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PROCEEDINGS

OF THE

THIRD INTERNATIONAL LOCUST CONFERENCE

LONDON, SEPTEMBER 18, 1934

Presented by the Secretary of State for the Colonies to Parliament
by Command of His Majesty
October 1934

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PROCEEDINGS OF THE THIRD INTERNATIONAL LOCUST CONFERENCE.

London, September 18, 1934.

THE delegates to the Third International Locust Conference met at the House of Lords, London, from the 11th–18th September, 1934, at the invitation of the Government of the United Kingdom of Great Britain and Northern Ireland, issued in consequence of the recommendations made by the Second International Locust Conference held in Paris in 1932.

The Conference had before it reports from the several delegations in regard to anti-locust work carried out in their respective territories and communications from individual specialists present at the Conference in regard to particular aspects of the locust problem, of which they had made a special study.

The following governments were represented at the Conference :—

Afghanistan, Union of South Africa, Belgium, Great Britain and Northern Ireland, Egypt, Spain, Abyssinia, France, India, Italy, Liberia, Portugal, Anglo-Egyptian Sudan.

The President of the Conference was Sir John Chancellor, G.C.M.G., G.C.V.O., D.S.O., formerly High Commissioner for Palestine and Transjordan, and prior to that Governor of Southern Rhodesia. The Secretary-General of the Conference was Mr. Francis Hemming, C.B.E., Secretary of the Economic Advisory Council of the United Kingdom.

The composition of the delegations to the Conference was as follows :—

AFGHANISTAN.

Delegate.

SARDAR ALI MOHAMMAD KHAN, the Afghan Minister.

Assistant Delegate.

ABDUL QADIR KHAN, Commercial Attaché, Afghan Legation.

UNION OF SOUTH AFRICA.

Delegate.

Professor J. C. FAURE, Director of Locust Research, Department of Agriculture, Union of South Africa.

COMPTES RENDUS DE LA TROISIEME CONFERENCE INTERNATIONALE POUR LES RECHERCHES ANTI-ACRIDIENNES.

Londres, le 18 septembre, 1934.

Les délégués à la Troisième Conférence Internationale pour les Recherches Antiacridiennes se sont réunis dans la Chambre des Pairs, à Londres, du 11 au 18 septembre 1934, sur l'invitation du Gouvernement du Royaume-Uni de Grande-Bretagne et d'Irlande du Nord, lancée en vertu des recommandations faites par la Deuxième Conférence Internationale pour les Recherches Antiacridiennes, tenue à Paris en 1932.

La Conférence était en possession de rapports de plusieurs délégations sur les travaux antiacridiens poursuivis dans leurs territoires respectifs, ainsi que de communications de spécialistes individuels assistant à la Conférence, traitant des aspects particuliers du problème acridien auxquels ils avaient consacré une étude spéciale.

Les Gouvernements suivants étaient représentés à la Conférence :—

Afghanistan, Union de l'Afrique du Sud, Belgique, Grande-Bretagne et Irlande du Nord, Égypte, Espagne, Éthiopie, France, Inde, Italie, Libéria, Portugal, Soudan Anglo-Égyptien.

Le Président de la Conférence était Sir John Chancellor, G.C.M.G., G.C.V.O., D.S.O., ancien Haut-Commissaire pour la Palestine et pour la Transjordanie, et précédemment Gouverneur de la Rhodésie du Sud. Le Secrétaire-Général de la Conférence était M. Francis Hemming, C.B.E., Secrétaire du Conseil Consultatif Économique du Royaume-Uni.

Les délégations à la Conférence étaient composées comme suit :—

AFGHANISTAN.

Délégué.

Sardar Ali MOHAMMAD Khan, Ministre de l'Afghanistan.

Délégué adjoint.

Abdul QADIR Khan, Attaché Commercial, Légation de l'Afghanistan.

UNION DE L'AFRIQUE DU SUD.

Délégué.

M. le Professeur J. C. FAURE, Directeur des Recherches Anti-acridiennes, Département de l'Agriculture, Union de l'Afrique du Sud.

BELGIUM.

Delegate.

M. JEAN GHESQUIÈRE, Plant Pathologist at the Institute for Agricultural Research of the Belgian Congo and formerly Government Entomologist of Belgian Congo.

UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND.

Delegates.

Sir GUY A. K. MARSHALL, C.M.G., F.R.S., Director, Imperial Institute of Entomology.

Mr. B. P. UVAROV, Senior Assistant, Imperial Institute of Entomology.

Mr. H. B. JOHNSTON, Head of the field Locust Staff in East Africa of the Imperial Institute of Entomology.

Mr. G. F. SEEL, Colonial Office.

Mr. M. C. MOSSOP, Government Entomologist, Department of Agriculture, Southern Rhodesia.

Advisers.

Mr. E. BALLARD, Government Entomologist, Palestine.

Mr. W. J. BIGG, Colonial Office.

Mr. E. G. BILHAM, Superintendent, British Climatological Division, Meteorological Office.

Dr. C. E. P. BROOKS, Superintendent, General Climatological Division, Meteorological Office.

Mr. D. C. CAMPBELL, Assistant Chief Secretary, Tanganyika Territory.

Mr. G. S. COTTERELL, Government Entomologist, Gold Coast.

Mr. F. D. GOLDING, Senior Entomologist, Agricultural Department, Nigeria.

Mr. A. G. HAMILTON, B.Sc., Superintendent, Locust Laboratory, Imperial Institute of Entomology.

Mr. H. HARGREAVES, Government Entomologist, Uganda.

Mr. JULIAN HUXLEY, formerly Professor of Zoology, King's College, London.

Dr. A. D. IMMS, F.R.S., Reader in Entomology, University of Cambridge.

Mr. N. K. JOHNSON, Chief Superintendent, Chemical Defence Research Department.

BELGIQUE.

Délégué.

M. J. GHESQUIÈRE, Phytopathologiste à l'Institut pour la Recherche Agronomique du Congo belge et ancien entomologiste du Gouvernement au Congo belge.

GRANDE-BRETAGNE ET IRLANDE DU NORD.

Délégués.

Sir Guy A. K. MARSHALL, C.M.G., F.R.S., Directeur de l'Institut Impérial d'Entomologie.

M. B. P. UVAROV, Assistant Supérieur, Institut Impérial d'Entomologie.

M. H. B. JOHNSTON, Chef de la Mission d'Études de la Biologie des Acridiens en Afrique Orientale, organisée par l'Institut Impérial d'Entomologie.

M. G. F. SEEL, Ministère des Colonies.

M. M. C. MOSSOP, Entomologiste du Gouvernement, Département de l'Agriculture, Rhodésie du Sud.

Experts.

M. E. BALLARD, Entomologiste du Gouvernement, Palestine.

M. W. J. BIGG, Ministère des Colonies.

M. E. G. BILHAM, Chef de la Section climatologique britannique, Bureau Météorologique.

M. le Dr. C. E. P. BROOKS, Chef de la Section climatologique mondiale, Bureau Météorologique.

M. D. C. CAMPBELL, Secrétaire en chef adjoint, Territoire de Tanganyika.

M. G. S. COTTERELL, Entomologiste du Gouvernement, Côte d'Or.

M. F. D. GOLDING, Entomologiste Supérieur du Gouvernement, Département de l'Agriculture, Nigéria.

M. A. G. HAMILTON, B.Sc., Chef du Laboratoire acridien, Institut Impérial d'Entomologie.

M. H. HARGREAVES, Entomologiste du Gouvernement, Ouganda.

M. Julian HUXLEY, ancien Professeur de Zoologie, King's College, Londres.

M. le Dr. A. D. IMMS, F.R.S., Lecteur en Entomologie, Université de Cambridge.

M. N. K. JOHNSON, Chef du Département pour les Recherches sur la Défense Chimique.

Advisers—continued.

Mr. H. H. KING, Officer in charge of aircraft experiments in Africa, Imperial Institute of Entomology.

Mr. A. S. KIRKBRIDE, O.B.E., M.C., Assistant British Resident, Transjordan.

Mr. O. B. LEAN, formerly Entomologist, Agricultural Department, Nigeria.

Mr. C. J. LEWIN, M.C., Director of Agriculture, Northern Rhodesia.

Mr. D. C. J. McSWEENEY, Dominions Office.

Dr. F. J. MARTIN, Director of Agriculture, Sierra Leone.

Mr. A. P. G. MICHELMORE, Member of the field Locust Staff in East Africa of the Imperial Institute of Entomology.

Sir HENRY MIERS, F.R.S., Chairman, Committee on Locust Control, Economic Advisory Council.

Mr. H. M. MORRIS, Government Entomologist, Cyprus.

Mr. G. M. RAMBAUT, D.S.O., Scientific Officer, Department of Scientific Research, Air Ministry.

Mr. J. D. TOTHILL, D.Sc., Director of Agriculture, Uganda.

Dr. C. B. WILLIAMS, Chief Entomologist, Rothamsted Experimental Station.

Mr. H. E. WIMPERIS, C.B.E., Director of Scientific Research, Air Ministry.

Secretary.

Mr. FRANCIS HEMMING, C.B.E., Secretary, Economic Advisory Council.

Assistant Secretary.

Mr. D. H. F. RICKETT, Assistant Secretary, Economic Advisory Council.

EGYPT.

Delegate.

ABDEL MEGID MOUSTAFA MISTIKAWI, Assistant Director of the Entomological Section, and Chief of the Division of Anti-locust Research, Ministry of Agriculture, Cairo.

SPAIN.

Delegate.

Don JOSÉ DA CASA CALZADA, Agricultural Attaché at the Spanish Embassy.

Experts—suite.

M. H. H. KING, Chef de la Mission pour les Expériences aériennes en Afrique, Institut Impérial d'Entomologie.

M. A. S. KIRKBRIDE, O.B.E., M.C., Résident britannique adjoint, Transjordanie.

M. O. B. LEAN, ancien Entomologiste du Gouvernement, Département de l'Agriculture, Nigéria.

M. C. J. LEWIN, M.C., Directeur de l'Agriculture, Rhodésie du Nord.

M. D. C. J. McSWEENEY, Ministère des Affaires des Dominions.

M. le Dr. F. J. MARTIN, Directeur de l'Agriculture, Sierra-Leone.

M. A. P. G. MICHELMORE, Membre de la Mission d'Études de la Biologie des Acridiens en Afrique Orientale, organisée par l'Institut Impérial d'Entomologie.

Sir HENRY MIERS, F.R.S., Président du Comité pour la Lutte contre les Acridiens, Conseil Consultatif Économique.

M. H. M. MORRIS, Entomologiste du Gouvernement, Chypre.

M. G. M. RAMBAUT, D.S.O., Officier Scientifique, Département des Recherches Scientifiques, Ministère de l'Air.

M. le Dr. J. D. TOTHILL, Directeur de l'Agriculture, Ouganda.

M. le Dr. C. B. WILLIAMS, Entomologiste en chef, Station Expérimentale de Rothamsted.

M. H. E. WIMPERIS, C.B.E., Directeur des Recherches Scientifiques, Ministère de l'Air.

Secrétaire.

M. FRANCIS HEMMING, C.B.E., Secrétaire, Conseil Consultatif Économique.

Secrétaire adjoint.

M. D. H. F. RICKETT, Secrétaire adjoint, Conseil Consultatif Économique.

ÉGYPTE.

Délégué.

M. ABDEL MEGID MOUSTAFA MISTIKAWI, Directeur adjoint du Bureau Entomologique, et Chef de la Section pour les Recherches Antiacridiennes, Ministère de l'Agriculture, Caire.

ESPAGNE.

Délégué.

Don JOSÉ DA CASA CALZADA, Ingénieur Agronome, Attaché à l'Ambassade d'Espagne.

ABYSSINIA.

Delegate.

Ato Ephrem TEWOLDE-MEDHEN, Chargé d'Affaires, Abyssinian Legation.

FRANCE.

Delegates.

M. P. de PEYERIMHOFF, President of the French Committee for the Study of the Biology of Locusts.

M. P. VAYSSIÈRE, Professor of the National Institute of Colonial Agronomy, representing the Ministry of Agriculture and the Ministry of the Colonies; representing also French West Africa, and the Mandated Territory of Togoland.

Dr. G. BOUET, representing French Equatorial Africa and Tunisia.

M. L. CHOPARD, Director of the Vivarium, Paris, representing the Cameroons.

M. R. PASQUIER, Professor of the Agricultural Institute, Maison Carrée, representing Algeria.

M. P. REGNIER, Head of the Plant Protection Service, at the General Directorate for Agriculture, Commerce, and Colonisation, Rabat, representing Morocco.

M. B. N. ZOLOTAREVSKY, Head of the Mission for the Study of the Biology of Locusts.

M. J. de LÉPINEY, Deputy Head of the Mission for the Study of the Biology of Locusts, Head of the Zoological Services, Sherifian Institute of Science, Rabat, representing Morocco.

INDIA.

Delegate.

Rao Sahib Y. RAMACHANDRA Rao, Locust Research Entomologist, Imperial Council of Agricultural Research, Simla.

ITALY.

Delegates.

Dr. Antonio de BENEDICTIS, Technical Director of the Association for the colonisation of Cirenaica and formerly Director of Agriculture in Eritrea, representing the Ministry of the Colonies.

Professor Filippo SILVESTRI, Director of the Entomological Laboratory, Portici, and Professor of General and Agricultural Zoology, Royal Superior Institute of Agriculture, Portici, representing the Ministry of Agriculture.

ÉTHIOPIE.

Délégué.

Ato Ephrem TEWOLDE-MEDHEN, Chargé d'Affaires, Légation d'Éthiopie.

FRANCE.

Délégués.

M. P. de PEYERIMHOFF, Président du Comité Français d'Études de la Biologie des Acridiens.

M. P. VAYSSIÈRE, Professeur à l'Institut National d'Agronomie Coloniale, délégué des Ministères de l'Agriculture et des Colonies; délégué de l'Afrique Occidentale Française et du Territoire sous mandat du Togo.

M. le Dr. G. BOUET, délégué de l'Afrique Équatoriale Française et de la Tunisie.

M. L. CHOPARD, Directeur du Vivarium, Paris, délégué du Cameroun.

M. R. PASQUIER, Professeur à l'Institut Agricole de Maison-Carrée, délégué de l'Algérie.

M. P. REGNIER, Chef du Service de la Défense des Végétaux, Direction Générale de l'Agriculture, du Commerce et de la Colonisation à Rabat, délégué du Maroc.

M. B. N. ZOLOTAREVSKY, Chef de la Mission d'Études de la Biologie des Acridiens.

M. J. de LÉPINEY, Chef-adjoint de la Mission d'Études de la Biologie des Acridiens, Chef des Services Zoologiques, Institut Scientifique chérifien à Rabat, délégué du Maroc.

INDE.

Délégué.

Rao Sahib Y. RAMACHANDRA Rao, Entomologiste pour les Recherches Antiacridiennes, Conseil Impérial des Recherches Agricoles, Simla.

ITALIE.

Délégués.

M. le Dr. Antonio de BENEDICTIS, Directeur Scientifique de l'Association pour la Colonisation de la Cyrénaïque et ancien Directeur de l'Agriculture en Erythrée, délégué du Ministère des Colonies.

M. le Professeur Filippo SILVESTRI, Directeur du Laboratoire Entomologique, Portici, et Professeur de Zoologie Générale et Agricole, Institut Royal supérieur d'Agriculture, Portici, délégué du Ministère de l'Agriculture.

LIBERIA.

Delegate.

Baron R. A. DE LYNDEN, Chargé d'Affaires, Liberian Legation.

PORTUGAL.

Delegate.

M. BRANQUINHO D'OLIVEIRA, Plant Pathologist, Department of Plant Pathology, Ministry of Education, Lisbon.

ANGLO-EGYPTIAN SUDAN.

Delegate.

Mr. H. B. JOHNSTON, Government Entomologist, Khartoum (seconded for service under the Imperial Institute of Entomology, London).

In the absence of the Right Honourable Sir Philip Cunliffe-Lister, Secretary of State for the Colonies, the Conference was opened on Tuesday, the 11th September, 1934, by the Right Honourable the Earl of Plymouth, Parliamentary Under-Secretary of State for the Colonies, who, after referring to the previous International Locust Conferences held at Rome and Paris in 1931 and 1932, and emphasising the importance to all the governments represented of finding effective means of controlling locusts, and thus preventing the heavy losses inflicted by these pests, invited Sir John Chancellor to take the Chair and preside over the deliberations of the Conference.

In an introductory speech, Sir John Chancellor referred to the principal tasks before the Conference and invited particular attention to the draft resolutions which had been submitted to the Conference in regard to a number of important aspects of the locust problem which would later engage their attention. These draft resolutions, some of which had been prepared by the United Kingdom delegation and others by the French delegation, would, he hoped, prove of assistance to the Conference in their discussion of these important questions.

On the proposal of the President, the Conference then elected by general acclamation M. P. de Peyerimhoff, head of the French delegation, as Vice-President.

The Conference, having decided to accept, as a basis of discussion, the draft resolutions prepared by the United Kingdom and French delegations, proceeded to discuss the first of these, which dealt with the problems presented by the outbreak areas of locusts and with the need for their study. This resolution was brought forward on behalf of the French delegation by M. Zolotarevsky. The following took part

LIBÉRIA.

Délégué.

M. le Baron R. A. DE LYNDEN, Chargé d'Affaires, Légation de Libéria.

PORTUGAL.

Délégué.

M. BRANQUINHO D'OLIVEIRA, Expert à la Section phytopathologique, Ministère de l'Education, Lisbonne.

SOUDAN ANGLO-ÉGYPTIEN.

Délégué.

M. H. B. JOHNSTON, Entomologiste du Gouvernement, Khartoum (détaché en service à l'Institut Impérial d'Entomologie, Londres).

En l'absence du très honorable Sir Philip Cunliffe-Lister, Secrétaire d'État pour les Colonies, la Conférence a été déclarée ouverte mardi le 11 septembre par le très honorable Comte de Plymouth, Sous-Secrétaire d'État Parlementaire pour les Colonies, qui, après avoir rappelé les Conférences Internationales anti-acridiennes tenues à Rome et à Paris en 1931 et en 1932, et souligné l'importance pour tous les gouvernements représentés de trouver des moyens effectifs de combattre les acridiens et de parer ainsi aux grandes pertes infligées par ce fléau, invita Sir John Chancellor à occuper le fauteuil présidentiel et à présider les délibérations de la Conférence.

Dans un discours préliminaire, Sir John Chancellor passa en revue les tâches principales dont s'occuperait la Conférence, en attirant spécialement son attention sur les projets de résolutions soumis à la Conférence, et portant sur quelques aspects du problème acridien qui demanderaient plus tard leur attention. Il exprima l'espoir que ces projets de résolutions, dont quelques-uns avaient été préparés par la délégation du Royaume-Uni et d'autres par la délégation française, puissent être utiles à la Conférence dans la discussion de ces questions importantes.

Sur la proposition du Président, la Conférence a élu par acclamation générale M. P. de Peyerimhoff, chef de la délégation française, Vice-Président.

La Conférence, ayant décidé d'adopter comme base de discussion les projets de résolutions préparés par les délégations du Royaume-Uni et de la France, passa à la discussion de la première résolution, traitant des problèmes présentés par les foyers grégarigènes d'acridiens, ainsi que de la nécessité de les étudier. Cette résolution fut proposée au nom de la délégation française par M. Zolotarevsky.

in the subsequent discussion on this resolution: M. de Peyerimhoff (France), Mr. Uvarov, Sir Guy Marshall and Dr. Imms (United Kingdom), Mr. Johnston (Anglo-Egyptian Sudan), and Professor Silvestri (Italy). At the conclusion of the discussion the Conference adopted a resolution and agreed to attach M. Zolotarevsky's paper to their Proceedings (see Appendix 1).

In the course of the discussion of the foregoing resolution, reference was made by several members of the Conference to the need for an agreed terminology both in English and French for certain terms of great importance in the consideration of the locust problem. On the proposal of the French delegation, the Conference agreed to appoint a committee charged with the duty of preparing a short glossary, in English and French, of such terms. The Conference further agreed that this committee should consist of M. Zolotarevsky (*Chairman*) (France), Mr. Uvarov (United Kingdom), M. Pasquier (France), and Professor Silvestri (Italy).

