least 5 transects of at least 100m in length each, if possible. The times and lengths of transects may be varied in relation to the resources available and the size of the colony or roost. If time permits, then comparisons should be made between a control area and the zone to be treated when two 1km transects should be marked at least 500m apart in the middle of both control and experimental blocks. Maintain a slow fifty-minute walk for each transect by covering 100m sections in 5 minutes at a uniform pace and record all birds seen or heard within 50m of the path. Counts to be done by the same observer on a daily basis in the early morning, alternating between replicate transects on a daily basis.

8.2. Transects conducted by vehicle. If very large colonies or roosts are involved, this method may be used to record all birds seen or heard within a 5 minute period and within 100m of the vehicle at sample points separated by 500m along replicate tracks of at least 5km in length.

9. Assessments of mammal populations

9.1. Bat populations can be assessed using bat detectors and small mammal populations can be estimated as part of before or after trapping studies but interpretations of such results may be difficult due to trap-shyness etc.

10. Carcass searches

These are required to measure direct mortality of vertebrates from pesticide application within treated blocks and require as many observers as possible. It is suggested that at least 10 people walk abreast 10m apart for a minimum of 1 km in swaths including the middle of both control and sprayed blocks, 24 hours, 48 hours and if possible 72 hours after treatment. Any carcasses found should be labelled and geographically recorded, placed in aluminium foil and frozen (-20 or as cold as possible) for subsequent residue analysis following identification. A record should be kept of search effort in man-hours.

11. Clearing-up

Dead and dying quelea and other carcasses should be removed from sprayed sites to prevent secondary poisoning of non-targets and buried or burnt at a safe site. Plastic containers and other material used for control with explosives should be collected, removed from the site and disposed of safely via burning or burying.

12. Pre- and post-control scaring of non-target animals.

Non-target animals, particularly raptors, should be scared from colonies before control and kept away for three days following treatment while residue levels decline and carcasses are collected. Beaters, gas cannons, or other methods could be used to disturb reed beds containing water birds and other species during the late afternoon before aerial spraying begins, and spray aircraft can conduct dummy runs to frighten non-targets away.

13. Reporting

Results of the EIAs conducted must be described in reports that can be made available for other investigators. This could be achieved by posting them on websites or information networks such as those maintained by relevant authorities e.g. National Environmental Councils, the International Red Locust Control Organisation for Central and Southern Africa (IRLCO-CSA), the Desert Locust Control Organisation for Eastern Africa (DLCO-EA), the Information Core for Southern African Migrant Pests (ICOSAMP), and the Southern African Development Community (SADC).

11. Biometrician’s Signature

The projects named biometrician must sign off the Final Technical Report before it is submitted to CPP. This can either be done by the projects named biometrician signing in the space provided below, or by a letter or email from the named biometrician accompanying the Final Technical Report submitted to CPP. (Please note that NR International reserves the right to retain the final quarter’s payment pending NR International’s receipt and approval of the Final Technical Report, duly signed by the project’s biometrician)

I confirm that the biometric issues have been adequately addressed in the Final Technical Report:

Signature:
Name (typed):
Position:
Date: