Weekly forecasts help prevent birds damaging crops

RIU

Validated RNRRS Output.

Weekly forecasts now warn pest managers in Botswana, Mozambique, Namibia, South Africa, Swaziland and Zimbabwe where and when to expect bird pests. They can then take action to control them and tip off farmers to protect their crops. The Red-billed Quelea devastates millet and sorghum crops throughout southern Africa. The birds migrate long distances to feed on grass seeds, so their migrations follow rains with a predictable time lag. Every week, a map posted on the internet shows where the bird pest season hasn't yet begun, where there's been enough rain to prompt the first migrations, where queleas could breed and where the season is ending. These forecasts have proved so successful that national crop protection teams all over southern Africa now use them.

Project Ref: **CPP41:**
Topic: **7. Spreading the Word: Knowledge Management & Dissemination**
Lead Organisation: **Natural Resources Institute (NRI), UK**
Source: **Crop Protection Programme**

Document Contents:

Description

CPP41

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

Botswana, Kenya, Mozambique, Namibia, South Africa, Swaziland, Zimbabwe,

Target Audiences for this content:

Crop farmers,

A. Description of the research output(s)

1. Working title of output or cluster of outputs.
In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

Title:
Medium- and short-term spatio-temporal forecasting of likely breeding areas for the Red-billed Quelea

Working title:
Quelea early warning systems (QUEWS)

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Crop Protection Programme

The activity received funds (1996 onwards) directly from DFID (R6823, R7967, R8314, R8426) and was collaborative with the ICOSAMP project (R7890, R8315).

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RIUP activities.

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*

Associated projects:
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*

Associated Programme Development / dissemination
1999-2000 *Migrant pest workshop (NRInt. Refs. ZA0274 & ZA0336)*
2002 *Presentation of paper, assistance with Planning of & Attendance at 2nd ICOSAMP Meeting, South Africa, April 2002 (NRInt. Ref. ZA0497)*
2002 *Southern Hemisphere Ornithological Congress (SHOC), Brisbane, Australia, 27 June - 2 July (NRInt. Ref. ZA0391*)
2003 *Submission of two papers on quelea birds, Jan-March 2003 (NRInt. Ref. ZA0554)*

2004 *Presentation of papers: grasshopper/locust, red-billed quelea birds International Plant Protection Congress, China 11-16 May 2004 (NRInt. Ref. ZA0555)*

Lead Institute: **The Natural Resources Institute**, University of Greenwich at Medway, Central Avenue, Chatham Maritime, Kent, ME4 4TB, UK

Lead person: **Prof. Robert A. Cheke**
Email: r.a.cheke@gre.ac.uk; Tel.: +44 (0)1634 883229
Fax.: +44 (0)1634 883379

Main partner institutions:

Botswana
(1) Department of Crop Production and Forestry, Ministry of Agriculture, Private Bag 003, Gaborone, Botswana. Contact person: M. Modise. Email: molmodise@yahoo.co.uk; MolModise@gov.bw.

Mozambique
(2) Ministerio da Agricultura, Direccao Nacional de Agricultura, Departamento de Sanidade Vegetal, C.P. 3658, Maputo, Mozambique. Contact person: Nicolau Faduca Madogolele. Email: nicofamadogolele@yahoo.com.br

Namibia
(3) Ministry of Agriculture, Water & Forestry, Private Bag X13184, Windhoek, Namibia. Contact person: Paulina Shiyelekeni. Email: Shiyelekenip@mawrd.gov.na

South Africa
(4) ARC Plant Protection Research Institute, Private Bag X134, Pretoria 0001, Republic of South Africa. Contact person: Margaret Kieser. Email: KieserM@arc.agric.za

(5) National Dept of Agriculture, Directorate of Land Use & Soil Management, P/Bag X120, Pretoria 0001, Republic of South Africa, Contact person: Mr Luka Geertsema. Email: lukag@nda.agric.za.