Rao Sahib Ramachandra Rao (India) then opened a discussion of the life-cycle of locusts, particularly their sexual maturation, in relation to climatic and other factors, and methods of their study. The following took part in the subsequent discussion: Mr. Michelmore, Sir Guy Marshall, Mr. Uvarov (United Kingdom), M. Vayssière, M. Zolotarevsky, and M. de Peyerimhoff (France), Professer Silvestri (Italy), M. Mistikawi (Egypt), and Professor Faure (Union of South Africa). At the conclusion of the discussion, the Conference adopted a resolution and agreed to attach to their Proceedings Rao Sahib Ramachandra Rao's paper on this subject (see Appendix 2).

Mr. Michelmore (United Kingdom) brought a resolution relating to the migration of locusts with proposals regarding the methods of studying this question. The following took part in the discussion which followed: Dr. Williams, Dr. Brooks, Dr. Martin, Mr. Lean, and Mr. Uvarov (United Kingdom), Mr. Johnston (Anglo-Egyptian Sudan), Professor Faure (Union of South Africa), MM. Vayssière, Zolotarevsky, and de Lépiney (France). In the course of the discussion, Dr. Brooks moved an addition to the resolution proposed by Mr. Michelmore, and the Conference decided to defer examination of this question until their next meeting.

At their session held on Wednesday, the 12th September, 1934, the Conference resumed the discussion on the resolution in regard to migration and its factors, which had been moved by Mr. Michelmore (United Kingdom) at their previous session, together with certain amendments put forward in the course of the discussion. The following speakers took part in the discussion: Mr. Uvarov, Mr. Bilham, Sir Guy Marshall, Mr. Golding (United Kingdom), M. de Peyerimhoff, M. Zolotarevsky, M. Pasquier (France), Rao Sahib Ramachandra Rao (India), M. Mistikawi (Egypt), and Professor Faure (Union of South Africa). At the conclusion of the discussion, the Conference agreed to appoint a small committee for

Les orateurs suivants prirent part à cette discussion: M. de Peyerimhoff (France), M. Uvarov, Sir Guy Marshall, et Dr. Imms (Royaume-Uni), M. Johnston (Soudan Anglo-Égyptien), et le Professeur Silvestri (Italie). Cette discussion terminée, la Conférence décida d'adopter la résolution en question et d'annexer le mémoire de M. Zolotarevsky aux comptes-rendus (voir annexe 1).

Au cours de cette discussion, plusieurs membres de la Conférence firent allusion à la nécessité d'une terminologie approuvée en anglais et en français en ce qui concerne certains termes d'une grande importance pour le problème acridien. Sur proposition de la délégation française, la Conférence décida de constituer un comité chargé de préparer un bref glossaire de ces termes, en anglais et en français. La Conférence nomma les délégués suivants pour prendre part à ce travail: M. Zolotarevsky (*Président*) (France), M. Uvarov (Royaume-Uni), M. Pasquier (France) et le Professeur Silvestri (Italie).

Rao Sahib Ramachandra Rao (Inde) ouvrit ensuite une discussion sur le cycle évolutif des acridiens, particulièrement sur la maturation sexuelle par rapport aux facteurs climatiques et autres, et sur les méthodes d'étude. Les délégués suivants prirent part à la discussion: M. Michelmore, Sir Guy Marshall, M. Uvarov (Royaume-Uni), MM. Vayssière, Zolotarevsky et de Peyerimhoff (France), le Professeur Silvestri (Italie), M. Mistikawi (Égypte), et le Professeur Faure (Union de l'Afrique du Sud). À l'issue de la discussion, la Conférence adopta une résolution et décida d'annexer aux comptes-rendus le mémoire de Rao Sahib Ramachandra Rao sur cette question (voir annexe 2).

M. Michelmore (Royaume-Uni) proposa une résolution relative à la migration des acridiens et aux méthodes d'étude de cette question. Les délégués suivants prirent part à la discussion: Dr. Williams, Dr. Brooks, Dr. Martin, M. Lean, et M. Uvarov (Royaume-Uni), M. Johnston (Soudan Anglo-Égyptien), le Professeur Faure (Union de l'Afrique du Sud), MM. Vayssière, Zolotarevsky et de Lépiney (France). Au cours de cette discussion, le Dr. Brooks proposa une addition à la résolution proposée par M. Michelmore, et la Conférence décida de remettre l'examen de cette question à la prochaine séance.

À la séance de mercredi, 12 septembre 1934, la Conférence reprit l'examen de la résolution touchant la migration et ses éléments principaux, proposée par M. Michelmore (Royaume-Uni) à la séance précédente, ainsi que de divers amendements proposés au cours du débat. Les orateurs suivants prirent part à cette discussion: MM. Uvarov, Bilham, Sir Guy Marshall, M. Golding (Royaume-Uni), MM. de Peyerimhoff, Zolotarevsky, Pasquier (France), Rao Sahib Ramachandra Rao (Inde), M. Mistikawi (Égypte), et le Professeur Faure (Union de l'Afrique du Sud). Cette discussion terminée, la Conférence décida de constituer un comité restreint chargé de préparer une nouvelle

the purpose of re-drafting of the amendments which had been submitted to the Conference by Dr. Brooks in regard to the types of meteorological charts likely to be of assistance in the analysis of the factors affecting migration. The committee was composed as follows: M. Zolotarevsky (*Chairman*), M. Pasquier (France), Mr. Uvarov, Mr. Bilham, Mr. Lean, and Mr. Michelmore (United Kingdom).

The Conference agreed, pending the receipt of the committee's report, to adjourn the discussion on the resolution before them.

The Conference next proceeded to consider a resolution moved by Mr. Johnston (Anglo-Egyptian Sudan) in regard to the ecology and habits of locusts in invasion areas, with special reference to dissociating factors.

In the subsequent discussion, the Conference was addressed by M. Ghesquière (Belgium), M. Zolotarevsky (France), Professor Faure (Union of South Africa), and Mr. Uvarov (United Kingdom), after which the Conference agreed to adopt the resolution and to attach Mr. Johnston's paper to their proceedings (see Appendix 5).

At this stage the Conference received the report of the committee which had been appointed at their previous session to agree upon certain definite terms in regard to the distribution and migration of locusts. The report was introduced by Mr. Uvarov (United Kingdom), and, after a brief discussion in which M. de Peyerimhoff (France) expressed the support of the French delegation, and in which M. de Lépiney also spoke, the Conference agreed to adopt the report of the committee.

Mr. Golding (United Kingdom) then placed before the Conference a resolution dealing with methods of field surveys. The following took part in the ensuing discussion: M. Zolotarevsky, M. Chopard, M. Pasquier, M. de Peyerimhoff, M. Vayssière (France), M. Ghesquière (Belgium), Mr. Michelmore, Mr. Williams, Mr. Lean, Sir Guy Marshall, Mr. Uvarov (United Kingdom), Mr. Johnston (Anglo-Egyptian Sudan), and Professor Faure (Union of South Africa). As the discussion of the resolution showed that there were a number of points on which further and more detailed consideration would be necessary, the Conference agreed to appoint a committee, which was instructed to prepare a revised text of the proposed resolution. The committee was composed as follows: Professor Faure (Union of South Africa) (*Chairman*), Mr. Golding (United Kingdom), M. de Lépiney (France), Mr. Johnston (Anglo-Egyptian Soudan), and Mr. Hemming (Secretary-General).

The Conference passed to the consideration of a resolution introduced by Mr. King (United Kingdom) on the subject of locust control by means of aircraft. The resolution was discussed by Professor Faure (Union of South Africa), Mr. Wimperis, Mr. Mossop, Mr. Johnson (United Kingdom), M. Pasquier (France) and Mr. Johnston (Anglo-Egyptian Sudan). At the conclusion of the discussion was adopted by the Conference subject to certain

rédaction des amendements proposés à la Conférence par le Dr. Brooks, au sujet du genre de carte météorologique propre à faciliter l'analyse des éléments influençant la migration. Le comité comprenait les délégués suivants: MM. Zolotarevsky, (*Président*), Pasquier, (France), MM. Uvarov, Bilham, Lean et Michelmore (Royaume-Uni).

En attendant le rapport du comité, la Conférence décida de remettre l'examen de la résolution proposée à plus tard.

La Conférence passa ensuite à l'examen de la résolution proposée par M. Johnston (Soudan Anglo-Égyptien), traitant de l'écologie et des habitudes des acridiens dans les aires d'invasion, spécialement en ce qui concerne les facteurs de dissociation.

Au cours du débat qui s'ensuivit, les orateurs suivants prirent la parole: MM. Ghesquière (Belgique), Zolotarevsky (France), le Professeur Faure (Union de l'Afrique du Sud), et M. Uvarov (Royaume-Uni). La Conférence décida ensuite d'adopter la résolution en question et d'annexer le mémoire de M. Johnston aux comptes-rendus (voir annexe 5).

La Conférence reçoit alors le rapport du comité constitué à la séance précédente pour préciser la signification de certaines expressions s'appliquant à la distribution et à la migration des acridiens. Ce rapport est présenté par M. Uvarov (Royaume-Uni), et, après un échange de vues au cours duquel M. de Peyerimhoff donna l'adhésion de la délégation française, et M. de Lépiney fournit certaines précisions, la Conférence décide d'adopter le rapport du comité.

M. Golding (Royaume-Uni) présente ensuite à la Conférence une résolution touchant les méthodes de travail des missions d'étude sur place. Les orateurs suivants prennent part au débat: MM. Zolotarevsky, Chopard, Pasquier, de Peyerimhoff, Vayssière (France), M. Ghesquière (Belgique), MM. Michelmore, Williams, Lean, Sir Guy Marshall, M. Uvarov (Royaume-Uni), M. Johnston (Soudan Anglo-Égyptien) et le Professeur Faure (Union de l'Afrique du Sud). L'examen de cette résolution ayant montré qu'il restait toute une série de questions nécessitant un examen plus détaillé, la Conférence décide de constituer un comité restreint chargé de préparer une nouvelle rédaction de la résolution proposée. Ce comité est composé comme suit: le Professeur Faure (*Président*) (Union de l'Afrique du Sud), M. Golding (Royaume-Uni), M. de Lépiney (France), M. Johnston (Soudan Anglo-Égyptien), et M. Hemming (Secrétaire-Général).

La Conférence passe à l'examen d'une résolution présentée par M. King (Royaume-Uni) traitant la question de la destruction des acridiens au moyen des avions. Cette résolution est discutée par le Professeur Faure (Union de l'Afrique du Sud), MM. Wimperis, Mossop, Johnson (Royaume-Uni), M. Pasquier (France), et M. Johnston (Soudan Anglo-Egyptien). Après avoir adopté plusieurs modifications, la Conférence accepte cette résolution. Elle décide

modifications. The Conference agreed to attach to their proceedings the report submitted by Mr. King on this subject (see Appendix 8), and a memorandum by Dr. T. J. Naudé, submitted by the delegation of the Union of South Africa (see Appendix 9).

M. de Peyerimhoff (France), then submitted two resolutions, the first dealing in general terms with the Tropical Migratory Locust, *Locusta migratoria migratorioides* (Reiche and Fairmaire), and the second with the allocation of the areas to be investigated in connection with this species of locust. After hearing further observations by M. Zolotarevsky (France), the Conference adopted these resolutions.

A resolution in regard to the Desert Locust, *Schistocerca gregaria* (Forskål), submitted by Mr. Uvarov (United Kingdom), and after some brief comments by Mr. Ballard (United Kingdom) was adopted by the Conference. The Conference further agreed to attach Mr. Uvarov's paper on this subject to their proceedings (see Appendix 10).

Mr. Michelmore (United Kingdom) moved a resolution on the subject of the Red Locust, *Nomadacris septemfasciata* (Serville), which was adopted. The Conference agreed to attach to their proceedings a memorandum submitted by Mr. Michelmore (see Appendix 11).

A resolution was introduced by M. de Peyerimhoff (France) dealing with the Moroccan Locust, *Dociostaurus maroccanus* (Thunberg), and, after Professor Silvestri (Italy) had expressed his support of the resolution, it was adopted by the Conference. It was also agreed to attach to the proceedings of the Conference the memorandum on this subject submitted by Professor Silvestri (see Appendix 12).

On reassembling on Thursday, the 13th September, the Conference proceeded to consider the question of fundamental research, a resolution in regard to which was brought forward by Mr. Uvarov (United Kingdom). The following took part in the subsequent discussion: M. Ghesquière (Belgium), Dr. Imms, Sir Guy Marshall (United Kingdom), M. Mistikawi (Egypt), MM. de Peyerimhoff, Chopard, de Lépiney, Vayssière and Zolotarevsky, and Dr. Bouet (France), Professor Silvestri (Italy), and Mr. Johnston (Anglo-Egyptian Sudan). At the conclusion of the discussion, the Conference adopted the resolution and agreed to attach to their proceedings the memorandum on the subject submitted by Mr. Uvarov (see Appendix 7).

Sir Henry Miers (United Kingdom) proposed a resolution containing suggestions for the improvement of the present system of reporting on locusts. After M. de Peyerimhoff (France) had intimated that the French delegation were in complete accord with the proposals put forward by Sir Henry Miers, the Conference agreed to adopt the resolution which had been moved.

M. Zolotarevsky (France) brought forward for the consideration of the Conference the report of the committee, of which he was chairman, which had been appointed to prepare the text of

en outre d'annexer aux comptes-rendus le rapport présenté par M. King à ce sujet (voir annexe 8) et un mémoire rédigé par le Docteur T. J. Naudé, que la délégation de l'Union de l'Afrique du Sud avait présenté à la Conférence (voir annexe 9).

M. de Peyerimhoff (France) présente alors deux résolutions, dont la première traite du Criquet Migrateur Tropical, *Locusta migratoria migratorioides* (Reiche et Fairmaire), en général, et la deuxième, de la répartition des régions habitées par l'espèce, dont l'étude serait nécessaire. Après observations de M. Zolotarevsky (France), la Conférence approuve le texte de ces deux résolutions.

Une résolution traitant du Criquet Pèlerin, *Schistocerca gregaria* (Forskål), est présentée par M. Uvarov (Royaume-Uni), et est adoptée par la Conférence après quelques observations de M. Ballard (Royaume-Uni). La Conférence décide en même temps d'annexer le mémoire préparé par M. Uvarov aux comptes-rendus (voir annexe 10).

M. Michelmore (Royaume-Uni) présente une résolution au sujet de la Sauterelle Rouge, *Nomadacris septemfasciata* (Serville), qui fut adoptée. La Conférence décide de même d'annexer aux comptes-rendus le mémoire préparé par M. Michelmore (voir annexe 11).

M. de Peyerimhoff (France) présente une résolution traitant du Criquet Marocain, *Dociostaurus maroccanus* (Thunberg); après avoir entendu le Professeur Silvestri (Italie) appuyant cette résolution, celle-ci est adoptée par la Conférence. Il est décidé d'annexer aux comptes-rendus le mémoire, relatif à cette espèce, présenté par le Professeur Silvestri (voir annexe 12).

Le jeudi 13 septembre, la Conférence passe à l'examen de la question des recherches fondamentales, question au sujet de laquelle une résolution est proposée par M. Uvarov (Royaume-Uni). Un débat est institué, au cours duquel les orateurs suivants prennent la parole : M. Ghesquière (Belgique), Dr. Imms, Sir Guy Marshall (Royaume-Uni), M. Mistikawi (Egypte), MM. de Peyerimhoff, Chopard, de Lépiney, Vayssière, Zolotarevsky, et le Dr. Bouet (France), le Professeur Silvestri (Italie), et M. Johnston (Soudan-Anglo-Egyptien). A la suite de ce débat la Conférence approuve la résolution, et décide d'annexer aux comptes-rendus le mémoire présenté par M. Uvarov (voir annexe 7).

Sir Henry Miers (Royaume-Uni) présente une résolution contenant une série de suggestions sur l'amélioration du système actuel d'informations concernant les acridiens. M. de Peyerimhoff (France) ayant indiqué que la délégation française était entièrement d'accord avec les propositions de Sir Henry Miers, la Conférence approuve la résolution présentée.

M. Zolotarevsky (France) lit ensuite à la Conférence le rapport du comité qu'il avait présidé. Ce comité était chargé de préparer un projet de résolution touchant le meilleur type de cartes météoro-

a resolution in regard to the type of meteorological charts of Africa and western Asia likely to be of assistance in the analysis of the factors affecting migration. All the points made in the previous discussions of various factors having been met in the committee's report, the Conference agreed to incorporate in their report the text prepared by the committee for paragraphs 5, 6, 7, 8, and 9 of the resolution relating to migration and its factors. Subject to this addition, and to the addition proposed at the previous session by the French delegation, the Conference adopted the resolution originally proposed by Mr. Michelmore at their first day's meeting. The Conference further agreed to attach to their proceedings the memorandum on the subject submitted by Mr. Michelmore (see Appendix 3).

Mr. Michelmore (United Kingdom) then moved a resolution in regard to the need for further investigation of *Empusa grylli* (Fresenius) and of other fungi and bacteria parasitic on locusts. After a short discussion, in which Mr. Uvarov (United Kingdom), M. d'Oliveira (Portugal) and Dr. Bouet (France) took part, the Conference adopted the resolution proposed by Mr. Michelmore, subject to an addition suggested by M. d'Oliveira, and agreed that it should be inserted in their report immediately after the resolution relating to the ecology and habits of locusts in invasion areas. The Conference further agreed to attach to their proceedings the memorandum on the subject by Dr. J. C. F. Hopkins, Senior Plant Pathologist, Southern Rhodesia, submitted by the United Kingdom delegation (see Appendix 6).

The Conference proceeded to give further consideration to the special problems of the Red Locust, *Nomadacris septemfasciata* (Serville), on which Mr. Michelmore brought forward a resolution in substitution for that adopted by the Conference at their session held on the previous day. Mr. Michelmore took the opportunity of moving a complementary resolution suggesting the allocation of work on this species in different territories. The following took part in the subsequent discussion: Mr. Lewin, Mr. Golding (United Kingdom), M. de Peyerimhoff (France), and M. d'Oliveira (Portugal). At the conclusion of the discussion, the Conference agreed to accept the revised resolution proposed by Mr. Michelmore in regard to the special problems of the Red Locust, and to adopt the resolution moved in regard to the allocation of the areas to be investigated in respect of this species.

Professor Faure (Union of South Africa) then submitted for the consideration of the Conference the report of the committee, of which he was chairman, which had been appointed on the previous day to prepare a revised text of the resolution dealing with the methods of field surveys. As all the points raised by the various delegations had been met in the revised text submitted by the committee, the Conference agreed to adopt it as one of their resolutions and to attach to their proceedings the memorandum submitted by Mr. Golding (see Appendix 4).

logiques des régions de l'Afrique et de l'Asie occidentale pour l'étude des éléments climatiques influençant l'émigration des acridiens. Ce rapport tient compte de toutes les considérations qui avaient été développées au cours des débats précédents; la Conférence décide d'incorporer dans son rapport le texte élaboré par le comité. Ce texte figure aux alinéas 5, 6, 7, 8, et 9 de la résolution traitant de l'émigration sous ses divers aspects. La Conférence approuve le texte présenté à la première séance par M. Michelmore, en y ajoutant les alinéas susindiqués, ainsi que l'alinéa supplémentaire présenté la veille par la délégation française. La Conférence décide également d'annexer aux comptes-rendus le mémoire présenté par M. Michelmore et qui traite de cette question (voir annexe 3).

M. Michelmore (Royaume-Uni) présente une résolution indiquant la nécessité de recherches étendues au sujet de l'*Empusa grylli* (Fresenius), et des autres champignons ou bactéries parasites des acridiens. Après un court débat auquel prirent part M. Uvarov (Royaume-Uni), M. d'Oliveira (Portugal) et le Docteur Bouet (France), la Conférence adopte la résolution de M. Michelmore, en y ajoutant un alinéa préparé par M. d'Oliveira. Il est décidé d'insérer cette résolution dans les comptes-rendus, immédiatement après la résolution sur l'écologie et les habitudes des acridiens dans les aires d'invasion. Il est également décidé d'insérer aux comptes-rendus le mémoire préparé à ce sujet par M. le Docteur J. C. F. Hopkins, Phytopathologiste en Chef dans la Rhodésie du Sud et présenté par la délégation du Royaume-Uni (voir annexe 6).