Swaziland
(6) Plant Protection Extension Unit, The Ministry of Agriculture & Co-operatives, P.O. Box 501, Manzini M200, Swaziland. Contact person: Boniface Makhubu. Email: hortcrops@africaonline.co.sz

United Kingdom
(10) University of Edinburgh : Institute of Evolutionary Biology (Ashworth Laboratories),University of Edinburgh, The King's Buildings, Edinburgh EH9 3JT Contact person: Dr P. J. Jones. Email: p.j.jones@ed.ac.uk

(11) University of London: Dept of Geography, University College, University of London, 26 Bedford Way, London WC1 8HR Contact person: Dr. Martin Todd. Email: m.todd@geog.ucl.ac.uk rietmek@plant2.agric.za

(12) University of Sussex, School of Chemistry, Physics and Environmental Sciences, Falmer, Brighton, BN1 9SJ Contact person: Dr. Dominic Kniveton. Email: d.r.kniveton@sussex.ac.uk

Zimbabwe
Plant Protection Research Institute, Department of Entomology, P.O.Box CY550, Causeway, Harare, Contact person: Dr G. Chikwenhere. Email: plantpro@ecoweb.co.zw

International Organizations
(7) Desert Locust Control Organisation for East Africa (DLCO-EA), P.O.Box 30023, Nairobi, Kenya Contact person: Joseph Ndege. Email:rietmek@plant2.agric.za ndege@wananchi.com

(8) Food and Agriculture Organization of the United Nations (FAO), Italy. Contact person: Peter Kenmore. Email: Peter.Kenmore@fao.org

(9) International Red Locust Control Organisation for Central and Southern Africa (IRLCO-CSA), P.O. Box 240252, Ndola, Zambia. Contact person: John Katheru Ngondi. Email: locust@zamnet.zm

4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? ***(max. 400 words)****. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

The Red-billed **Quelea** *Quelea quelea* is a major pest of subsistence agriculture in semi-arid areas throughout sub-Saharan Africa. The birds devastate millet and sorghum fields of subsistence farmers and attack wheat and rice produced commercially, causing up to US$70 million worth of damage per annum. The Red-billed Quelea, the most numerous land bird in the world (population 1,500 million), is a long distance (up to 3000 km) migrant. The birds migrate in response to rainfall and the availability of seeds of annual grasses. Queleas breed and roost communally at sites providing targets for control with avicides or destruction with explosives. In South Africa alone there is an annual average of 173 control operations killing c.50 million birds.

Hitherto, pest managers did not know where and when to expect queleas to appear and so when crops were threatened they were unprepared. Project technologies forecast (a) in the medium-term (three months) the likelihood of high populations of quelea occurring and (b) in the short-term (one month) the places and times of **breeding** opportunities. The outputs, developed through projects starting in 1996 [R6823, R7967, R8314 & R8426], can be divided into three processes and two technologies [**data-base** and short-term **forecasting model**]:

- *Data collation*: An electronic data-base of quelea occurrences in southern Africa from 1834 to 1974 was created in 1999. Data on breeding colonies reported in southern Africa since 1974 were collated.
- *Development of models*: The model was designed from knowledge of quelea biology in 1998 and programmed in 2000 using automated systems recording satellite-derived rainfall. Effort was concentrated on a model for southern Africa but a prototype model for eastern Africa was also developed.

Ø *Model* ***Validation****:* Outputs using different algorithms were compared with data from the field and the most successful ones adopted. The southern Africa model was validated by analyses of model predictions in relation to the times and places of reported quelea colonies, 2000-2005.

Ø *Short-term Forecasting model:* From Sept 2000 to date a weekly map was provided showing where (a) the season has not yet started; (b) sufficient rain has fallen for the first migrations to be stimulated; (c) where queleas could breed and (d) where the season was ending and new colonies were unlikely but breeding could still be in progress. Means for users to refine the forecasts were made available on the **website** as maps of known breeding areas, river systems and soil types.

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	***Technology***	***Service***	***Process or Methodology***	***Policy***	***Other Please specify***
	X	X	X		

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

Main commodity: Small-grain cereals (grain sorghum *Sorghum bicolor,* millet *Panicum miliaceum,* bullrush millet *Pennisetum typhoides*, finger millet *Eleusine coracana* and Italian millet *Setaria italica*) and rice *Oryza sativa*.