La Conférence reprend ensuite l'examen des problèmes spéciaux que soulève la Sauterelle Rouge, *Nomadacris septemfasciata* (Serville); M. Michelmore présente une nouvelle résolution pour remplacer celle que la Conférence avait adoptée la veille. Il profite également de cette occasion pour exposer une résolution complémentaire dans laquelle il donne certaines suggestions au sujet de la répartition des recherches touchant cette espèce dans les différents territoires. Les orateurs suivants prennent part aux discussions: MM. Lewin, Golding (Royaume-Uni), M. de Peyerimhoff (France) et M. d'Oliveira (Portugal). A la fin de ce débat la Conférence décide d'accepter la nouvelle résolution préparée par M. Michelmore, traitant des problèmes spéciaux présentés par la Sauterelle Rouge. Elle décide également d'adopter la résolution présentée au sujet de la répartition des territoires dans l'étude de cette espèce.

Le Professeur Faure (Union de l'Afrique du Sud) soumet ensuite à l'examen de la Conférence le rapport du comité constitué la veille en vue d'arrêter la nouvelle rédaction sur les méthodes d'études sur place, et qu'il avait présidé. Ce comité ayant tenu compte de toutes les observations développées par les divers orateurs dans la préparation du nouveau texte, la Conférence décide d'insérer ce texte parmi ses résolutions et d'annexer aux comptes-rendus le mémoire présenté par M. Golding (voir annexe 4).

The Conference then turned their attention to the special problem of the Tropical Migratory Locust, *Locusta migratoria migratorioides* (Reiche and Fairmaire) on which M. de Peyerimhoff (France) moved a resolution. After a short discussion in which Sir Guy Marshall (United Kingdom), and M. Zolotarevsky (France) took part, the Conference agreed to incorporate in their proceedings the resolution proposed by the French delegation.

Mr. Uvarov (United Kingdom) then proposed a resolution regarding the allocation as between different areas on work of the Desert Locust, *Schistocerca gregaria* (Forskål). In the ensuing discussion the following delegates took part: M. de Peyerimhoff, Dr. Bouet, M. Zolotarevsky (France), and Professor Faure (Union of South Africa). Don José da Casa Calzada (Spain) indicated that the Spanish Government desired the closest co-operation with other Governments in anti-locust work in the territory of Rio de Oro. He was already in informal communication on this subject with the head of the French delegation. Further, the Spanish Government were willing to give every assistance to the Governments of other countries that might desire to conduct anti-locust research in Spanish territories. At the conclusion of the discussion, the Conference agreed to adopt the resolution proposed by Mr. Uvarov subject to slight modifications agreed on during the discussion.

The Conference then considered the question of the exchange of reports between field investigators, on which Mr. Uvarov (United Kingdom) proposed a resolution. After M. Zolotarevsky (France) had indicated the concurrence of the French delegation in the proposals contained in this resolution, the Conference agreed to adopt for their report the text proposed by Mr. Uvarov.

Professor Faure (Union of South Africa) then brought forward a resolution dealing with the need for further research with regard to arsenical and other compounds in locust control. Professor Faure's proposals commanded the general approval of the Conference, who agreed to adopt the text of his resolution.

The Conference agreed to add the following documents to their proceedings as appendices:—

The organisation for the collection of information on locusts in the Union of South Africa. Memorandum by Jacobus C. Faure, Director of Locust Research, Department of Agriculture, Union of South Africa (see Appendix 13).

Summary of locust research work carried on in north-west India under the auspices of the Imperial Council of Agricultural Research, Simla. Memorandum by Rao Sahib Y. Ramachandra Rao, Locust Research Entomologist, Imperial Council of Agricultural Research (see Appendix 14).

La Conférence passe ensuite au problème particulier du Criquet Migrateur Tropical, *Locusta migratoria migratorioides* (Reiche et Fairmaire), au sujet duquel M. de Peyerimhoff (France) lit un projet de résolution. Après un court débat au cours duquel Sir Guy Marshall (Royaume-Uni) et M. Zolotarevsky (France) prennent la parole, la Conférence décide d'adopter la résolution préparée par la délégation française et de la faire figurer aux comptes-rendus.

Puis M. Uvarov (Royaume-Uni) propose un texte de résolution traitant de la répartition entre les divers territoires de recherches sur le Criquet Pèlerin, *Schistocerca gregaria* (Forskål). Les orateurs suivants prennent part au débat : M. de Peyerimhoff, le Docteur Bouet, M. Zolotarevsky (France) et le Professeur Faure (Union Sud-Africaine). Don José da Casa Calzada (Espagne) fait savoir que le Gouvernement espagnol désire établir la collaboration la plus étroite avec les autres Gouvernements dans les recherches antiacridiennes sur le territoire du Rio de Oro. Il s'est entretenu à ce sujet avec le chef de la délégation française. Le Gouvernement espagnol est disposé à offrir toutes facilités aux Gouvernements des autres pays qui seraient amenés à entreprendre des recherches antiacridiennes sur les territoires espagnols. La Conférence adopte la résolution préparée par M. Uvarov après y avoir apporté quelques modifications de détail.

La Conférence passe à l'examen de la question de l'échange des rapports entre missions ou explorateurs travaillant sur place. M. Uvarov (Royaume-Uni) présente un projet de résolution. M. Zolotarevsky (France) ayant indiqué que la délégation française donnait son adhésion aux propositions fondamentales de cette résolution, la Conférence décide de l'approuver et de l'insérer dans ses comptes-rendus.

Le Professeur Faure (Union de l'Afrique du Sud) présente une résolution traitant de la nécessité d'entreprendre de nouvelles recherches sur la destruction des acridiens par les composés à base d'arsenic et d'autres substances. Les propositions du Professeur Faure à ce sujet rencontrent l'appui général des délégations et la Conférence adopte le texte de sa résolution.

On décide d'ajouter en annexe, aux comptes-rendus de la Conférence, les documents suivants :

Organisation de la centralisation des informations sur les acridiens dans l'Union de l'Afrique du Sud : Mémorandum par Jacobus C. Faure, Directeur des Recherches Antiacridiennes, Département de l'Agriculture, Union de l'Afrique du Sud (voir annexe 13) ;

Résumé des recherches antiacridiennes effectuées dans le Nord-Ouest de l'Inde sous les auspices du Conseil Impérial des Recherches Agricoles, Simla : Mémorandum par Rao Sahib Y. Ramachandra Rao, entomologiste pour les Recherches Antiacridiennes, Conseil Impérial des Recherches Agricoles (voir annexe 14).

Summary of the work done on the Desert Locust, *Schistocerca gregaria* (Forskål) at Lyallpur during the years 1931 to 1933. Memorandum by Afzal Husain. Submitted by the Indian Delegation (see Appendix 15).

A brief summary of investigations on locust problems in the Union of South Africa. Memorandum by Jacobus C. Faure, Director of Locust Research, Department of Agriculture, Union of South Africa (see Appendix 16).

The occurrence of the Tropical Migratory Locust, *Locusta migratoria migratorioides* (Reiche and Fairmaire), in the Union of South Africa in 1933–34 and in South-West Africa in 1931–34. Memorandum by Jacobus C. Faure, Director of Locust Research, Department of Agriculture, Union of South Africa (see Appendix 17).

The swarming of *Schistocerca gregaria* (Forskål) in the Union of South Africa and in South West Africa in 1934. Memorandum by Jacobus C. Faure, Director of Locust Research, Department of Agriculture, Union of South Africa (see Appendix 18).

Declarations and resolutions submitted by the Belgian delegation (see Appendix 19).

Locusts in Southern Rhodesia. Memorandum by Rupert W. Jack, Chief Government Entomologist, Southern Rhodesia, submitted by the United Kingdom delegation (see Appendix 20).

Locust research in Egypt. Memorandum by Abdel Megid Moustafa Mistikawi, Assistant Director of the Entomological Section and Chief of the Division of Anti-Locust Research, Ministry of Agriculture, Cairo (see Appendix 21).

Preliminary report on the work of the Mission for the Study of the Biology of Locusts in the years 1932–34. Memorandum by B. N. Zolotarevsky, Head of the Mission (see Appendix 22).

Declarations and resolutions submitted by the French delegation (see Appendix 23).

The Conference further agreed to annex to their proceedings the political and administrative map of Africa and western Asia, which had been circulated to the Conference (see Appendix 24).

The Conference were informed that the two principal documents describing the anti-locust work undertaken by the United Kingdom, namely, the Sixth Report of the Committee on Locust Control of the Economic Advisory Council, and the survey of the locust outbreak in Africa and western Asia in the year 1933 prepared by Mr. Uvarov, which they would otherwise have desired to add to their proceedings, were being published separately by the Government of the United Kingdom.

Résumé des travaux sur le Criquet Pèlerin, *Schistocerca gregaria* (Forskål) à Lyallpur pendant les années 1931–33 : Mémorandum par Afzal Husain, document soumis par la délégation de l'Inde (voir annexe 15);

Résumé des recherches sur les problèmes acridiens dans l'Union de l'Afrique du Sud : Mémorandum par Jacobus C. Faure, Directeur des Recherches Antiacridiennes, Département de l'Agriculture, Union de l'Afrique du Sud (voir annexe 16);

La présence du Criquet Migrateur Tropical, *Locusta migratoria migratorioides* (Reiche et Fairmaire) dans l'Union de l'Afrique du Sud en 1933–34 et dans le Territoire du Sud-Ouest Africain en 1931–34 : Mémorandum par Jacobus C. Faure, Directeur des Recherches Antiacridiennes, Union de l'Afrique du Sud (voir annexe 17);

Les vols de *Schistocerca gregaria* (Forskål) dans l'Union de l'Afrique du Sud et dans le Territoire du Sud-Ouest africain en 1934 : Mémorandum par Jacobus C. Faure, Directeur des Recherches Antiacridiennes, Département de l'Agriculture, Union de l'Afrique du Sud (voir annexe 18);

Déclarations et vœux soumis par la délégation belge (voir annexe 19).

Les acridiens dans la Rhodésie du Sud : Mémorandum par Rupert W. Jack, entomologiste en chef du Gouvernement, Rhodésie du Sud, document soumis par la délégation du Royaume-Uni (voir annexe 20);

Les recherches antiacridiennes en Égypte : Mémorandum par Abdel Megid Moustafa Mistikawi, Directeur adjoint du Bureau Entomologique et Chef de la Section pour les Recherches Antiacridiennes, Ministère de l'Agriculture, Caire (voir annexe 21);

Rapport préliminaire sur l'action de la Mission d'Études de la Biologie des Acridiens en 1932–34 : Mémorandum par B. N. Zolotarevsky, chef de la Mission (voir annexe 22);

Déclarations et résolutions soumises par la délégation française (voir annexe 23).

La Conférence décide également d'annexer aux comptes-rendus la carte politique et administrative de l'Afrique et de l'Asie occidentale distribuée à la Conférence (voir annexe 24).

La Conférence est informée que les deux documents principaux traitant des recherches antiacridiennes faites par le Royaume-Uni (Sixième Rapport du Comité pour la Lutte contre les Acridiens du Conseil Consultatif Économique, et rapport sur l'épidémie des acridiens en Afrique et en Asie occidentale en 1933, rédigé par M. Uvarov), qu'elle aurait désiré annexer aux comptes-rendus, seront publiés séparément par le Gouvernement du Royaume-Uni.

At their meeting held on Monday, 17th September, the Conference then turned to a discussion of the question of the time and place of their next meeting. M. de Peyerimhoff (France) proposed that the Fourth International Locust Conference should be held at Cairo in the year 1936. After M. Mistikawi (Egypt) had indicated that he had the authority of the Egyptian Government to inform the Conference that they warmly welcomed the proposal that the next meeting of the Conference should be held at Cairo, and would be happy to make the necessary arrangements. Thereupon the Conference agreed by acclamation that their next session should be held at Cairo in the spring of 1936.

The Conference proceeded then formally to adopt the following resolutions :—

RESOLUTIONS OF THE CONFERENCE.

1.—THE GENERAL PROBLEMS CONCERNING ALL THE SPECIES OF LOCUST FOUND IN AFRICA AND WESTERN ASIA.

(a) Outbreak areas and factors inducing transformation of the solitary phase of migratory locusts into the swarming phase.

1. The results of the investigations carried out in different countries leave no doubt that the swarms of locusts initiating an invasion (*i.e.*, the primary swarms) appear in restricted areas, possessing definite characteristics, *i.e.*, outbreak areas.

2. The factors determining the transformation of phase *solitaria* into phase *gregaria* may differ for each species, or for each geographical race of the same species, according to the conditions in which the insects live.

3. The main object of the international anti-locust research must be the delimitation of the outbreak areas.

4. The exact delimitation of the outbreak centres and the possibility of foreseeing the appearance of the primary swarms, should be pursued by means of a thorough study of the factors determining the transformation of phase *solitaria* into phase *gregaria* in each species, or in each geographical race of the same species.

5. Among the ecological conditions determining or facilitating the transformation of phases, the effect of the following on the bionomics and physiology of locusts must be specially studied:

(*a*) humidity, temperature and other micro-climatic elements of the habitat;

A la séance de lundi, 17 septembre, la Conférence passe à l'examen de la question du lieu et de la date de la prochaine réunion. M. de Peyerimhoff (France) propose que la Quatrième Conférence Internationale pour les Recherches Antiacridiennes se réunisse en le Caire. M. Mistikawi (Égypte) fait savoir qu'il a été autorisé par le Gouvernement égyptien à déclarer à la Conférence que ce dernier accueillait chaleureusement la proposition de convoquer la prochaine réunion de la Conférence au Caire, et qu'il serait heureux de prendre les dispositions nécessaires. La Conférence décide par acclamation que la prochaine réunion sera convoquée au Caire au printemps 1936.

La Conférence sanctionne ensuite les résolutions suivantes :—

RÉSOLUTIONS DE LA CONFÉRENCE.

1.—PROBLÈMES GÉNÉRAUX CONCERNANT TOUTES LES ESPÈCES D'ACRIDIENS TROUVÉS EN AFRIQUE ET EN ASIE OCCIDENTALE.

(a) Aires grégarigènes et facteurs de transformation de la phase solitaire des acridiens migrateurs dans la phase grégaire.

Les résultats des investigations faites dans les différents pays, ne laissent pas de doutes sur la localisation des zones d'apparition des bandes primitives d'acridiens, par lesquelles débutent les invasions, sur des superficies restreintes à caractères définis, c'est-à-dire, les aires grégarigènes.

2. Les facteurs déterminant la transformation de la phase *solitaria* dans la phase *gregaria* de chaque espèce ou de chaque groupe géographique d'une même espèce peuvent être différents suivant les conditions d'existence des insectes;

3. La délimitation des aires grégarigènes doit être le but principal des recherches antiacridiennes internationales;

4. La délimitation définitive des foyers grégarigènes, et la prévision de l'apparition des bandes primitives d'invasions, sont subordonnées à une étude approfondie des facteurs qui déterminent la transformation de la phase *solitaria* dans la phase *gregaria* de chaque espèce ou de chaque groupe géographique d'une même espèce.

5. Parmi les conditions écologiques, déterminant ou facilitant la transformation des phases, les facteurs suivants, en ce qui concerne leur répercussion sur le comportement et les fonctions organiques des acridiens, doivent être étudiés spécialement :

(*a*) l'humidité, la température et autres éléments microclimatiques du milieu habité par les insectes;

(*b*) the food, particularly as a factor determining the habitat of individuals in different stages of their development;

(*c*) associations with other species of animals (in particular parasites and predators) and plants;

(*d*) accumulation of individuals of the same species.

6. Research in the outbreak areas must be supplemented by a thorough experimental study on the influence of different factors on locusts, and this study should be carried out in central laboratories, working in a close contact with the investigators in the field.

(b) Life-cycle, particularly sexual maturation, in relation to climatic and other factors; and methods of study.

1. The evidence so far obtained tends to show that the initial increase in numbers of solitary locusts which lead to the formation of incipient swarms may occur as a result of the acceleration of the life-cycle. This increase is due—according to the district and the species in question—in most cases so far studied to a rapid succession of generations during a short favourable season, but it may also be due to a gradual multiplication over a period of years. Studies of the life-cycle are, therefore, of vital importance for the solution of the locust problem.

2. The ability of locusts to change their life-cycle under the direct influence of climatic factors has been repeatedly demonstrated. The importance of this fact for the correct forecasting of invasions and for the planning of anti-locust campaigns is evident. Studies of the life-cycle are, therefore, of immediate practical importance.

3. Tropical conditions are usually favourable for the development of eggs and larvae without a diapause, but diapauses in the adult stage, consisting of the delayed sexual maturation, are of common occurrence. The duration, therefore, of the total life-cycle depends mainly on the absence or presence of a diapause in the adult stage. The presence or absence of this diapause should accordingly be regarded as the central problem of the life-cycle.

4. The effects of the following factors on sexual maturation should be studied:—

(*a*) air temperature (constant and fluctuating);
(*b*) air humidity (constant and fluctuating);
(*c*) rainfall;
(*d*) temperature and humidity in combination;
(*e*) solar radiation;
(*f*) food;
(*g*) activity.

(*b*) la nourriture, en particulier comme facteur déterminant la localisation des individus à leurs différents stades de développement;
(*c*) les associations avec d'autres espèces animales (parasites et prédateurs en particulier) et végétales;
(*d*) l'accumulation des individus d'une même espèce.

6. Les recherches dans les aires grégarigènes doivent être complétées et contrôlées par une étude expérimentale approfondie de l'influence des différents facteurs sur les espèces d'acridiens, et cette étude doit être faite dans des laboratoires centraux agissant en étroit contact avec les investigateurs dans la nature.

(b) Cycle évolutif, particulièrement maturation sexuelle, par rapport aux facteurs climatiques et autres; et méthodes d'étude.

1. Il semble jusqu'ici démontré que l'augmentation initiale du nombre des acridiens solitaires qui amène le début de la formation des essaims peut survenir à la suite d'une accélération du cycle évolutif. Cette augmentation est due—suivant la région et l'espèce considérées—dans la plupart des cas jusqu'à présent étudiés, à une rapide succession de générations pendant une courte saison favorable, mais peut-être également à une multiplication graduelle s'étendant sur quelques années. L'étude du cycle évolutif est donc d'une importance capitale pour la solution du problème acridien.

2. On a souvent démontré que les acridiens sont capables de changer leur cycle évolutif sous l'influence directe des facteurs climatiques. L'importance de ce fait pour la prévision correcte des invasions et pour l'organisation des campagnes antiacridiennes est évidente. L'étude du cycle évolutif est donc d'une importance pratique immédiate.

3. Les conditions tropicales sont ordinairement favorables au développement d'œufs et de larves sans diapause, bien que des diapauses dans le stade adulte, consistant en une maturation sexuelle retardée, s'observent fréquemment. Or la durée du cycle évolutif total dépend principalement de l'absence ou de la présence d'une diapause dans le stade adulte. Par conséquent l'absence ou la présence de cette diapause doit être considérée comme le problème central du cycle évolutif.

4. On devrait étudier les effets des facteurs suivants sur la maturation sexuelle:

(*a*) température de l'air (constante et variable);
(*b*) humidité de l'air (constante et variable);
(*c*) pluviosité;
(*d*) température et humidité en combinaison;
(*e*) radiation solaire;
(*f*) nourriture;
(*g*) activité.

5. The initial data bearing on the problem of diapauses should be collected in the field. For this purpose, the life-cycle of locusts under natural conditions should be studied at temporary field laboratories, fully equipped for observations on weather and microclimate.

6. The data so collected should form a basis for exact experimental work in central laboratories, in which alone the full significance of the various factors can be investigated.

(c) Migration and the factors inducing it with regard to all phases, and methods of their study, with special reference to the type of meteorological maps likely to be of assistance.

1. The aim of the study of migration and the factors inducing it is to build up a forecasting system in order to enable countries to prepare for locust invasions in advance. Good meteorological services in all areas would facilitate the evolution of such a system.

2. In view of the importance of meteorological research in connection with present and future biological investigations on locusts, the Conference hopes that the co-operating Governments will establish, either permanently or temporarily, meteorological stations supplementary to the existing stations wherever the reports of field investigators show the necessity therefor.

3. In view of the uncertainty as to which climatic factors are important in controlling locust migrations, the heads of the meteorological services of all countries invaded by locust swarms should be asked by their respective Governments to arrange that records of the movements of flying swarms should be made a routine observation at all first and second class meteorological stations. In order to establish correlations between such movements and local weather conditions, the data obtained should be analysed by meteorologists and entomologists working together. Instructions for recording should be supplied to all observers by the national locust organisations.

4. Temperature, humidity, and wind are already known to affect the migrations of locusts. Records of these factors are of great value for the study of locusts, if presented in the form of meteorological maps. In the case of humidity, the data should be translated into terms of saturation deficiency or evaporating power, and not presented in terms of absolute or relative humidity, which do not affect insects directly. Since actual humidity records are taken only at a few stations, monthly rainfall maps would serve as an approximation over areas for which there are no humidity data.

5. Les données initiales portant sur le problème des diapauses devraient être recueillies sur le terrain. Dans ce but, le cycle évolutif des acridiens dans le milieu naturel devrait être étudié dans les laboratoires locaux complètement outillés pour des observations sur le temps et le microclimat.

6. Les données ainsi recueillies devraient servir de base à des travaux expérimentaux exacts dans les laboratoires centraux, car ce n'est que dans ceux-ci qu'on peut examiner toute l'importance des facteurs divers.

(c) **La migration et ses facteurs déterminants par rapport à toutes les phases, méthodes d'étude, et spécialement type de cartes météorologiques qui pourraient être utiles.**

1. L'objet de l'étude de la migration et de ses facteurs est de construire un système de prévisions qui permettrait aux pays de se prémunir d'avance contre les invasions d'acridiens. De bons services météorologiques dans toutes les contrées faciliteraient l'évolution d'un tel système.

2. Étant donné l'importance des données météorologiques dans les recherches présentes et futures de biologie acridienne, il est à souhaiter que les Gouvernements coopérants installent des stations météorologiques complémentaires au réseau déjà créé, stations soit permanentes, soit temporaires, partout où les indications fournies par les missions d'études en feront apparaître la nécessité.

3. Vu l'incertitude qui règne sur les facteurs climatiques qui ont le plus d'importance pour les migrations des acridiens, les chefs des services météorologiques de tous les pays envahis par des essaims devraient être priés par leurs Gouvernements respectifs de veiller à ce que les mouvements d'essaims volants soient enregistrés comme observations de routine dans toutes les stations météorologiques de première et de deuxième classe. Pour établir des corrélations entre ces mouvements et les conditions locales du temps, les données obtenues devraient être analysées par les météorologistes et les entomologistes travaillant de concert. Des instructions pour l'enregistrement devraient être fournies à tous les observateurs par les organisations nationales antiacridiennes.

4. La température, l'humidité et le vent sont déjà connus comme affectant les migrations des acridiens. L'enregistrement de ces facteurs est d'une grande valeur pour l'étude des acridiens, à condition qu'il soit présenté sous forme de cartes météorologiques. Dans le cas de l'humidité, les données devraient exprimer le déficit de saturation ou pouvoir d'évaporation et non pas l'humidité absolue ou relative, lesquelles n'affectent pas directement les insectes. Puisque l'humidité même n'est enregistrée que dans quelques stations peu nombreuses, des cartes de pluie mensuelle serviraient de donnée approximative, dans les contrées où il n'y a pas de données formelles sur l'humidité.

5. In order that meteorological maps may be of use in the study of locust migrations, they should contain the original meteorological data for each meteorological station.

6. The following meteorological data represent the minimum amount of information which it is desirable to obtain from each meteorological station :—

(*a*) altitude of the station;
(*b*) maximum and minimum temperatures;
(*c*) dry bulb temperature;
(*d*) wet bulb temperature;
(*e*) rainfall;
(*f*) wind direction and wind force;
(*g*) cloud amount;
(*h*) atmospheric pressure.

7. Monthly maps representing the territory studied should show by means of continuous lines of equal value the following data :—

(*a*) maximum and minimum temperatures;
(*b*) relative humidity;
(*c*) rainfall;
(*d*) atmospheric pressure;
(*e*) wind direction.

8. It is desirable that the information and maps prepared locally at monthly intervals should be transmitted without delay to the meteorological centres and should be published as soon as possible.

9. In view of the importance of climatological factors for the study of the locust problem, the Conference considers it desirable that Governments should attach meteorologists to the locust research organisations.

10. In view of the poverty of meteorological records over many of the areas infested by locusts and the ease with which such records may be misinterpreted, the analysis of swarm records in connection with climatic factors should only be undertaken by, or in collaboration with, persons having some personal experience of the areas in question.

(d) Ecology and habits of locusts in invasion areas, with special reference to dissociating factors.

1. The study of locusts in invasion areas is of importance because :—

(*a*) these areas have not yet been fully defined and delimited, and in certain parts contain habitats which may prove suitable for the solitary phase (phase *solitaria*);
(*b*) the study of dissociating factors is likely to provide valuable indications of those ecological and climatic conditions which characterise outbreak centres;

5. Les cartes météorologiques, pour être utiles à l'étude des migrations des acridiens, devraient contenir les données météorologiques originales pour chaque station météorologique.

6. Les données climatologiques suivantes représentent le minimum de renseignements qu'il faudrait obtenir de chaque poste météorologique :

(*a*) altitude du poste;
(*b*) températures maxima et minima;
(*c*) température au thermomètre sec;
(*d*) température au thermomètre mouillé;
(*e*) pluviosité;
(*f*) direction et force du vent;
(*g*) nébulosité;
(*h*) pression atmosphérique.

7. Les cartes mensuelles du territoire étudié devraient porter, en lignes reliant les valeurs égales, les données suivantes :—

(*a*) températures maxima et minima;
(*b*) humidité relative;
(*c*) pluviosité;
(*d*) pression atmosphérique;
(*e*) direction du vent.

8. Il est désirable que les renseignements et les cartes établies mensuellement sur place parviennent sans retard aux centres météorologiques et qu'elles soient publiées aussitôt que possible.

9. Considérant l'importance des facteurs climatiques pour l'étude du problème acridien, la Conférence souhaite que les Gouvernements attachent des météorologistes aux organisations de recherches anti-acridiennes.

10. Vu la rareté des rapports météorologiques dans beaucoup de contrées infestées par les acridiens et la facilité avec laquelle l'interprétation de ces rapports prête aux erreurs, l'analyse des indications fournies sur les essaims, par rapport aux facteurs climatiques, ne devrait être entreprise que par des techniciens ayant une expérience personnelle des contrées en question, ou en collaboration avec eux.

(d) Écologie et comportement des acridiens dans les aires d'invasion, eu égard spécialement aux facteurs dissociants.

1. L'étude des acridiens dans les aires d'invasion est importante parce que :—

(*a*) ces aires ne sont pas encore nettement délimitées, et dans certaines parties elles contiennent des stations qui peuvent favoriser la phase solitaire (phase *solitaria*);
(*b*) il est probable que l'étude des facteurs de dissociation fournira de précieuses indications sur les conditions écologiques et climatiques qui caractérisent les foyers grégarigènes;

(c) countries situated within invasion areas desire convincing evidence not only regarding the position of outbreak centres outside their borders, but also that it is impossible for swarms to arise within their own territories.

2. It is desirable that the attention of Governments should be drawn to the importance of carrying out research in regard to locusts in their gregarious phase when the invasion is declining in intensity.

3. An important aspect of locust investigations in the invasion areas is a study of the preferences exhibited by invading swarms in the selection of egg-laying sites, with special reference to the effect on such choice of present and past cultivation.

(e) Research on *Empusa grylli* (Fresenius) and other fungi and bacteria parasitic on locusts.

1. Certain recent evidence suggests that the occurrence of epidemics of the locust fungus, *Empusa grylli* (Fresenius), is not as closely bound up with weather conditions as has been supposed of late years, but that sources of infection are sometimes wanting.

2. The Conference therefore recommends that a combined field and laboratory study of the fungus should be made with a view, not only to discovering the rôle played by it in swarm cycles, but also to investigating the possibility of disseminating it artificially as a practical-control method. This study would best be made in one of the more developed countries of the southern half of Africa, such as Southern Rhodesia or the Union of South Africa.

3. In order to facilitate research on *Empusa grylli* (Fresenius) and other fungus and bacterial parasites of locusts, the Conference hopes that workers in this field will deposit their cultures of fungi at the Centraalbureau voor Schimmelcultures, Baarn (Holland), and cultures of bacteria at the Lister Institute, London, and the Pasteur Institute, Paris.

(f) Methods of field surveys.

The Conference considers that in each country entomologists engaged in field work should themselves choose the methods which in their opinion are the most likely to secure the objects to which their research is directed.

The Conference, however, desires to draw the attention of entomologists to the following special points:—

1. *Uniformity in methods of study.*

Uniformity in the methods of estimating locust populations and of recording the ecological characteristics of habitats is desirable as between different territories, and is essential within each territory.

(c) les pays compris dans les aires d'invasion désirent recevoir des renseignements décisifs tant sur la position des foyers grégarigènes au delà de leurs frontières que sur l'éventualité d'un transport d'essaims sur leurs propres territoires.

2. Il est désirable d'attirer l'attention des Gouvernements sur l'importance de la poursuite des recherches sur les acridiens dans leur phase grégaire à l'époque du déclin d'invasion.

3. Un aspect important de l'étude des acridiens dans les aires d'invasion est la préférence que manifestent les essaims dans le choix des endroits de ponte, et tout spécialement l'influence de cultures passées et présentes sur le choix de ces endroits.

(e) Recherches sur *Empusa grylli* (Fresenius) et autres champignons ou bactéries, parasites des acridiens.

1. Certaines constatations récentes font penser que les épidémies du champignon des acridiens, *Empusa grylli* (Fresenius), ne sont pas aussi étroitement liées avec les conditions climatiques qu'il avait été supposé pendant les dernières années, mais que les sources d'infection sont parfois absentes.

2. La Conférence recommande donc qu'une étude combinée, sur le terrain et en laboratoire, soit entreprise pour découvrir le rôle joué par le champignon dans le cycle grégarigène, et aussi pour examiner les possibilités de dissémination artificielle comme méthode de lutte pratique. Cette étude pourrait être entreprise de préférence dans un des pays les plus évolués de l'Afrique méridionale, tels que la Rhodésie du Sud ou l'Union de l'Afrique du Sud.

3. Afin de faciliter les recherches sur l'*Empusa grylli* (Fresenius) et sur tout autre champignon ou bactérie parasite des acridiens, la Conférence exprime l'espoir que les techniciens de ces questions déposent leurs cultures au Centraalbureau voor Schimmelcultures, Baarn (Hollande), pour les champignons et, pour les bactéries, au Lister Institute à Londres et à l'Institut Pasteur de Paris.

(f) Méthodes d'études sur le terrain.

La Conférence estime que dans chaque pays les entomologistes travaillant sur le terrain doivent choisir eux-mêmes les méthodes qu'ils jugent les plus propres à assurer la réussite de leurs recherches.

Cependant, la Conférence attire l'attention des entomologistes sur les points particuliers suivants :—

1. *Uniformité dans les méthodes d'études.*

L'uniformité dans les méthodes d'évaluation numérique des populations acridiennes et dans les méthodes de détermination des caractères écologiques de leurs stations est à souhaiter entre les différents pays, mais elle est surtout essentielle dans l'intérieur de chaque pays.

2. *Study of locust populations.*

(*a*) In making population studies of locusts it may in some circumstances be of value to include other species of insects or even other animals.

(*b*) The ideal method of estimating population is by the counting of numbers per unit area. Where in any particular territory the density of vegetation or other causes prevent this method from being sufficiently accurate, countings should be by numbers seen or caught per unit of time. Where the method of estimating is based on the number of specimens captured, captures should be made in the morning before the commencement of full activity.

(*c*) On account of the difficulties encountered in the use of the methods indicated above and the possible variations in their detailed application, the Conference recommends that in making reports entomologists should indicate with the greatest precision the methods which they have employed.

3. *Analysis of plant communities.*

(*a*) Plant communities, in habitats where a number of species occur, should be analysed by one of the recognised methods employed in ecological botany.

(*b*) In habitats consisting only of one species of plant, the average height of the plants, the average number of plants per unit of areas, and the green weight (measured in grammes) of plants from one unit of area should form the standard of comparison.

4. *Meteorological methods in the field.*

(*a*) Field laboratories should include a meteorological station in which, as far as possible, the following climatic data should be recorded:—

(i) precipitation;
(ii) wind direction;
(iii) wind intensity;
(iv) relative humidity observed at the standard hours of the meteorological offices of the territories concerned;
(v) maximum and minimum shade temperatures, and shade temperatures observed at the standard hours of the meteorological offices of the territories concerned.

(*b*) Microclimates are best studied by means of self-recording instruments. These should be of a type which can be readily moved from one station to another. The opinion of expert meteorologists should be obtained as to the types of instrument best suited for each purpose and for each territory.

2. *Etude des populations acridiennes.*

(*a*) En faisant l'étude des populations acridiennes il peut être d'une grande utilité, en certains cas, d'y adjoindre celle d'autres espèces d'insectes ou même d'autres animaux.

(*b*) La méthode idéale pour évaluer une population acridienne est de compter par unité de surface. Dans les territoires où la densité de la végétation ou d'autres causes rendent cette méthode insuffisamment sûre, il y a lieu de compter les insectes, vus ou pris, par unité de temps. Là où la méthode d'évaluation sera basée sur le nombre des captures, il y aura lieu d'effectuer ces captures le matin avant le début de la pleine activité.

(*c*) En raison des difficultés d'emploi des méthodes ci-dessus indiquées, et des variations de détail qui interviendront dans leur application, la Conférence recommande aux entomologistes de décrire ces méthodes avec grande précision, dans les rapports qu'ils rédigeront.

3. *Analyse des associations végétales.*

(*a*) La végétation des stations où existent plusieurs espèces devra être analysée à l'aide d'une des méthodes accréditées en phytogéographie.

(*b*) Dans les stations où n'existe qu'une seule espèce de plante, la hauteur moyenne des plantes, le nombre moyen de plantes par unité de surface et le poids vert (mesuré en grammes) par unité de surface peuvent former les éléments de comparaison.

4. *Méthodes météorologiques sur le terrain.*

(*a*) Les laboratoires de recherches sur le terrain doivent comprendre une station météorologique dans laquelle autant que possible on notera les éléments climatiques suivants :—

(i) précipitations;
(ii) direction du vent;
(iii) force du vent;
(iv) humidité relative observée aux mêmes heures que dans les services météorologiques régionaux;

(v) maximum et minimum de la température à l'ombre, et températures à l'ombre observées aux mêmes heures que dans les services météorologiques régionaux.

(*b*) L'étude des microclimats sera effectuée au mieux à l'aide d'instruments enregistreurs. Ceux-ci doivent appartenir à un type permettant de les déplacer facilement d'une station à une autre. L'opinion des experts météorologistes sera demandée en ce qui concerne les types d'instruments les mieux adaptés à chaque usage et à chaque territoire.

(g) The need for fundamental research.

1. Fundamental research in locust biology and locust physiology is urgently needed, as the solution of many practical problems depends on it.

2. Since the present international locust investigations have a purely practical aim in view, it is desirable that the attention of research laboratories should be concentrated on those problems which have the greatest immediate value for the elucidation of the locust problem.

3. It is desirable that financial assistance should be provided by locust organisations to enable research laboratories to undertake such studies.

4. The following problems particularly require fundamental investigation :—

(*a*) the rate of activity of different phases as regulated by environmental factors (heat, humidity, light, food, density of population, &c.);
(*b*) the conditioning of behaviour by crowding and isolation;

(*c*) the biochemical nature of pigments and their rôle in metabolism;
(*d*) the reactions of hoppers and adults to environmental stimuli;
(*e*) the resistance of different stages and phases to the physical factors of environment;
(*f*) the importance of diapauses to the life-cycle;
(*g*) the diseases and parasites of locusts.

5. In order to avoid the duplication of work, it is desirable that the information on the research work undertaken in various laboratories should be communicated to the Imperial Institute of Entomology, London (the international centre for anti-locust research), for distribution to other laboratories.

(h) Research on arsenical and other compounds in locust control.

It is generally accepted that the use of arsenical compounds in the form of poison baits, dust or spray is at present the most efficient, cheap and convenient method available for destroying locusts. There are certain disadvantages attaching to this method, and the Conference considers, however, that further effort be made to elucidate the following points :—

(*a*) the reasons for the variation in efficiency said to attach to the use of poison bait with certain species of locust in certain countries;

(g) Nécessité de recherches fondamentales.

1. Des recherches fondamentales de biologie et de physiologie acridiennes sont d'une nécessité urgente, puisque la solution de beaucoup de problèmes pratiques en dépend.

2. Les études internationales actuelles envisageant un but purement pratique, il est à souhaiter que l'attention des laboratoires de recherches se concentre sur les problèmes ayant la plus grande valeur immédiate pour la solution du problème acridien.

3. Il est à souhaiter que des aides financières soient fournies par les organisations antiacridiennes pour permettre aux laboratoires de recherches d'entreprendre de telles études.

4. Les problèmes suivants demandent surtout une investigation fondamentale :—

(*a*) le degré d'activité des phases différentes sous l'influence des facteurs du milieu (chaleur, humidité, lumière, nourriture, densité de population, etc.);
(*b*) le comportement des acridiens conditionné par la congrégation et l'isolement;
(*c*) la nature biochimique des pigments et leur importance dans le métabolisme;
(*d*) la réaction des larves et des adultes à la stimulation du milieu;
(*e*) la résistance des différents stades et phases aux facteurs physiques du milieu;
(*f*) l'importance des diapauses dans le cycle évolutif;
(*g*) les maladies et les parasites des acridiens.

5. Afin d'éviter le dédoublement des recherches, il est à souhaiter que les informations concernant le travail déjà commencé dans chaque laboratoire soient communiquées à l'Imperial Institute of Entomology à Londres, centre international pour les recherches antiacridiennes, pour être distribuées aux autres laboratoires.

(h) Recherches sur les composés à base d'arsenic ou autres comme méthode de destruction des acridiens.

On admet généralement que l'emploi des composés à base d'arsenic, sous forme d'appât empoisonné, poudre ou liquide, est actuellement le plus efficace, le moins cher et le plus pratique des moyens de destruction des acridiens. Cette méthode présente cependant quelques inconvénients. La Conférence estime de toutes façons que les questions suivantes doivent être résolues :—

(*a*) raisons pour lesquelles l'efficacité des appâts empoisonnés ne serait pas la même selon l'espèce d'acridiens et selon le pays;

(*b*) the exact toxic action of arsenic on locusts, particularly when applied as a dry dust;

(*c*) the possibility of finding substitutes for arsenic compounds which are more efficient, cheaper and more convenient in use.

(i) Locust control by means of aircraft.

1. The recent experiments in the use of aircraft against locusts suggest that:—

(*a*) locusts in flight make no effort to avoid a cloud of sodium arsenite dust, even when the cloud is dense, but instead pass steadily through it; and further, that the passage of an aircraft through a locust swarm and across its line of flight does not cause the swarm to change its course;

(*b*) the dust cloud should be discharged as close as possible to the front of the swarm; and that in the case of large swarms more than one discharge is necessary;

(*c*) the majority of the locusts which actually pass through a dust cloud ultimately drop out of the swarm and die;

(*d*) under normal atmospheric conditions, it is possible to discharge from an aircraft a cloud of sodium arsenite dust of sufficient density to remain toxic to locusts for a period of not less than three minutes;

(*e*) if a swarm on migration flight passes through a dust cloud, a large percentage of the locusts fall to the ground and die, and that it appears that this is due to paralysis of the wings brought about by inhalation of the dust;

(*f*) it is important that the sodium arsenite dust should be uniform in fineness, and that the swarms should be flying not less than 100 ft. above the ground, if risk of damage to livestock and crops through contact with the arsenite is to be avoided;

(*g*) valuable results may also be obtained by the use of aircraft for distributing sodium arsenite dust over swarms resting in trees or on the ground, where this can be done without risk to livestock and crops.