Quelea birds are also major pests of wheat *Triticum* sp. and attack oats *Avena aestiva*, barley *Hordeum disticum*, buckwheat *Phagopyrum esculentum*, manna *Setaria italica*, triticale (hybrid between wheat and rye *Secale cereale*), teff *Eragrostis tef* and sunflower *Helianthus annuus*. Therefore the output could be applied to these commodities e.g. rice (Chad, Kenya, Malawi, Mali, Mozambique, Senegal and Tanzania), wheat (Ethiopia, Kenya, Sudan, Tanzania) and teff (Ethiopia).

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	***High potential***	***Hillsides***	***Forest-Agriculture***	***Peri-urban***	***Land water***	***Tropical moist forest***	***Cross-cutting***
X	X				X		X

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	***Irrigated***	***Wetland rice based***	***Smallholder rainfed highland***	***Smallholder rainfed dry/cold***	***Dualistic***	***Coastal artisanal fishing***
	X			X		

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**).*

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

Value could be added to the output by clustering it with those of other migrant pest projects, in particular those dealing with the forecasting of armyworms and locusts. A possible 'migrant pest' cluster could include Quelea (R8426, R7967, R6823, R8314), Brown Locust *Locustana pardalina* (R7779), Red Locust *Nomadacris septemfasciata* (R7818), Desert Locust *Schistocerca gregaria* (R6809, R6822), Senegalese Grasshopper *Oedaleus senegalensis* (R6788), Community-based Armyworm Forecasting (CBAF, R8407/R7966/R6762), Novel control of armyworm (R8408), ICOSAMP (R8315, R7890), Armoured Bush Cricket (ABC; R8253, R7428) and Larger Grain Borer *Prostephanus truncatus* (LGB; R7486,R6684). ABC and LGB are not strictly migrants but their control is often organised by the same organisations. From the perspective of quelea forecasting, the most important link has been with ICOSAMP for information exchange and dissemination, but useful economies were obtained by sharing technologies for satellite-derived rainfall data with the armyworm project.

Validation

B. Validation of the research output(s)

*10**. How** were the output(s) validated and **who** validated them?*

*Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation **(max. 500 words)**.*

The main validation process for the short-term predictions was to test if the model's forecasts of where and when Red-billed Quelea could breed in southern Africa were accurate. This involved collaboration between the project researchers and the end-user groups (national plant protection organisations) who supplied information on the locations and dates of reports of quelea breeding colonies, either directly or via ICOSAMP. In the three seasons 2002/2003, 2003/2004 and 2004/2005, 95%, 85% and 99% of colonies, respectively, were in 0.5 X 0.5 degree grid squares that the model had predicted to be suitable for breeding. Of those colonies reported from areas where the model had not predicted suitability, most (68%) were located next to squares that were deemed suitable.

The value of the model and its potential for eastern Africa was recognized by delegates at a workshop on quelea management held in Kenya during 2005. A prototype model for eastern Africa was developed and was uploaded on the NRI quelea website (see http://www-web.gre.ac.uk/directory/nri/quel/) but it has not been validated.

The research on the medium-term forecasts led to the conclusion that quelea abundances in terms of numbers

of colonies per season were associated with high rainfall in the December to January period which, in turn, could be predicted in November. This was validated statistically using data on colonies supplied by the end-user groups.

*11. **Where and when** have the output(s) been validated?*

*Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

The performance of the model was validated in-country by end-user groups (national plant protection organisations) who reported at workshops in South Africa (2005) and Kenya (2005) that they found the model outputs useful for their control operations planning.

In 2003, staff from the Botswana plant protection department visited an area denoted as suitable for breeding by the model and this led directly to the finding of a colony in a part of southern Botswana where quelea breeding had not previously been recorded.

The conclusions of the medium-term forecasting research were used by the South African quelea control teams to conclude that there would be few quelea breeding during 2003/2004 and many quelea breeding during 2005/2006.

The outputs are not targeted directly at particular social groups but to the national plant protection teams who then seek to protect the crops of resource-poor farmers in smallholder rainfed dry/cold and irrigated systems in semi-arid areas.