2. The Conference considers that it is highly desirable that further experiments should be carried out with a view to developing the foregoing methods of controlling locusts by means of aircraft.

(*b*) nature exacte de l'effet toxique de l'arsenic sur les acridiens, surtout sous forme de poudre sèche;
(*c*) possibilités de remplacer l'arsenic par des matières plus efficaces, moins chères et d'emploi plus facile.

(i) L'emploi d'avions contre les acridiens.

1. Les expériences récemment faites par les avions dans la lutte antiacridienne portent à croire que:

(*a*) les acridiens volant ne font aucun effort pour éviter une nuée de poudre d'arsénite de soude quand même elle serait épaisse; elles la traversent, sans s'arrêter. En outre, le passage d'un avion dans un essaim d'acridiens et à travers sa ligne de vol ne les fait pas changer de route;
(*b*) la nuée de poudre devrait être lancée en avant de l'essaim et aussi près que possible. Dans le cas des grands essaims plus d'un lancement est nécessaire;
(*c*) la majorité des acridiens qui traversent une nuée de poudre tombe finalement de l'essaim et meurt;
(*d*) dans des conditions atmosphériques normales, il est possible de lancer d'un avion une nuée de poudre d'arsénite de soude d'une densité suffisante pour rester toxique aux acridiens pour une période d'au moins trois minutes;
(*e*) si un essaim en vol migratoire traverse une nuée de poudre, une grande proportion des acridiens tombe à terre et meurt. On attribue ce résultat à la paralysie des ailes amenée par l'inhalation de la poudre;
(*f*) il est important que la poudre d'arsénite de soude soit uniformément fine et que les essaims attaqués ne volent pas à une hauteur inférieure à une trentaine de mètres au-dessus de la terre, si on veut éviter de nuire au bétail et aux cultures;
(*g*) des résultats précieux peuvent être obtenus par l'emploi d'avions pour distribuer l'arsénite de soude sur des essaims posés, partout où l'opération ne nuira ni au bétail ni aux cultures.

2. La Conférence considère comme fort souhaitable que des expériences ultérieures soient exécutées en vue de développer les méthodes précitées de lutte au moyen d'avions.

2.—THE SPECIAL PROBLEMS OF EACH SPECIES OF LOCUST AND THE STEPS TO BE TAKEN FOR THEIR FURTHER INVESTIGATION.

(a) The Tropical Migratory Locust, *Locusta migratoria migratorioides* (Reiche and Fairmaire).

The problem of the outbreak centres of the Tropical Migratory Locust in the French Soudan has reached the stage of systematic research in the field, at specified points and by local observers.

The Conference, considering that the work of field investigators whose principal function is to determine the outbreak centres should after their departure be carried on by staffs of observers whose duty it should be to apply and develop the methods laid down by the field investigators and to enlarge at a later stage the existing nucleus of organisations responsible for preventing the formation of migratory swarms, hopes that the co-operating Governments will select from their agricultural staffs observers for service in each region in which it seems necessary who shall act under the instructions of the principal field officers.

(*Note.—These are enumerated in Resolution* 3 (*a*) (i) *below.*)

(b) The Desert Locust, *Schistocerca gregaria* (Forskål).

The problem of the Desert Locust is further from solution than that of other locust species. This is due to the fact that there is still very little known regarding its outbreak areas, owing to the wide extent and difficult nature of the countries in which they are suspected to be located.

It is, therefore, urgently necessary that the Governments concerned should arrange for at least preliminary surveys to be undertaken of the regions suspected of being outbreak areas.

(*Note.—These are enumerated in Resolution* 3 (*a*) (ii) *below.*)

(c) The Red Locust, *Nomadacris septemfasciata* (Serville).

1. To assist in the delimitation of the outbreak areas and outbreak centres of the Red Locust, it is desirable that all African territories south of the Sahara, whether known to be liable to invasion by this species or not, should prepare vegetation maps to show the distribution and nature of open and very thinly bushed grasslands. Copies of these should be sent to the international centre for anti-locust research (the Imperial Institute of Entomology, London), either direct or through their own national anti-locust

2.—LES PROBLEMES SPÉCIAUX À CHAQUE ESPECE D'ACRIDIEN ET LES MESURES À PRENDRE POUR LEUR INVESTIGATION FUTURE.

(a) **Le Criquet Migrateur Tropical,** *Locusta migratoria migratorioides* (Reiche et Fairmaire).

La question des foyers grégarigènes du Criquet Migrateur Tropical dans le Soudan français passe dans la phase des recherches méthodiques sur place, en des points définis, par des observateurs locaux.

En effet, les missions d'études, dont le rôle principal est de délimiter les foyers grégarigènes doivent être, après leur départ, prolongées par des équipes de surveillance qui appliqueront et développeront leurs méthodes d'investigation et constitueront plus tard les noyaux des organismes chargés de s'opposer à la formation des essaims. La conférence souhaite donc que les Gouvernements coopérants désignent parmi leur personnel agricole, et dans chaque région où la nécessité s'en manifestera, des observateurs qui recevront les directives des chefs de mission.

(*Note.—Ces régions sont énumérées au bas de la Résolution* 3 (*a*) (i).)

(b) **Le Criquet Pèlerin,** *Schistocerca gregaria* (Forskål).

Le problème du Criquet Pèlerin est plus éloigné de sa solution que celui de n'importe quelle autre espèce d'acridien. Ceci résulte du fait que l'on sait très peu de chose sur ses aires grégarigènes par suite de la grande étendue et de la nature difficile des pays où on en soupçonne la présence.

Or, il est d'une nécessité urgente que les Gouvernements intéressés ordonnent l'entreprise d'études au moins préliminaires dans les régions à aires grégarigènes présumées.

(*Note.—Ces régions sont énumérées au bas de la Résolution* 3 (*a*) (ii).)

(c) **La Sauterelle Rouge,** *Nomadacris septemfasciata* (Serville).

1. Afin de faciliter la délimitation des aires et des foyers grégarigènes de la Sauterelle Rouge, il est à souhaiter que tous les territoires africains au Sud du Sahara, qu'ils soient déjà reconnus propres à l'invasion de cette espèce ou non, fassent préparer des cartes de végétation indiquant la distribution et la nature des prairies ouvertes ou très peu boisées. Des exemplaires de ces cartes seraient adressés au centre international des recherches antiacridiennes (l'Imperial Institute of Entomology à Londres), soit directement,

organisations or through the Southern African Locust Bureau. Such maps will be greatly increased in value if photographs and notes on the vegetation can be added.

2. In all countries general observations should be made on the changes in distribution of isolated locusts during the later stages of the swarm outbreak.

3. In addition to the laboratory work already carried out in various places to solve the problems set by field work on the Red Locust, at least one extra whole-time laboratory worker with adequate facilities is needed. This worker should keep in the closest possible touch with the field workers and should work on the problems which they find most urgent but are unable to investigate themselves; he should therefore work in the southern half of Africa. Rhodesia, the Union of South Africa and Mozambique appear to be the most suitable countries for such studies.

4. Entomological reconnaissance is still needed in certain areas.

(Note.—These are enumerated in Resolution 3 (a) (iii) below.)

(d) The Moroccan Locust, *Dociostaurus maroccanus* (Thunberg).

In view of the very promising results obtained in several Mediterranean countries in biological studies on the Moroccan Locust, it is highly desirable that such studies should be continued by the Governments concerned and initiated by the Governments of other countries suffering from the ravages of this locust.

3.—ARRANGEMENTS FOR FURTHER INTERNATIONAL CO-OPERATION IN ANTI-LOCUST RESEARCH.

(a) Allocation for each species of locust of the areas to be investigated.

(i) The Tropical Migratory Locust, *Locusta migratoria migratorioides* (Reiche and Fairmaire).

The regions of the Middle Niger (zone of inundation and South Sahelien zone) are of international interest. They should be regarded as the principal objective for research on the outbreak centres of the Tropical Migratory Locust. The biological study of this species, already begun by the French authorities, should be pursued in the Middle Niger preferably for the moment, as this is at present believed to be the only outbreak area of this species.

soit par l'entremise des organisations antiacridiennes nationales ou du Bureau Acridien de l'Afrique du Sud. La valeur de ces cartes serait accrue si elles étaient accompagnées de photographies et de mémoires sur la végétation.

2. Des études générales devraient être faites dans tous les pays sur les changements de la distribution des acridiens isolés au cours des dernières phases de l'invasion.

3. Outre les recherches déjà faites dans les laboratoires de divers pays sur les problèmes posés par la prospection de la Sauterelle Rouge, au moins un expert devrait travailler en laboratoire, de manière continue et avec toutes les facilités nécessaires. Cet expert se maintiendrait en liaison étroite avec les missions, et concentrerait ses efforts sur les problèmes que celles-ci indiqueraient comme les plus urgents, sans pouvoir les aborder elles-mêmes. Il devrait donc travailler dans la partie méridionale de l'Afrique. La Rhodésie, l'Union de l'Afrique du Sud et le Moçambique semblent être les pays les plus propres à cette étude.

4. Les travaux de reconnaissance entomologique sont encore nécessaires dans certaines régions.

(Note.—Ces régions sont énumérées au bas de la Résolution 3 (*a*) (iii).)

(d) Le Criquet Marocain, *Dociostaurus maroccanus* (Thunberg).

En raison des résultats très utiles obtenus dans divers pays méditerranéens par l'étude biologique du Criquet Marocain, il est très souhaitable que les Gouvernements en question poursuivent ces études, et que les Gouvernements d'autres pays attaqués par cette espèce entreprennent des études parallèles.

3.—ARRANGEMENTS PRÉVUS POUR LA COOPÉRATION INTERNATIONALE ANTIACRIDIENNE.

(a) Répartition, pour chaque espèce d'acridiens, des régions à étudier.

(i) Le criquet migrateur tropical, *Locusta migratoria migratorioides* (Reiche et Fairmaire).

Les régions du Moyen-Niger (zone d'inondations et zone sud-sahélienne) sont d'intérêt international. Elles doivent être considérées comme l'objectif principal des recherches sur les foyers grégarigènes du Criquet Migrateur Tropical. L'étude biologique de cette espèce déjà commencée par les missions françaises, devra être poursuivie dans le Moyen-Niger, puisqu'on suppose actuellement que l'aire grégarigène de l'espèce est limitée à cette région.

(ii) THE DESERT LOCUST, *Schistocerca gregaria* (Forskål).

The main areas where further investigations are required are shown in the following list in which are indicated also those areas already investigated.

Regions and area.	Type of investigation required.	Countries by which work should be undertaken.
A.—*Moroccan-Senegambian region*—		
i. Mauritania	Reconnaissance... ...	France.
ii. Rio de Oro	Reconnaissance... ...	Spain.
iii. Draa Valley	Reconnaissance... ...	France.
B.—*Algerian-Nigerian region*—		
i. Nema area	(Already investigated).	
ii. Adrar des Iforas	(Already investigated).	
iii. Area north and north-east of lake Chad	Reconnaissance... ...	France.
iv. Southern part of the Niger Colony ("Tegama") ...	Reconnaissance... ...	France.
C.—*Sudanese-Arabian region*—		
i. Kordofan	(Already investigated).	
ii. Darfur	Reconnaissance in progress	Great Britain.
iii. African coast of the Red Sea:		
(*a*) Sudan Coast	Stationary work ...	Great Britain.
(*b*) Coast of Eritrea	Reconnaissance... ...	Italy.
(*c*) Abyssinia	Reconnaissance... ...	Abyssinia.
iv. Arabia:		
(*a*) Coastal plains of Yemen	Reconnaissance... ...	Yemen.
(*b*) Nefud	Reconnaissance... ...	Saudi Arabia.
(*c*) Batina plain	Reconnaissance... ...	Oman.
(*d*) Lahej	Reconnaissance... ...	Great Britain.
D.—*Somali region*—		
Italian Somaliland	Reconnaissance... ...	Italy.
E.—*Indian region*	Stationary and reconnaissance work in progress	India.
F.—*South West African region* ...	Detailed survey ...	Union of South Africa.

(iii) THE RED LOCUST, *Nomadacris septemfasciata* (Serville).

1. A primary reconnaissance would be of value in the Belgian Congo, where the Lualaba Valley should be regarded as a probable outbreak centre.

2. It is desirable that:—

(*a*) work on the grasslands of Mozambique should be undertaken by the Portuguese and Union of South Africa Governments;

(ii) LE CRIQUET PÈLERIN, *Schistocerca gregaria* (Forskål).

Les régions principales où des recherches sont nécessaires figurent dans la liste suivante, qui indique aussi les régions déjà étudiées.

Régions ou Territoires.	Type de recherche demandée.	Pays par lesquels le travail devrait être entrepris.
A.—*Région Maroc-Sénégambie*—		
i. Mauritanie	Reconnaissance... ...	France.
ii. Rio de Oro	Reconnaissance... ...	Espagne.
iii. Vallée du Draa	Reconnaissance... ...	France.
B.—*Région Algéro-Nigérienne*—		
i. District de Néma	(Déjà étudiée).	
ii. Adrar des Iforas	(Déjà étudiée).	
iii. Contrée au nord et au nord-est du lac Tchad	Reconnaissance... ...	France.
iv. Sud de la Colonie Niger ("Tegama")...	Reconnaissance... ...	France.
C.—*Région Soudano-Arabe*—		
i. Kordofan	(Déjà étudiée).	
ii. Darfur	Reconnaissance en progrès.	Grande-Bretagne.
iii. Côte africaine de la Mer Rouge:		
(*a*) Côte soudanaise	Travaux stationnaires	Grande-Bretagne.
(*b*) Côte d'Erythrée	Reconnaissance... ...	Italie.
(*c*) Ethiopie	Reconnaissance... ...	Ethiopie.
iv. Arabie:		
(*a*) Plaines littorales du Yémen	Reconnaissance... ...	Yémen.
(*b*) Néfud	Reconnaissance... ...	Arabie Saudienne.
(*c*) Plaine Batina	Reconnaissance... ...	Oman.
(*d*) Lahej	Reconnaissance... ...	Grande-Bretagne.
D.—*Région somalienne*—		
Somalie Italienne	Reconnaissance... ...	Italie.
E.—*Région indienne*	Reconnaissance et travaux stationnaires en cours	Inde.
F.—*Région de l'Afrique du Sud-Ouest*	Étude détaillée... ...	Union de l'Afrique du Sud.

(iii) LA SAUTERELLE ROUGE, *Nomadacris septemfasciata* (Serville).

1. Une reconnaissance préliminaire serait très utile dans le Congo belge, où la Vallée du Lualaba devrait être considérée comme foyer grégarigène probable.

2. Il est à souhaiter que:—

(*a*) des travaux sur les prairies du Moçambique soient entrepris par les Gouvernements du Portugal et de l'Union de l'Afrique du Sud;

(*b*) the Government of Nyasaland should initiate work on Lake Shirwa and Zomba Mountain and this work should be correlated with the work in progress in the Lower Shire in Portuguese East Africa;

(*c*) the Government of Northern Rhodesia should arrange to watch the Kafue Flats at Mazabuka;

(*d*) the Government of the Union of South Africa should arrange for the study of the Red Locust in the eastern grasslands of the Union.

3. A primary reconnaissance in Oubangi-Shari, in the southern parts of the Anglo-Egyptian Sudan and in Uganda before these areas are overrun by swarms would assist in the discovery of the essential features of outbreak centres.

4. It is desirable that investigations of the swarming phase (phase *gregaria*) should be undertaken by the Portuguese Government in the Mossamedes and Huila districts of Southern Angola and in the Kwango district of Northern Angola.

5. The authorities in the Belgian Congo should investigate the Belgian sector of the Kwango region.

6. It is desirable that the grasslands of the Mweru-Tanganyika lowlands of Northern Rhodesia should be mapped.

7. The southern shores of Lake Chad must be regarded as a potential outbreak centre of the Red Locust. At the moment, there is hardly any evidence available regarding the distribution of this locust in those parts of the shore lying in French territory to the east of Nigeria. It is desirable that this area should be examined. It is recommended that the British and French authorities should collaborate in this matter.

(iv) Other species of locust.

In view of the fact that the biological study of local species of migratory locusts of secondary importance may provide valuable information and serve to enlarge the means of control available against the principal migratory species, the Conference hopes that side by side with the programme of research already drawn up at this Conference, investigations should be carried out in regard to the secondary migratory species such as *Tylotropidius* sp., *Acrotylus* sp., &c.

(b) Improvements on the present system of reporting on locusts.

1. It is a matter of great satisfaction to the Conference that the recommendations made by the First and Second International Locust Conferences, held respectively in Rome and Paris, in regard to the preparation in every territory of reports on locust activities have met with the ready support of the majority of the authorities concerned.

(*b*) le Gouvernement du Nyassaland devrait entreprendre des travaux sur le Lac Shirwa et la Montagne de Zomba et ces travaux devraient concorder avec les travaux en cours sur le Shire inférieur dans l'Afrique Orientale Portugaise;

(*c*) le Gouvernement de la Rhodésie du Nord devrait se charger de l'observation des plaines de Kafue à Mazabuka;

(*d*) le Gouvernement de l'Union de l'Afrique du Sud devrait se charger de l'étude de la Sauterelle Rouge dans les prairies orientales de l'Union.

3. Une reconnaissance préliminaire en Oubangui-Chari, dans les parties méridionales du Soudan Anglo-Egyptien et dans l'Ouganda avant que ces régions soient envahies par des essaims, contribuerait beaucoup à la découverte des caractéristiques essentielles de leurs foyers grégarigènes.

4. Il est à souhaiter que des investigations de la phase grégaire (phase *gregaria*) soient entreprises par le Gouvernement portugais dans les districts Mossamedes et Huila d'Angola méridionale, ainsi que dans la région Kwango de l'Angola du Nord.

5. Les autorités du Congo belge devraient explorer le secteur belge de la région du Kwango.

6. Il est souhaitable que l'on dresse des cartes indiquant les plaines ouvertes du pays Mweru-Tanganyika, en Rhodésie du Nord.

7. Les rivages sud du Lac Tchad doivent être considérés comme aire grégarigène possible de la Sauterelle Rouge. Actuellement les connaissances font presque entièrement défaut sur la distribution de cet acridien dans la portion des confins du Tchad située en territoire français à l'est de la Nigérie. L'étude de cette région est très désirable. Il est recommandé qu'elle soit faite en collaboration par les autorités britanniques et françaises.

(iv) Autres espèces d'acridiens.

Considérant que l'étude biologique des acridiens migrateurs locaux d'importance secondaire pourrait fournir de précieux renseignements et contribuer à augmenter les moyens d'action sur les grands migrateurs, la Conférence souhaite que parallèlement aux divers programmes qu'elle a arrêtés, des recherches soient entreprises sur les migrateurs secondaires tels que *Tylotropidius* sp., *Acrotylus* sp., &c.

(b) Amélioration du système actuel des rapports sur les acridiens.

1. La Conférence est en droit de se féliciter du fait que les recommandations faites par la Première et la Deuxième Conférences Internationales pour les Recherches Antiacridiennes, tenues respectivement à Rome et à Paris, ayant trait à la préparation dans chaque contrée de rapports sur les acridiens, aient reçu promptement l'appui

It is particularly important that these efforts should not be relaxed when there is a reduction in the intensity of locust invasions, since exact data on the last stages of the invasions would throw important light on their origin.

2. It is, however, to be regretted that in some of the territories subject to locust invasions there are still no organisations for the regular collection of information on locusts. While the Conference realise the administrative difficulties often involved, they hope that effective steps will be taken by the Governments concerned to establish such organisations wherever possible.

3. International locust investigations would, the Conference further point out, be greatly assisted if there were greater uniformity in the preparation of the locust reports and if these were forwarded to the international centre (Imperial Institute of Entomology, London) with greater regularity. To this end, the action recommended by the Second International Locust Conference should be supplemented as follows:—

(*a*) Reports should be prepared for monthly (or shorter) periods and copies sent direct to the international centre as soon as practicable.

(*b*) All reports should be accompanied by sketch maps marked with the conventional signs approved by previous conferences as modified below.

CONVENTIONAL SIGNS FOR THE RECORDING ON MAPS OF DATA REGARDING THE MIGRATION, EGG-LAYING, AND EMERGENCE OF LOCUSTS.

 a swarm flying in a known direction.

 a flying swarm, direction not known.

 a settled swarm.

 a settled swarm departing in a known direction.

 a settled swarm which came from a known direction.

 a circling swarm.

 an ovipositing swarm.

 egg deposits.

 hoppers.

 adults in the solitary phase.

(The date should be written beside the sign.)

des autorités intéressées. Il importe surtout que les efforts ne soient nullement diminués quand on constate une réduction dans l'intensité des invasions d'acridiens, puisque des données exactes sur les dernières phases de ces invasions en éclairciraient notablement l'origine.

2. Il est à regretter, cependant, que dans quelques-unes des contrées sujettes à des invasions d'acridiens on manque d'organisations chargées de fournir des renseignements sur les acridiens. Tout en se rendant compte des difficultés administratives invoquées, la Conférence espère que des mesures effectives seront prises par les Gouvernements intéressés pour établir de telles organisations partout où il leur sera possible.

3. On apporterait un concours précieux aux recherches anti-acridiennes internationales si l'on rédigeait d'une façon plus uniforme les rapports sur les acridiens et si on les expédiait avec plus de régularité au centre international (l'Imperial Institute of Entomology à Londres). Dans ce but, on croit devoir ajouter les recommandations suivantes à celles qui ont été formulées par la Deuxième Conférence Internationale pour les Recherches Antiacridiennes :—

(*a*) Des rapports devraient être préparés pour des périodes mensuelles (ou plus courtes) et des copies devraient être envoyées directement au centre international le plus tôt possible.

(*b*) Tous les rapports devraient être accompagnés de cartes-croquis portant les signes conventionnels approuvés par les conférences antérieures et modifiés comme suit :

SIGNES CONVENTIONNELS POUR LA NOTATION CARTOGRAPHIQUE DE DONNÉES RELATIVES À LA MIGRATION, PONTE, ET ÉCLOSION DES ACRIDIENS.

↑	un essaim volant dans une direction connue.
⊤	un essaim volant dans une direction inconnue.
▲	un essaim posé.
▲↑	un essaim posé qui part dans une direction connue.
↑▲	un essaim posé qui est venu d'une direction connue.
◎	un essaim tourbillonnant.
△	un essaim qui pond.
o	foyers de pontes.
●	larves.
S	adultes de la phase solitaire.

(*La date doit figurer à côté du signe.*)

Records of adult locusts (but not hoppers) should be made with the following colours:—

Red—young swarms.
Blue—swarms ready to oviposit or ovipositing.
Black—swarms of intermediate maturity or of which the maturity is unknown.

(*c*) Great care should be taken to differentiate between the various species of locust observed. Separate reports and maps should be prepared for each species. Undetermined species should be reported on separately.

(*d*) Monthly reports should include a brief summary of the situation during the month. Special attention should be paid to the first and last dates of the appearance of (i) eggs, (ii) hoppers, and (iii) adults. When swarms of two successive generations are observed, the data in regard to them should be discriminated in the reports and maps. Distinct colours should be used to indicate different generations.

(*e*) Where only reports for periods longer than one month (three monthly, annual) are prepared by local administrations, it is particularly important that copies should be forwarded direct to the international centre at the earliest possible date and where possible by air-mail.

(*f*) In periods of locust invasions it is desirable that warning notices of local breeding and of probable swarm movements should be communicated by administrative authorities to the corresponding authorities of adjoining territories.

(c) The exchange of reports between field investigators.

1. In the interests of a closer co-operation in anti-locust research, it is desirable that the Governments of locust-infested countries should arrange for the communication as expeditiously as possible by the responsible departments of reports relating to the locust problem to the international centre for anti-locust research (Imperial Institute of Entomology, London).

2. It is desirable that Governments should instruct their officers receiving such reports to treat them as strictly confidential until their publication by the respective authors.

3. It is further desirable that Governments should authorise the communication of such reports to government entomologists engaged in anti-locust work in neighbouring territories, either direct or through the international centre.

Des précisions sur les acridiens adultes (mais non pas sur les larves) devraient être marquées par les couleurs suivantes :

Rouge—essaims jeunes.
Bleu—essaims près ou en train de pondre.
Noir—essaims de maturité intermédiaire, ou dont la maturité est inconnue.

(*c*) On devrait avoir grand soin de distinguer entre les espèces diverses d'acridiens observées. Des rapports et cartes séparés devraient être préparés pour chaque espèce. Les espèces indéterminées devraient faire l'objet d'un rapport séparé.

(*d*) Les rapports mensuels devraient comprendre un résumé concis de la situation pendant le mois écoulé. On devrait consacrer une attention spéciale aux dates initiales et finales de l'apparition (i) des œufs, (ii) des larves, et (iii) des adultes. Quand on observe des essaims de deux générations successives, les données qui les concernent devraient être spécifiées sur les rapports et les cartes. Des couleurs différentes devraient être employées pour indiquer les générations différentes.

(*e*) Où l'administration locale ne fait préparer que des rapports sur une période de plus d'un mois (trimestriels ou annuels), il est spécialement important que des copies soient expédiées directement au centre international au plus tôt et, s'il est possible, par poste aérienne.

(*f*) Pendant les périodes d'invasion acridienne, il est recommandé que des avertissements concernant les foyers ainsi que les mouvements probables des essaims soient échangés de territoires à territoires voisins.

(c) Échange de rapports entre missions.

1. Pour assurer la coopération la plus étroite, il est nécessaire que tous les rapports traitant des questions acridiennes doivent être adressés le plus rapidement possible au centre international des recherches antiacridiennes (l'Imperial Institute of Entomology à Londres). On demande aux Gouvernements coopérants de prendre toutes dispositions à cet effet.

2. Il est à souhaiter que les Gouvernements donnent des instructions à leurs fonctionnaires recevant de tels rapports pour qu'ils les considèrent comme strictement confidentiels jusqu'à leur publication par les auteurs respectifs.

3. Il est à souhaiter en outre que les Gouvernements autorisent la communication de tels rapports à l'entomologiste officiel s'occupant de travaux antiacridiens dans les territoires voisins, soit directement ou par l'entremise du centre international.

(d) Definition of the terms relating to the distribution and migration of locusts.

In view of the great diversity which at present exists in the use of the terms relating to the distribution and migration of locusts, it is desirable that the following terms should be used in all reports in the sense indicated below :—

1. *Distribution area of species.*

All the territories where the solitary phase (phase *solitaria*) of a species lives permanently.

2. *Invasion area of a species.*

All the territories which can be invaded by a species in its swarming phase (phase *gregaria*).

(a) *The area of normal migration.*

All the territories normally visited by a species in its swarming phase (phase *gregaria*), and in which it can breed.

(b) *The area of occasional migration.*

All the territories to which a species in its swarming phase (phase *gregaria*) migrates only occasionally, but in which it can breed.

(c) *The area of exceptional invasions.*

All the territories which can be invaded in exceptional cases by a species in its swarming phase (phase *gregaria*), but in which it does not breed.

3. *Outbreak area.*

All the centres of outbreaks.

4. *Outbreak centre.*

A station the ecological conditions of which sometimes provoke the transformation of a species into its swarming phase (phase *gregaria*).

(e) Standardisation of biometric methods.

In view of the diversity which at present exists in the methods of measuring locusts and in the expression of these measurements it is desirable that all workers in this field should adopt uniform methods.

1. *Methods of measuring.*

It is desirable that all workers should follow the methods of Zolotarevsky given in his "Contribution à l'étude biologique du Criquet Migrateur, *Locusta migratoria capito* (Saussure) dans ses

(d) Définition des termes concernant la distribution et la migration des acridiens.

Il y a une trop grande diversité dans les termes actuellement employés pour définir la distribution et les migrations des acridiens. Il est désirable que les expressions suivantes soient adoptées dorénavant dans tous les rapports :—

1. *Aire d'habitat de l'espèce.*

Ensemble des territoires où la phase solitaire (phase *solitaria*) de l'espèce vit en permanence.

2. *Aire d'invasion de l'espèce.*

Ensemble des territoires qui peuvent être envahis par l'espèce dans sa phase grégaire (phase *gregaria*).

(a) *Aire de migration normale.*

L'ensemble des territoires visités normalement par l'espèce en sa phase grégaire (phase *gregaria*) et où elle se reproduit.

(b) *Aire de migration occasionnelle.*

L'ensemble des territoires où l'espèce n'effectue qu'accidentellement la migration pendant la phase grégaire (phase *gregaria*) mais où elle peut se reproduire.

(c) *Aire d'invasion exceptionnelle.*

L'ensemble des territoires qui peuvent être envahis exceptionnellement par l'espèce en sa phase grégaire (phase *gregaria*) mais où elle ne se reproduit pas.

3. *Aire grégarigène.*

L'ensemble des foyers grégarigènes.

4. *Foyer grégarigène.*

Station où se trouvent parfois réalisées des conditions écologiques provoquant la transformation de l'espèce en sa phase grégaire (phase *gregaria*).

(e) Fixation des méthodes biométriques.

Pour éviter les variations existant actuellement dans les méthodes de mesures d'acridiens et dans l'expression de ces mesures, il est recommandé à tous les travailleurs intéressés par cette question d'adopter des méthodes uniformes.

1. *Méthodes de mesures.*

Il est désirable que tous les travailleurs suivent les méthodes indiquées par Zolotarevsky dans son travail intitulé " Contribution à l'étude biologique du Criquet Migrateur, *Locusta migratoria capito*

foyers permanents " (1933, Ann. Epiphyt., Paris 19, Parties 1 et 2), employing the following symbols :—

E length of elytron.
F length of femur.
P length of pronotum.
M width of constriction of pronotum (width of middle).
H height of pronotum.
C maximum width of head.

2. *Methods of expressing ratios.*

It is desirable that the various ratios should always be expressed in the same way and that the following should be adopted :—

E/F ratio of elytron to femur.
P/C ratio of pronotum to maximum width of head.

H/C ratio of height of pronotum to maximum width of head.

M/C ratio of width of constriction of pronotum to maximum width of head.

3. *Methods of calculating averages.*

The true average ratio is obtained by calculating the ratio of the totals of the actual measurements and not the average of the individual ratios.

The Conference expressed the hope that the Government of the United Kingdom would communicate certified true copies of the text of the present proceedings to all the Governments attending the Conference, at which the present Proceedings have been drawn up, as well as to any other Government to which the Government of the United Kingdom might deem it desirable to send a copy.

Further, the Conference expressed the view that though the first three international locust conferences were concerned only with the species of locusts occurring in Africa and western Asia, the locust problem is essentially the same in all parts of the world. The Conference, therefore, expressed the hope that the Egyptian Government would invite every country suffering from locusts to participate in the Fourth International Locust Conference, in order to establish a close co-operation in the anti-locust research throughout the world.

(Saussure) dans ses foyers permanents" (1933, Ann. Epiphyt., Paris 19, Parties 1 et 2). Les symboles suivants doivent être employés :—

E longueur de l'élytre.
F longueur du fémur.
P longueur du pronotum.
M largeur de l'étranglement du pronotum (prise au milieu).
H hauteur du pronotum.
C largeur maxima de la tête.

2. *Méthodes employées pour exprimer les rapports.*

Il est désirable que les différents rapports soient toujours exprimés d'une manière uniforme et que les rapports suivants soient adoptés :

E/F rapport de l'élytre à la longueur du fémur.
P/C rapport de la longueur du pronotum à la largeur maxima de la tête.
H/C rapport de la hauteur du pronotum à la largeur maxima de la tête.
M/C rapport de l'étranglement du pronotum à la largeur maxima de la tête.

3. *Méthodes employées pour calculer les moyennes.*

La moyenne réelle des rapports doit être obtenue, non pas en utilisant des mesures individuelles, mais la moyenne des mesures prises sur un grand nombre d'individus.

La Conférence exprime l'espoir que le Gouvernement du Royaume-Uni transmettra des copies, certifiées conformes, des comptes-rendus de ses travaux à tous les Gouvernements ayant pris part aux réunions, au cours desquelles les présents Comptes-Rendus ont été rédigés, ainsi qu'à tout autre gouvernement auquel le Gouvernement du Royaume-Uni jugerait désirable de communiquer une copie.

Bien que les trois premières conférences internationales anti-acridiennes ne se soient occupées que des espèces d'acridiens habitant l'Afrique et l'Asie occidentale, la Conférence estime que le problème acridien est le même dans le monde entier. Elle exprima donc l'espoir que le Gouvernement égyptien voudra bien inviter toutes les nations atteintes par les acridiens à participer à la Quatrième Conférence Internationale, afin d'établir une coopération étroite des recherches antiacridiennes dans le monde entier.

In faith whereof the Undersigned have signed the present Proceedings.

Done in London, this eighteenth day of September, 1934, in a single copy, which shall remain deposited in the archives of the Government of the United Kingdom of Great Britain and Northern Ireland.

En foi de quoi les Soussignés ont signé les présents Comptes-Rendus.

Fait à Londres, ce dix-huit septembre 1934, en une seule copie, qui restera déposée aux archives du Gouvernement du Royaume-Uni de Grande-Bretagne et d'Irlande du Nord.

President of the Conference: Président de la Conférence:

J. R. CHANCELLOR.

Secretary-General of the Conference: Secrétaire Général de la Conférence:

FRANCIS HEMMING.

Afghanistan: Afghanistan:

ALI MOHAMMAD.

Union of South Africa: Union de l'Afrique du Sud:

JACOBUS C. FAURE.

Belgium: Belgique:

JEAN GHESQUIÈRE.

Great Britain and Northern Ireland: Grande-Bretagne et Irlande du Nord:

GUY A. K. MARSHALL.
B. P. UVAROV.
H. B. JOHNSTON.
G. F. SEEL.
MERVYN C. MOSSOP.

Egypt: Égypte:

A. M. MISTIKAWI.

Spain : Espagne :

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Abyssinia : Éthiopie :

EPHREM T. MEDHEN.*

France : France :

P. DE PEYERIMHOFF.
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G. BOUET.
L. CHOPARD.
P. REGNIER.
PASQUIER.
B. ZOLOTAREVSKY.
J. DE LÉPINEY.

India : Inde :

Y. RAMACHANDRA RAO.

Italy : Italie :

ANTONIO DE BENEDICTIS.
FILIPPO SILVESTRI.

Liberia : Libéria :

R. A. DE LYNDEN.

Portugal : Portugal :

BRANQUINHO D'OLIVEIRA.

Anglo-Egyptian Sudan : Soudan Anglo-Égyptien :

H. B. JOHNSTON.

* This signature is subject to confirmation by the Ethiopian Government.

APPENDIX 1.

AIRES GRÉGARIGÈNES ET FACTEURS DE TRANSFORMATION DE LA PHASE SOLITAIRE DES ACRIDIENS MIGRATEURS DANS LA PHASE GRÉGAIRE.

Par B. N. Zolotarevsky, *Chef de la Mission d'Études de la Biologie des Acridiens, organisée par le Comité d'Alger.*

La théorie de phases, fondée sur le polymorphisme des acridiens migrateurs, formulée en 1921 par B. P. Uvarov d'après ses investigations personnelles ainsi que d'après les observations de V. I. Plotnikov sur *Locusta migratoria* (Linn.) et de J. C. Faure sur *Locustana pardalina* (Walker), est à la base de notre conception actuelle des "aires grégarigènes," c.-à.-d. des lieux où les espèces d'acridiens vivent en permanence et d'où elles entreprennent leurs migrations pendant les années de développement en masse.

Les expériences entreprises à la suite de V. I. Plotnikov et J. C. Faure n'ont fait que confirmer l'existence du phénomène des phases et l'étendre à d'autres espèces. Les observations dans la nature de H. B. Johnston sur *Schistocerca gregaria* (Forskål), de S. A. Predteichenski, H. B. Johnston et R. C. Maxwell-Darling, de même que les miennes, sur *Locusta migratoria* (Linn.) et R. Pasquier sur *Dociostaurus maroccanus* (Thunberg) ont attesté que la transformation de la phase solitaire de ces espèces dans la phase grégaire existe dans la nature et que cette transformation est le résultat des réactions des individus aux conditions éthologiques de leur existence.

La documentation que nous possédons actuellement nous permet donc d'affirmer, en ce qui concerne les espèces d'acridiens présentant deux phases: *solitaria* et *gregaria*, que l'apparition des bandes primitives, par lesquelles débutent les invasions, peut être attribuée à la transformation des individus de la phase solitaire dans la phase grégaire et que les "aires grégarigènes" sont les régions où ces espèces vivent en permanence en leur phase solitaire dans les conditions éthologiques dont les modalités peuvent déterminer leur transformation dans la phase grégaire et l'émigration.

Il devient évident que la délimitation des aires grégarigènes, dont la portée pratique pour l'organisation de la lutte antiacridienne est incontestable, n'est pas concevable sans une connaissance approfondie de l'éthologie de chaque espèce et sans une détermination des particularités éthologiques qui peuvent entraîner la transformation de l'espèce dans la phase grégaire.

L'aire de distribution géographique de la phase solitaire d'un acridien migrateur peut être très vaste, comme le montre l'exemple de *Locusta migratoria* (Linn.) ou de *Dociostaurus maroccanus* (Thunberg), mais les zones d'apparition de la phase grégaire, c'est-à-dire les aires grégarigènes, sont limitées aux régions ne constituant qu'une partie de l'aire de distribution géographique.

Les acridiens étant très prolifiques, c'est aux facteurs limitant

leur pullulation que doit être attribué le nombre d'individus réduit qui représente normalement l'espèce en sa phase solitaire dans son aire d'habitation permanente en dehors des époques de pullulation. La puissance limitative de ces facteurs, pour entraver une pullulation, doit être très élevée : en effet, B. P. Uvarov estime que, pour que le nombre d'individus de *Dociostaurus maroccanus* (Thunberg) sur une superficie donnée n'augmente pas d'une génération à l'autre, il faut que sa mortalité soit de près de 98%. Un pourcentage de mortalité se rapprochant de celui de *Dociostaurus maroccanus* (Thunberg), ou même le dépassant, peut être admis pour d'autres espèces.

Dans l'état actuel de nos connaissances, l'accumulation des individus de la phase solitaire apparaît comme un facteur primordial de la transformation de la phase solitaire dans la phase grégaire. Il faut donc admettre qu'il existe dans les aires grégarigènes des périodes pendant lesquelles l'influence des facteurs limitant la pullulation est atténuée ou absente : les observations dans la nature montrent que l'apparition de la phase grégaire se produit à la suite d'une pullulation résultant des perturbations climatiques et de leur répercussion sur les conditions d'existence des espèces. Nous pouvons par conséquent considérer l'instabilité des facteurs limitant la pullulation de la phase solitaire comme un des caractères des foyers permanents.

J'ai démontré dans mon étude de *Locusta migratoria capito* (Saussure) à Madagascar que seule l'augmentation du nombre d'individus de la phase solitaire sur de grandes superficies de stations à conditions optimales pour l'existence de l'espèce ne peut pas justifier leur accumulation nécessaire pour l'apparition de la phase grégaire. B. P. Uvarov, en étudiant *Dociostaurus maroccanus* (Thunberg) en Anatolie occidentale, aboutit à une conclusion similaire.