Current Situation

C. Current situation

*12. **How and by whom** are the outputs currently being used? Please give a brief description **(max. 250 words**).*

The model is currently being used by scientists in the national plant protection departments of the Ministries of Agriculture in southern Africa. The model has been handed over to, and is now being run by, the Regional Remote Sensing unit of the Southern African Development Community (SADC), based in Gaborone, Botswana. Each week during the quelea breeding season (September to May), they post a forecasting map of the model's outputs on to a website (http://gisdata.usgs.net/sa_floods/files/region/quel/). This is then available for all to examine and use to target particular zones for quelea surveys and control actions, as appropriate.

*13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used **(max. 250 words).***

The model outputs are currently being used by plant protection personnel in Botswana, Mozambique, Namibia, South Africa, Swaziland and Zimbabwe.

14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading ***(max 250 words).***

Usage was slow until the success of the model's predictions was established. Then, following dissemination of the model via a link on the ICOSAMP website, it is now used on a weekly basis during September-April by plant protection personnel in Botswana, Mozambique, Namibia, South Africa, Swaziland and Zimbabwe.

Pre-season rainfall amounts are noted and the results of the medium-term forecast used to predict the likely severity of a season in Botswana and South Africa.

15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? ***(max 350 words).***

The Southern African Development Community (SADC), the Desert Locust Control Organisation for Eastern Africa (DLCO-EA, responsible also for quelea control within its region), The Food and Agriculture Organization of the United Nations (FAO), the International Red Locust Control Organisation for Central and Southern Africa (IRLCO-CSA, responsible for quelea control in some countries within its region e.g. Mozambique, Zambia) and the Information Core for Southern African Migrant Pests (ICOSAMP) have all assisted with the promotion and adoption of the outputs. In addition, national plant protection departments have supported the work.

In terms of capacity strengthening, the key facts of success have hinged on the training of SADC staff in how to run the model and put it on a website themselves which they have done very successfully. In addition, three training courses covering aspects of quelea management were supported and attended by representatives of national plant protection departments, DLCO-EA and IRLCO-CSA. At each of these (one held in Botswana in February 2004, one in Kenya in May 2005 and one in South Africa in September 2005) the quelea short-term forecasting model was explained and demonstrated to trainees selected by the national plant protection departments as being those staff responsible for operational control of quelea. During the meeting in South Africa an opportunity arose to explain the project work to Professor Richard Mkandawire the agricultural advisor to the New Partnership for Africa's Development (NEPAD), thus bringing the project's work and the importance of border-crossing migrant pests in general to policy-makers at NEPAD. International policy on quelea control was also raised through meetings with SADC officials instrumental in drawing up their Migratory Pest Control policy. The outputs and national policies on the control of quelea were also discussed at senior levels in the Ministries of Agriculture in Botswana, Mozambique, Namibia and Zimbabwe.

Dissemination

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

The technologies developed are largely beneficial in their effects on the environment. Early warning of quelea breeding colonies, leads to successful control, which means fewer birds go on to breed elsewhere and thus fewer control interventions are required overall. The fewer control actions that take place the less the environmental damage, be it by contamination with organophosphate pesticides or the result of explosions, and thus the fewer non-target organisms killed or poisoned.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

No, except that when control does take place there are negative impacts. The outputs minimise the number of such control actions (see under 24).

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 200 words)***

Yes. The models will predict where any climate-induced changes in rainfall patterns will have effects and thus draw attention to changes in quelea birds' breeding habits. This will in turn be reflected by appropriate responses by the control teams which will lead to benefits for poor people in rural communities.

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. 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. These decisions will in turn have impacts on poor people.

Annex

References

Cheke, R. A. & Tucker, M. R. (1995) An evaluation of potential economic returns from the strategic control approach to the management of African armyworm *Spodoptera exempta* (Lepidoptera: Noctuidae) populations in eastern Africa. *Crop Protection* 14: 91-103.

Elliott, C.C.H. (1989a) The pest status of the quelea. *Quelea quelea: Africa's Bird Pest* (eds R. Bruggers & C.C.H. Elliott), pp. 17-34. Oxford University Press, Oxford.