Il n'a pas été observé chez les acridiens migrateurs dans leur phase solitaire l'existence d'une interattraction qui les grouperait, en dehors toutefois de l'interattraction entre le mâle et la femelle au moment de la pariade et de l'accouplement ; par contre, ces espèces se montrent comme très sélectives vis-à-vis de leurs stations. Les premiers groupements des individus de la phase solitaire ne sont que des foules rassemblées par la similitude des réactions de chaque individu aux facteurs extérieurs. Si ces facteurs, retenant les individus groupés, disparaissent, ces foules se disloquent rapidement. La sélectivité des acridiens vis-à-vis des stations aboutit à ce fait que les individus de la phase solitaire, principalement sous l'influence des facteurs microclimatiques, se trouvent groupés sur des parcelles de terrain disséminées dans la région d'aires grégarigènes. Il devient évident que l'accumulation des individus et les pontes sur de petites superficies, si les conditions retenant l'espèce sur ces superficies se réalisent également pour le stade larvaire, peuvent facilement aboutir à un " surpeuplement " nécessaire pour l'apparition de la phase grégaire. La distribution par îlots des stations des acridiens migrateurs dans leurs aires grégarigènes a été constatée par S. A. Predtetchensky pour *Locusta migratoria rossica* Uvarov &

Zolotarevsky, par B. P. Uvarov et R. Pasquier pour *Dociostaurus maroccanus* (Thunberg) et par moi-même pour *Locusta migratoria capito* (Saussure). Il est encore prématuré de parler avec précision des aires grégarigènes de *Schistocerca gregaria* (Forskål), mais il peut être noté que les recherches sur cette espèce, faites dernièrement par R. C. Maxwell-Darling et par J. de Lépiney et moi-même, montrent également l'inclusion en îlots de ces stations dans les régions arides du Sahara.

La localisation temporaire ou permanente des stations de la phase solitaire des acridiens migrateurs sur des petites superficies et leur inclusion dans une région évitée par l'espèce à certains ou à tous les stades du développement individuel est le deuxième caractère essentiel des aires grégarigènes.

La localisation des foyers grégarigènes par rapport à l'ensemble de l'aire d'habitation permanente d'une espèce peut différer suivant chaque cas particulier. Leur situation dans les zones de contact de deux régions climatiques paraît toutefois être assez généralisée. Les foyers grégarigènes de *Dociostaurus maroccanus* (Thunberg) en Anatolie occidentale se trouvent sur une bande étroite à conditions climatiques intermédiaires entre les climats des plateaux et de la plaine; ceux de *Locusta migratoria migratorioides* (Reiche & Fairmaire) sont localisés dans la zone de contact entre le Sahel et la zone d'inondation du Niger et, peut-être, dans la zone de contact entre le Sahel et les régions de savane soudano-guinéenne. Les stations de *Schistocerca gregaria* (Forskål) paraissent être localisées dans la zone de contact entre le Sahara et le Sahel.

La prédominance de l'influence, fortuite ou périodique, sur ces zones intermédiaires des éléments d'un régime climatique ou d'un autre peut déterminer l'instabilité des facteurs éthologiques des espèces habitant ces zones. Mais l'instabilité du climat caractérisant les aires grégarigènes peut être réalisée en dehors des zones de contact des régions à régime climatique différent: à Madagascar cette instabilité paraît être déterminée par les passages des cyclones.

Les caractères particuliers des foyers grégarigènes, qui ne se rencontrent pas sur tous les points de l'aire d'habitation permanente d'une espèce dans sa phase solitaire, incitent à distinguer deux groupes de lieux occupés par les insectes: 1°) l'aire d'habitation permanente et 2°) les foyers grégarigènes, ceux-ci ne constituant qu'une certaine partie de l'aire d'habitation permanente.

L'aire d'habitation permanente de la phase solitaire coïncide avec l'aire de distribution géographique de l'espèce, mais les bandes de la phase grégaire peuvent, au cours de leurs migrations, visiter les régions situées au delà de cette aire, comme il a été observé pour les bandes de *Schistocerca gregaria* (Forskål). Si dans ces cas les acridiens trouvent dans les régions visitées un ensemble de facteurs leur permettant de s'y perpétuer ou si cet ensemble de facteurs y est présent temporairement à l'époque de l'invasion, les individus restés sur place après le passage des bandes peuvent se reproduire et, en se transformant dans la phase solitaire, peuvent créer de

nouvelles zones d'habitation permanente ou temporaire; dans ce dernier cas l'espèce y existera aussi longtemps que les conditions permettant son existence seront présentes. Les foyers d'apparition de la phase grégaire peuvent s'y constituer dans les mêmes conditions que dans les limites de l'aire d'habitation permanente. Il s'agit là d'un cas particulier d'extension de l'aire d'habitation permanente ou d'un cas accidentel qui ne paraissent pas exiger leur distinction de principe.

L'instabilité des conditions d'existence et la localisation sur des petites superficies des individus de la phase solitaire dans les foyers grégarigènes, ainsi que la constatation de l'importance primordiale de l'accumulation comme facteur de transformation, ne sont que les traits généraux indiquant la voie dans laquelle les recherches sur le phénomène de transformation de phases et sur ses causes réelles doivent être engagées.

Dans chaque cas particulier, la nature de facteurs climatiques peut être différente et ces facteurs peuvent exercer leur influence sur différents stades de développement des individus, suivant la nature des conditions habituelles d'existence de chaque espèce, ou même de chaque groupe géographique d'une même espèce. La pullulation de *Locusta migratoria rossica* Uvarov & Zolotarevsky est provoquée par une période d'années chaudes et peu humides en Russie centrale dont l'humidité élevée et les basses températures entravent normalement la pullulation de cette espèce. *Locusta migratoria capito* (Saussure) à Madagascar, *Locusta migratoria migratorioides* (Reiche & Fairmaire) dans le Soudan français, *Schistocerca gregaria* (Forskål) dans le Soudan anglo-égyptien, espèces qui dans ces pays habitent normalement les régions sèches, pullulent pendant les années exceptionnellement pluvieuses.

La transformation dans la phase grégaire de *Locusta migratoria capito* (Saussure) à Madagascar et, comme le montrent les investigations récentes de la Mission d'Études de la Biologie des Acridiens, la transformation dans la phase grégaire de *Locusta migratoria migratorioides* (Reiche & Fairmaire) dans le Soudan français, se produisent sous l'influence combinée de périodes de pullulations sur des superficies relativement grandes suivies de périodes pendant lesquelles les individus de l'espèce s'accumulent sur des superficies restreintes. Dans d'autres cas, en présence des stations d'une espèce couvrant normalement des superficies petites mais stables, l'accumulation nécessaire pour la transformation paraît pouvoir se réaliser sous l'influence directe de la pullulation, sans concentration active des individus.

La transformation elle-même, pour aboutir à l'apparition des bandes d'insectes ailés de la phase grégaire et à l'émigration, doit se produire dans des conditions définies: l'apparition des bandes d'insectes ailés peut être compromise si des facteurs particuliers (par exemple, l'échelonnement des pontes et des éclosions et, par conséquent, l'échelonnement de la transformation dans le stade ailé) interviennent au cours de la transformation des phases.

Enfin, les facteurs prédominants au point de vue de la détermination des fluctuations du nombre d'individus de différentes espèces peuvent agir sur différents stades de développement des individus de ces espèces; ainsi la pullulation de *Locusta migratoria capito* (Saussure) est entravée par une courte durée de la période d'activité génitale et par une période prolongée d'inactivité génitale, pendant laquelle l'espèce, qui la passe au stade ailé, est sujette à une forte mortalité. Par contre, pour d'autres espèces, les facteurs limitant la pullulation peuvent agir principalement sur l'œuf, en l'exposant à un développement irrégulier ou aux attaques des parasites.

Si l'accumulation peut être considérée actuellement comme un facteur primordial de transformation des phases, la nature de son influence reste encore à étudier. Nous ne savons pas exactement si c'est l'accumulation elle-même ou si ce sont ses répercussions sur le comportement des individus qui entraînent la transformation; l'étendue de l'influence de l'accumulation sur les individus à différents stades de leur développement est également à déterminer; en effet, les observations de J. C. Faure sur *Locustana pardalina* (Walker) et les miennes sur *Locusta migratoria capito* (Saussure) montrent que le fait de l'existence à l'état d'accumulation ou à l'état d'isolement influe sur l'aspect morphologique de leur descendance.

Malgré la prépondérance du facteur accumulation les autres aspects du problème des phases ne doivent pas être négligés. En particulier, l'étendue de l'influence du degré d'humidité sur l'état morphologique et le comportement des acridiens doit être recherchée: l'étude morphologique des individus de *Locusta migratoria capito* (Saussure) ayant évolué dans les conditions d'humidité différentes montre que les individus ont les caractères morphologiques de la phase solitaire d'autant plus atténués que la sécheresse du milieu dans lequel ces individus ont évolué est plus accentuée.

Tous ces exemples montrent que, si les connaissances acquises sur les acridiens migrateurs nous permettent d'en dégager l'aspect général du phénomène de transformation des phases, elles sont loin d'être complètes et que chaque espèce ou même chaque groupe géographique d'une même espèce doivent être étudiés séparément dans chaque cas particulier.

D'autre part, les observations dans la nature ne donnant que des indications au hasard des conditions de vie d'un insecte rencontrées au moment des recherches, ces observations doivent être contrôlées et approfondies par une étude expérimentale dans des laboratoires appropriés.

APPENDIX 2.

THE LIFE-CYCLE, PARTICULARLY SEXUAL MATURATION, IN RELATION TO CLIMATIC AND OTHER FACTORS AND METHODS OF STUDY.

By Rao Sahib Y. Ramachandra Rao, *Locust Research Entomologist, Imperial Council of Agricultural Research, Simla.*

Before venturing to start the discussion on the "Life-cycle of the Locust," I wish to preface it by making a few remarks. Although a fair amount of work has been done in India, I am not sure if sufficient data have yet accumulated to justify my speaking with authority or confidence thereon, but I do hope that my remarks will serve the purpose of exciting discussion on this most interesting subject. Secondly, there is only one species of locust, *Schistocerca gregaria* (Forskål), that is at present of practical importance in north India, and consequently all our observations are confined to that species. It is possible that the generalisations made therefrom may not be applicable to the other locusts on which investigations are being made in Africa and other parts of Asia.

The life-cycle of the locust may be considered under the following heads: 1. the egg-stage and the incubation period; 2. the hopper stage; 3. the adult, its sex-maturity and longevity; and 4. the total duration of the life-cycle and the number of generations.

It may be stated that the scheme of Locust Research inaugurated in India in December 1930 under the auspices of the Imperial Council of Agricultural Research was intended to be prosecuted in a spirit of team-work, particular parts of the investigations being assigned to particular workers. All research work in regard to the life-history and bionomics of the locust was carried out at the laboratories at Lyallpur Agricultural College directly under the guidance of Mr. M. Afzal Husain during the years 1931, 1932 and 1933, and the results cited in this paper are extracted from the yet unpublished, preliminary reports of his work, while most of the statements made regarding the solitary phase of the locust are referable to observations made at Pasni and Ambagh by Dr. K. R. Karandikar and his colleagues.

I.—The egg-stage.

Laboratory experiments at Lyallpur have shown that *wetness of the soil* is a necessary pre-requisite of oviposition. This has been confirmed by the observations made under natural conditions in the reservations of the Desert Locust at Pasni, where it was found that egg-laying occurred only after a fall of rain sufficient to secure a penetration of soil-moisture of over 6 inches depth in the "rek" soils.

The incubation period. The average duration of incubation in summer in times of locust invasion in India is about 2 weeks.

Laboratory experiments at Lyallpur have shown that under optimum conditions of soil-moisture the duration of incubation tended to become prolonged under conditions of low temperature, while high temperatures shortened it. The shortest period recorded at Lyallpur was 9 days at a temperature of 43° C.

In the desert breeding grounds at Pasni, several instances of delayed hatching were noted in the winter months, in small field-cages kept under semi-natural conditions, where the main difference from the conditions in the field was caused by the maintenance of high soil-moisture by artificial watering. During the last season a record of hatching after about 55 days of incubation was obtained at Pasni in January–February 1934, while an instance of about 9 days was obtained recently in July 1934 under the high temperature conditions that then prevailed.

Soil moisture. In Baluchistan, as probably elsewhere, it is believed by many that, in the case of the Desert Locust, eggs laid in the field might remain in a viable condition till the year following and hatch out after rainfall. In order to test the validity of this claim, Mr. Husain carried out a series of experiments, subjecting egg-masses kept in sterilised soil to conditions of desiccation for various periods, at the end of which their viability was tested by the addition of the requisite moisture. A record of delayed incubation of 81 days was made by him in this way under conditions of desiccation. As the egg-mass of *Schistocerca* is not protected by any hardened water-proof envelope, it is, however, evidently unlikely that the eggs will remain viable during long periods of drought under ordinary field conditions.

As regards the number of eggs laid by individuals, Mr. Husain has recorded a case of 11 egg-masses laid by a female in the course of 75 days, the total number of eggs laid being 853.

II.—Hopper stage.

The normal period for this stage is about 5 to 6 weeks in summer in India. Mr. Husain found, in the course of rearing experiments under different temperature conditions, that at 39° C the larval period was as short as 21 days, and that it could be greatly prolonged under lower temperatures. Under semi-natural conditions at Pasni, the shortest record of post-embryonic development was about 32 days in summer, and the longest about 90 days in winter.

III.—The adult stage.

Whereas certain other locusts tide over long periods of unfavourable weather conditions in the egg stage, *Schistocerca* does so only in the adult stage. It overwinters as an adult during the colder months, and during long periods of dry hot weather it remains sexually immature. This is specially noticeable in locusts of the solitary type found in locust reservations, where adults have been

found to remain in a sexually immature state for the greater part of the year. It is certainly rather tempting to explain this as due to the existence of a compulsory diapause in *Schistocerca*.

Experimental observations made by Mr. Husain at Lyallpur have proved that, given the requisite conditions of humidity and temperature, *Schistocerca* would attain sexual maturity in about a fortnight and would be able to pair and lay eggs immediately. Six generations of the locust were obtained by him in the course of a year in cages at a temperature constant of 37–39° C at Lyallpur, and since he found that in one case the period from oviposition to sex-maturity of the adult was covered in 44 days at a temperature constant of 43° C, he considers it not improbable that even 8 successive broods might be obtainable in a year. At Pasni, locusts have been kept in pairs in small portable cages, provided with soil at the bottom, under more or less natural conditions in the open. In some of them the soil at the bottom has been maintained in a fairly damp condition by periodical watering, while others have been kept unwatered as controls. In the course of the last two years, it has been invariably found that, whereas the locusts in the watered cages sooner or later attained sexual maturity and oviposited, those in the controls remained sexually immature. During 1932, four successive generations of the locust were produced from a single pair at the Pasni Field Research Station, the rearing being carried on in the portable cages, above referred to, which were kept in the open in the desert, but watered periodically so as to maintain a fairly high degree of soil-humidity. It is presumed that the quicker attainment of sex-maturation of locusts kept in such cages is to be ascribed to their reaction to conditions of the higher soil-moisture of the soil at the bottom, and to the consequent maintenance of a higher degree of atmospheric humidity inside the cages, not obtainable outside in nature. The inference to be drawn from the above data would appear to be that, provided that similar conditions of atmospheric humidity and soil-moisture are obtainable in nature, the locust could have produced four successive generations in nature in the deserts around Pasni under the prevailing temperature conditions.

Sexual maturation. The excitement of sexual maturity is an important point in the life-history of the locust. Field observations on this point have been in progress at Pasni during the last three years, and latterly also in other localities such as Ambagh and Chachro, and some interesting data have been obtained.

At Pasni the following observations are on record:

1932. There was practically no rainfall between January and June 1932, but the atmospheric relative humidity varied from 60 to 70 per cent. on the average up to April. From May there was a rise in the humidity owing to the setting in of the moist south-west sea wind. There was no sign of sex maturity in specimens collected from the breeding grounds till the end of June. There was very

heavy rainfall amounting to 6·16 inches between the 9th and the 14th July, and oviposition would appear to have occurred almost immediately, since the first hopper of the new generation was noted on the 30th July. Egg-laying continued up to the end of August, and hoppers were noted till the beginning of October, and adults of the new generation appeared from September onwards.

1933. There was no rainfall of any consequence till February 1933. Signs of sexual maturation was first noticed about the middle of February. There was a light shower about the 13th February, after which there was a heavy downpour of rain between the 24th and the 28th February amounting to 4·25 inches. Oviposition had apparently occurred at once, since the first hopper was noticed on the field on the 10th March. The first adult of the new generation was noted on the 23rd April. There was heavy rainfall again in the first week of April, amounting to 4·75 inches. As newly hatched hoppers continued to appear till the first week of June, it is to be presumed that they had emerged from eggs laid by the adults of the first generation appearing in April–May. There were light showers totalling 0·82 inch during July, but they were not followed by breeding. There was no further fall of rain till the end of the year.

1934. About an inch of rain was received in January 1934, which was followed immediately by an intense cold wave accompanied by frost. There has been no further rain at Pasni till the present. No signs of sexual maturation was noticeable in February or March, and none also in May, June or July, even after the usual rise in atmospheric humidity with the setting in of the S.W. wind.

At Ambagh, the following observations are recorded:

1933. There was no rainfall in the area from January 1933; and no sign of maturation was noticeable in spite of the seasonal rise in atmospheric humidity since May. Heavy rainfall amounting to about 9·50 inches was recorded between the 16th and the 23rd July, 1933. Egg-laying followed almost immediately, and hoppers were noticed during August, September and October.

1934. No rainfall from January up to the middle of June 1934, and no sign of sexual maturation was noticed in spite of a rise in atmospheric humidity. Rainfall occurred at the end of June and the beginning of July; and apparently oviposition had followed almost at once, as hoppers of different stadia were noticeable by the last week of July 1934.

At Chachro (Thar-Parkar district, in Sind), solitary phase locusts to be found in nature in the desert were kept under close observation this year, and the few that were observed did not evince signs of maturation till June. With the fall of rain at the end of June and the beginning of July, however, breeding would appear to have started immediately, as hoppers were noticeable by the middle of July.

The field observations apparently indicate that in the environmental conditions of the desert, heavy rainfall along with the

concomitant reaction thereof on local atmospheric humidity and temperature, has a profound influence on the sexual mechanism of the locust, which needs detailed elucidation under controlled laboratory conditions.

Longevity of the adult. Mr. Husain's investigations at Lyallpur, indicate that atmospheric temperature has an intimate bearing on longevity. According to him, at high temperatures all the life-processes are quickened, and the life-span shortened. In the case of the first-brood adults, found in an active condition in the summer months in India, he found the duration of life not to exceed 79 days for a male, and 69 days for the female, while in the case of the second or summer brood adults found active in the autumn and winter, records of a life-duration of 246 and 240 days for a male and a female respectively were made in the laboratory.

Field observations in the breeding grounds, however, indicate that, in addition to temperature, there are other factors, as, for instance, atmospheric humidity, that have a controlling influence on the life duration of the adult. Wherever conditions happen to be favourable, the locust would appear to be able to respond to them and breed, but when the environment is unfavourable, it presumably remains inactive in a sexually immature condition, till conditions suitable for breeding are obtainable.

As instances, the following observations may be cited:

(1) *Pasni.* With the occurrence of heavy summer rainfall in July 1932 a summer generation was produced, which became winged in September–October 1932. The adults of this generation continued to exist on the "rek" areas in a sexually immature condition till February 1933, when, on receipt of heavy rainfall, they laid eggs. They disappeared, however, by the end of March 1933. A new generation of adults made its appearance in April. With the fall of further rains in April, a new brood of hoppers became noticeable in May and June 1933, and presumably these represented the second generation, being the progeny of the April brood of adults. Except in certain peculiarly situated areas of the Pasni Rek, where on account of the existence of abundant soil-moisture breeding appears to have extended till September 1933, breeding ceased from July 1933 on the Pasni Reks. On account of the prevalence of drought at Pasni, and the Mekran coast in general, there has been no breeding from July 1933, but adult locusts are still being encountered, though in greatly diminished numbers, during the periodic surveys carried out around Pasni and Gwadar. There is little doubt that some of these have survived a dry spell of 13 months' duration.

(2) *Ambagh.* At Ambagh, breeding occurred in summer 1933, after good rainfall in July–August, and a generation of new adults appeared in October 1933. As there has been no rainfall since then up to June 1934 there was no possibility of breeding having taken

place in the interim, and the adults found in June 1934 had doubtless survived a period of nearly 9 months.

On the whole it would appear to be difficult to desist from coming to the conclusion that the prolongation of the life of the adult in the above cases is due to the action of unfavourable environmental conditions brought about by drought, for, unless these are safely tided over by the locust, its continuance as a race would itself be jeopardised.

IV.—The total duration of the life-cycle and the number of generations in the year.