Elliott, C.C.H. (1989b) The quelea as a major problem in a food-deficient continent. *Africa's Feathered*

Locust (eds P.J. Mundy & M.J.F. Jarvis), pp. 90-99. Baobab Books, Harare, Zimbabwe.
Geertsema, L. (1998) Redbilled Quelea: Annual Report. Unpublished report, National Department of Agriculture, South Africa.

Publications on the Outputs

JONES, P. J., CHEKE, R. A. & DALLIMER, M. (2000) *Quelea* migration in Africa. Abstract in Astheimer, L. B. & Clarke, M. F. (eds.) Proceedings of the 2nd. Southern Hemisphere Ornithological Congress (SHOC), Griffith University, Brisbane, Australia, 27 June – 2 July 2000. *Birds Australia Report Series* no. 9: 97.

CHEKE, R. A. (2001) DFID CPP Project on forecasting Quelea breeding in southern Africa. Abstract, p. 13. ICOSAMP Workshop, 2-4 May 2001, Pretoria, South Africa.

CHEKE, R. A. (2001) Information requirements for the Quelea Project on forecasting Quelea breeding in southern Africa. Abstract, p.15. ICOSAMP Workshop, 2-4 May 2001, Pretoria, South Africa.

CHEKE, R. A. (2002) DFID CPP Project: forecasting Quelea breeding in southern Africa. Abstract, p. 27 in M. E. Kieser (ed.) Proceedings of the ICOSAMP Workshop, 2-4 May 2001, Pretoria, South Africa.

CHEKE, R. A. (2002) Information requirements for the Quelea Project on "forecasting Quelea breeding in southern Africa". Abstract, p.29 in M. E. Kieser (ed.) Proceedings of the ICOSAMP Workshop, 2-4 May 2001, Pretoria, South Africa.

CHEKE, R. A. (2002) DFID CPP Project on forecasting Quelea breeding in southern Africa. Abstract, p. 15-17 ICOSAMP Workshop, 21-23 May 2002, Pretoria, South Africa.

CHEKE, R. A. (2003) Environmental impacts of quelea control and a model for forecasting quelea movements and breeding in southern Africa. pp. 58-65 in M. E. Kieser (ed.) Proceedings of the ICOSAMP Workshop, 21-23 May 2002, Pretoria, South Africa.

CHEKE, R. A. (2006) Early warnings of threats to food security – the importance of uptake by policymakers. *ID21 Insights* no 61: 8. (see http://www.id21.org/insights/insights61/art09.html).

CHEKE, R. A. VENN, J. F. & JONES, P. J. (2006) Forecasting suitable breeding conditions for the Red-billed Quelea *Quelea quelea* in southern Africa. *Journal of Applied Ecology* (accepted subject to revision).

CHEKE, R. A., VENN, J. F. & JONES, P. J. (2006) A spatio-temporal model for predicting when and where Red-billed Quelea will breed in southern Africa. Abstract of poster presentation, 24th International Ornithological Congress, Hamburg, Germany, 13-19 August 2006. *Journal of Ornithology* 147 suppl.: 147.

JONES, P. J., CHEKE, R. A., MUNDY, P. J., DALLIMER, M. & VENN , J. F. (2000) Quelea populations and forecasting based in southern Africa. Pp. 139-150 in Cheke, R.A., Rosenberg, L.J. & Kieser, M. (eds.) *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.

TODD, M., CHEKE, R. A., VENN, J. F., KNIVETON, D. & JONES, P. J. (2006?)
Variability of annual breeding records of the Red-billed Quelea bird *Quelea quelea lathamii* in southern Africa and the relationship with climate. *Journal of Applied Ecology* (submitted).

VENN, J., CHEKE, R. A. & JONES, P. J. (1999) *Quelea Bird-pest Database: Southern Africa Data*. Natural Resources Institute, Chatham, Kent, UK

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

VENN, J., CHEKE, R.A. & JONES, P. J. (2004) Forecasting breeding opportunities for the red-billed quelea in southern Africa. Abstract. p. 302 in Proceedings of the 15th International Plant Protection Congress, Beijing, 11-16 May 2004. Foreign Languages Press.