On the average, under the conditions prevalent in summer in India, the duration of the egg stage is about 2 weeks, of the hopper stage, about 5 to 6 weeks, and of the pre-maturation stage of the adult, about 4 weeks, so that a period of about 3 months would be needed for a new generation to come into existence. Mr. Afzal Husain was able to rear 6 generations in the course of one year under controlled conditions in cages, and in one case the whole cycle was passed through in 44 days at a temperature constant of 43° C. As already stated, four successive generations were reared at Pasni in breeding cages kept in semi-natural conditions in the open. Again, in 1933, as a result of very favourable rainfall, there were clear indications to show that two successive broods had come into existence in nature. Moreover, in the course of a study of the old records of previous infestations in the Rajputana States, concrete instances of the production of more than one generation during the monsoon season, in case the rains happened to be protracted, have been noted. It appears, therefore, justifiable to conclude that in the case of the Desert Locust sexual maturation is entirely dependent on the environmental conditions, and that there is no definite diapause in the adult stage. As Bodenheimer has shown in his recent article (1932, Biol. ZBl., **52**: 598–619), the gregarious phase is able to maintain its numbers mostly by the fact that the swarms are able to fly from regions of winter to summer rainfall, and *vice versa*, and thus able to produce at least two generations in one year, and possibly more than two if the rainfall be favourable.

V.—Life-cycle and outbreaks.

In regard to the great question of the actual transformation of the phase *solitaria* into phase *gregaria*, it appears to me that, apart altogether from the factor of concentration and crowding (which is of course essential), the most important step is the building up of the numbers of the locust population, which could happen only if a quick succession of two or more generations over wide areas of the country is rendered possible by specially favourable climatic conditions. When multiplication has occurred, concentration of the population in restricted areas would follow for the purposes of

breeding and feeding, and would bring about the transformation into phase *gregaria* in the next generation. If, next, the formation of swarm flights from summer rainfall areas into those of winter rainfall, or *vice versa*, were to occur, the beginning, probably, of a new cycle of locust infestation would have been started. I may add that some of the meteorological data, which I have been able to gather recently in Sind and Baluchistan in regard to the locust cycles of the past in India, appear to indicate that the development of a new cycle need not necessarily be the result of a slow building-up in the course of several successive years, but may be very rapidly brought about in the course of a year or two of concentrated breeding as a result of favourable conditions.

APPENDIX 3.

MIGRATION AND THE FACTORS INDUCING IT WITH REGARD TO ALL PHASES, AND METHODS OF THEIR STUDY, WITH SPECIAL REFERENCE TO THE TYPE OF METEOROLOGICAL MAPS LIKELY TO BE OF ASSISTANCE.

By A. P. G. MICHELMORE, *Member of the field Locust Staff in East Africa of the Imperial Institute of Entomology, London.*

ONE of the most urgent needs in the war against locusts is that of a forecasting system to enable countries to prepare in advance for a campaign. Though this is well known, no such system has yet been worked out, owing to the facts that migrations do not obey one obvious universal law, and that the basic factors causing and directing them remain unknown. One difficulty is that in one region the movements of locusts seem to be due to one particular factor, while elsewhere they are governed apparently by something entirely different. For instance, as I have pointed out in my second unofficial report, in Northern Rhodesia the Red Locust migrates almost entirely with the wind, but in the adjoining territory of Tanganyika it does nothing of the sort. Also, in the Anglo-Egyptian Sudan, while the Migratory Locust flies north-east with the prevailing wind during the rains, and after the breeding in the dry country the young generation returns in the opposite direction with the beginning of the north-north-east winter wind, King has pointed out that the Desert Locust leaves the same breeding grounds at the same time in the opposite direction.

With regard to the **causes of migration,** the simplest theory, and the one to which I subscribe for the present, is that migration of hoppers and adults is merely a manifestation of an instinct of each individual to move when it sees another do so, this being perhaps

a safety reflex, and a less easily explicable tendency for such movement to be consistently in one direction when the locusts are in any numbers. My own field observations of solitary-coloured hoppers of the Red Locust in bands, swarm-coloured hoppers isolated and swarm-coloured hoppers living isolated have led me to believe that the behaviour of an individual locust does not depend on its phase, but on its environment, particularly the degree of crowding to which it is subjected. If this is true, a locust migrates only because it is in the company of numerous others. It is inherently capable of doing so whenever it is in such a position, whatever its phase, unless some external factor prevents migration. The statement of these views has produced interesting confirmatory evidence from Faure, Golding, and Maxwell-Darling, who have suspected the migration of *solitaria* adults with *gregaria* swarms in the case of the Brown and Migratory Locusts. On the other hand, Zolotarevsky and de Lépiney in a recent paper (1934) have mentioned that a population of *solitaria Schistocerca* hoppers was unaffected by the passage of bands of phase *gregaria* over their home. This observation suggests that there is, after all, some inherent difference between the phases, and that mere crowding is not enough to cause migration. As Hill and Taylor (1933) have shown, the colour differences themselves cause differences in the absorption of radiation and therefore in the internal workings of individuals of the different phases. Although some such inherent differences between the phases certainly do exist, it seems that they are not nearly as fundamental as some of us have supposed, and that differences in behaviour are mainly due to the different environments and only to a small degree inherent. Another observation which throws some doubt on the hypothesis that migration is entirely a reaction to crowding is that of the migration of scattered though very numerous phase *congregans* Brown Locusts made by Faure and Marais this year. Zolotarevsky's discovery (1929: 212) of the Madagascar Migratory Locust with *congregans* appearance, while numerous but before the formation of actual bands, points in the same direction.

Once started, migration is **controlled** by a number of factors, some of which are **limiting** and some **guiding.**

Some workers definitely hold, and others by the use of the term "pre-breeding migration" seem to support, the view the intensity of migrations at different times of the year is largely governed by the **degree of maturity** of the adults. Though this opinion cannot be refuted, it may be pointed out that most of the variations in intensity can be explained by climate and degree of crowding alone. The circling flights of young swarms of the tropical locusts are at first doubtless due to the softness of the integument, but later they may merely be due to the small size of the swarms before coalescing. The increase in the activity of locust swarms in central Africa at the end of the dry season over that in the middle, coincides, not only with the oncoming of sexual maturity, but also with the rise of temperature.

Of climatic factors, **temperature** has a clear effect. There is no reason to believe that a gradient in temperature can influence the direction of a migration, but cold is commonly a limiting factor. Usually it acts by lessening the activity of the locusts, as in the case of the sluggishness of Red Locust swarms in the winter in south and central Africa. Another example is that of those swarms of the Desert Locust which, having bred up in the summer rains in the tropics, migrate northwards. Given sufficient warmth these swarms probably would breed quite early in the winter rains of the southern fringe of the temperate zone, but they are held back and have their breeding deferred to the spring by the cold. Cold can occasionally act as a lethal factor in the tropical species, as in the case of the swarm of Desert Locusts which died in the saddle of Kilimanjaro a few years ago. De Lépiney (1930) and Rungs (1933) have also published accounts of similar cases. In the case of the subtropical and temperate species of locust, cold is important in killing off the old swarms at the beginning of winter. There is no evidence that too great heat is ever a direct limiting factor to the spread of locusts, though it may possibly be so sometimes in the case of the subtropical and temperate species. Jack suggests that the northward spread of the Brown Locust is limited by its susceptibility to the locust fungus, *Empusa grylli* (Fresenius), and that this is greater in a tropical climate.

Humidity is a factor whose importance has been pointed out by Lean (1931) with reference to the Migratory Locust in Nigeria, and Smee, in a recent unpublished report, has collected facts to show that it also limits the dry season distribution of the Red Locust in Nyasaland. There is little doubt that too dry a climate can kill locusts or prevent them from breeding, thus limiting further migration. It is not unlikely that too damp a one can have the same effect, perhaps in this case greater liability to disease. Some may think that humidity not only acts as a limiting factor to migration, but that it can also direct the course of migration within the limits thus set, and that this control is shown by a tendency for swarms to move always towards a certain optimum humidity. It is, however, difficult to understand how a locust in a certain humidity in one place can know in what direction to go in order to approach a more suitable humidity. In all but the most uniform country local humidity gradients are superimposed on and mask the general regional one. Also C. B. Williams has pointed out that the daily gradients in time usually are steeper than and obscure the regional one in space. Unless locusts are credited with intelligence, the right direction can only be found out by trial and error. Lean and others think that this method is the one used, but my own observations lead me to believe that many locust migrations are far too regular for their direction to have been determined by this means alone. There is no doubt that the correlation found by Lean exists, but it is probably an indirect one, the direction of migration within the limits set by temperature, humidity and other factors being governed by some

unknown factor which usually varies with the humidity. That humidity is not always the deciding factor is shown by the great abortive invasion of South Africa from moister regions further north by the Migratory Locust in the dry season of 1932 (Uvarov, 1933, pp. 30, 56). One common fault with observations on the effect of humidity is that they record relative humidity, which is a composite factor. Unless insects are equipped with special sense organs for the perception of humidity, the only way in which locusts can be affected by the dampness of the air is by its effect on the loss of moisture from the body. Humidity should therefore be measured as saturation deficiency or evaporating power.

Instances of the correlation of swarm movements with winds are too many to be enumerated, but, as with humidity, the correlation is by no means universal. In this case, however, there can be no doubt of the direct effect of wind on the direction of locust flight. It seems probable that the correlation here is direct, but that it only holds under certain conditions, which are unknown. As a result of the observations of Allan, Harris, Jack, Smee and myself, I suspect that the Red Locust during most of the dry season moves with the winds on the great plateaux of medium elevations and humidities in central Africa, but that in the damper broken uplands connected with the great escarpments and rift valleys they hang about with constantly changing directions, flying sometimes with and sometimes against the wind.

A number of factors have been suggested as governing the directions of the **movements of hoppers.** There is so little agreement on this subject, that little can be gained by summarising it, but the frequency with which all the bands in one district are found to move in one direction suggests that the direction is not due merely to chance. I have just a very vague suspicion that a band may be attracted from a little distance by the smell of food or of another band. On one occasion, while trying to photograph a marching band of Red Locust hoppers, I found that their progress seemed to be disturbed every time that there was a puff of wind. Maxwell-Darling in an early report on the Desert Locust considered and rejected a similar possibility. The variation in behaviour of Red Locust hoppers on meeting a path has been explained by Allan on the basis of temperature differences.

In conclusion, it may be repeated that, although there is plenty of evidence that locust migrations are largely governed by weather, very little is yet known of the actual climatic factors involved. All that has yet been proved is partial correlations with humidity and wind. Further study of the effect of these and other climatic factors on locust migration is needed urgently, for while control in the reservations may prevent future outbreaks from reaching such a size that a forecasting system will be needed, such a system would assist the campaigns against the present outbreak.

Finally, it must be explained that the draft resolutions and the paper written to open this discussion were produced hurriedly at short

notice and without any study of the subject, and can be considered as no more than a butt for argument.

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APPENDIX 4.

METHODS OF FIELD SURVEYS IN LOCUST RESEARCH.

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THE object of these notes is to provide a basis for the discussion of the problems of field technique in locust research. It is fortunate that so many field workers have been able to attend this Conference, which will thus provide an unique opportunity for solving those problems.

The choice of methods is to some extent dependent upon the system which is employed for the study of an outbreak area. There are two main systems, which may be termed "extensive" and "intensive." In the first, the worker travels from place to place noting the ecological conditions in each locality and the abundance of locusts in the various habitats. As a rule the investigator seldom stays more than a few days in any one place, and, therefore, his observations are concerned with conditions prevailing at different times in numerous localities throughout the outbreak area. It is true that the worker may return to one locality after an absence of weeks or, perhaps, months in order to study the changes which have

occurred since his previous visit; but it is probable that he will find difficulty in determining the reasons for those changes.

In the "intensive" system the worker remains in one section of the reservation for several months or, preferably, years, and thus is able continuously to study the seasonal changes in the habitats and the effect of those changes upon the locust population.

In Nigeria the first step in the study of the Chad area was an extensive survey with dual object of selecting the best locality for intensive work in the future and of noting the distribution of locusts and vegetation along the strip of land bordering the lake. Intensive work was begun in the selected area in January 1933; but, whenever an opportunity has occurred, short visits have been paid to other parts of the outbreak area in order that a check might be kept upon the conditions prevailing elsewhere.

Some investigators may consider that it is preferable to rely entirely upon the extensive system, so it must be borne in mind that the methods best suited to an intensive survey may not be practicable for a worker who is frequently moving from place to place.

Uniformity in methods of research.

The writer considers that the first question which should be decided is whether a certain degree of uniformity is desirable in the methods employed by workers in the different outbreak areas. Complete uniformity is obviously impracticable, and probably undesirable. The writer believes that valuable comparative data would be obtained if all workers utilised identical methods in estimating the locust population and in denoting the ecological characteristics of the habitats favoured by the locusts.

If the delegates decide that some degree of uniformity is desirable, it will be necessary for them, when deciding upon the uniform methods to be used, to take into consideration the extent of the funds and the number of trained assistants available for the various field workers.

Estimation of population.

The estimation of the locust population in various stations over a period of time provides valuable data concerning the ecological plasticity and requirements of the species being studied. Before devising the method of making the estimation it is necessary to decide whether the study should be confined to locusts only, or should include also the various species of grasshoppers occurring in the reservation. If it is decided to include all species of ACRIDIDAE in the population study, it is obvious that the requisite data can only be obtained by means of sample collections and subsequent analysis of the catches.

The estimation may be based on a time or area unit, *i.e.*, the worker may collect for a standard period of time or from a standard area. The writer is of the opinion that, unless a method is used in

which all the ACRIDIDAE can be removed from the sample areas, it is preferable to employ the time unit. The employment of the area unit implies an accuracy which is difficult to achieve in the ecological study of ACRIDIDAE.

Rubtzov (1932), who utilised sweeping, has stated that the actual density of a grasshopper population in a given habitat can be estimated almost exactly by counting the insects on plots one metre square. Collecting of this type would obviously have to be carried out before the ACRIDIDAE became active and could only be entrusted to trained assistants. In addition, it would be essential to collect from a large number of metre squares. This method might be valuable in areas where there is a lengthy period between dawn and the beginning of activity or to those workers who possess a large staff of trained assistants. Neither of these conditions was present in the Chad area.

The writer decided to include all ACRIDIDAE in his estimation of population and to employ the time unit. The sample collections were made by ten men in line who kept at constant distances from their neighbours and proceeded slowly for 15 minutes through each habitat. Several collections were made in each habitat every month and the mean of the catches was calculated for the various stations. It cannot be assumed that all the ACRIDIDAE are removed from the collecting areas, so it is not permissible to convert the results from a time to an area basis. The writer submits that this method is satisfactory provided that the collectors are trained to advance slowly. If they move rapidly it is probable that the smaller species of ACRIDIDAE will escape their notice.

If the investigator plans to estimate the population of locusts only he may be able to utilise a method which does not involve collecting, although the writer must confess that he is sceptical of the value of methods based upon sight alone. Locusts do not take to flight as readily on some days as on others, and in Chad, at any rate, it is not always possible to distinguish them from other species of ACRIDIDAE when on the wing.

The Imperial Institute of Entomology has issued a typewritten memorandum entitled "Instructions for locust survey," in which several methods of estimating population are suggested for trial. The first method described was individual collecting by a unit of time in which the observer (always the same, as the results depend on the individual powers of observation) traverses a selected plot, with uniform soil and vegetation, in several directions and notes the number of solitary locusts taken (or seen, if there is no doubt as to the species) within the hour. The most serious objections to this method are that it presumes the continued good health of the observer and that, except in cold weather, there would not be time to collect in more than one habitat on any one day.

The second method is collecting by time with a line of natives. It is suggested that the natives should be provided with nets and trained to catch locusts, and that the whole line should move along

an area of uniform soil and vegetation for an hour. If the locusts were active it would be impossible to keep the natives in line, as the insects would fly off in different directions before the advancing line. The degree of activity would vary on different days, and, if the line were maintained, an inaccurate idea of abundance would be obtained. If we assume that the collecting is done before the beginning of activity, nets are unnecessary; in addition, one hour as the standard period is impracticable.

The third method is collecting with a line of natives by area. The line moves over a definite stretch of ground and the total catch may then be calculated by a unit of area. The importance of sample collecting is stressed. The chief objection to this method is that it would be essential to stake out the sample areas beforehand. The boundary marks would have to be moved for each collection in a habitat unless the catch was released (after being counted) on the area from which it had been taken. This method would probably be the best for estimating the abundance of locusts provided the sample areas were previously demarcated and the collecting was carried out before the beginning of activity; but, unless trained assistants were employed, it is doubtful if the results would bear a close relationship to the actual population of the sample areas.

Vegetation studies.

The examination of the vegetation in the various stations is a less complex problem owing to the comparatively advanced stage which plant ecology has reached and to the static nature of plants. If the habitat consists of a mixture of several species of plants the ordinary methods of quadratting and line transects can be utilised in the analysis of the species forming the community. When only one species of plant forms the station the average height and the average number of individuals per square metre can be readily determined and prove to be useful data for comparing the vegetation of different stations. Gause (1930) in his work on the ecology of Orthoptera determined the green weight in grams of plants from one square metre sample plots in each habitat. This method is valuable for comparative purposes and was adopted by the writer, who cut the plants at a height of one inch above ground level.

If differences in the density of the vegetation are apparent in a habitat, the writer suggests that it is advisable to treat the dense and sparse sections separately and to regard them as being two distinct habitats.

Cover degree varies throughout the day, as the shade thrown by the plants is dependent on the position of the sun. Unless cover degree is determined at intervals throughout the day, its estimation is not likely to be of value.

The analysis of the soils in the various habitats is a necessary feature of the study of the vegetation.

Climatic and microclimatic observations.

The writer suggests that a meteorological station is a valuable adjunct to a field laboratory. Although shade temperatures and relative humidity figures have little or no bearing on the conditions experienced by locusts in the field, they enable a comparison to be made between climatic conditions in the reservation and elsewhere. The measurement of precipitation and the determination of wind direction are both easily made and essential. Wind intensity can be indicated by the use of the Beaufort scale.

The writer believes that the study of the microclimate will prove to be the main key to the understanding of the ecological requirements of locusts. In his experience, the graminivorous species of ACRIDIDAE are not monophagous, and their choice of stations appears to be influenced by microclimatic conditions rather than by the nature of the vegetation itself.

The study of the microclimate presents more difficulties than any other branch of our work. The simultaneous recording of temperature and relative humidity in a number of habitats is desirable so that a comparison can be made between the microclimates. This necessitates the use of either a large number of expensive self-recording instruments, or a large number of trained assistants with less costly apparatus. Some instruments of the self-recording type, such as the Edney thermo-hydrograph, have serious disadvantages for field work quite apart from the question of their costliness. Weekly evaporation can be measured by means of Livingstone atmometers, but is it sufficient to rely upon evaporation figures only, the extent of which is determined by a complex of meteorological factors? The writer is of the opinion that evaporation alone is not sufficient for our purposes and that separate records of both temperature and relative humidity are required.

If the study of the microclimate is to be complete, readings must be taken at fixed intervals throughout the period of locust activity or else a self-recording instrument must be used. Complete records in a number of habitats would require the whole time of a corresponding number of trained assistants. In practice, even if the requisite number of assistants were available, it is doubtful if the investigator would be inclined to devote them almost entirely to this one aspect of the study. The only solution appears to be the use of self-recording instruments, which are both efficient and not prohibitive in cost. The writer suggests that, if the delegates decide that self-recording instruments are essential, the opinion of expert meteorologists should be obtained as to the best type of instruments for our purpose.

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APPENDIX 5.

THE ECOLOGY AND HABITS OF LOCUSTS IN AN INVASION AREA (UGANDA), WITH SPECIAL REFERENCE TO *LOCUSTA MIGRATORIA MIGRATORIOIDES* (Reiche and Fairmaire) ph. *TRANSIENS.*

By H. B. Johnston, *Chief Locust Investigator, Imperial Institute of Entomology, London.*

The main subjects to be kept in view during the present investigation are the search for outbreak areas, and the definition of the conditions which determine the existence of phase *solitaria* there during long periods and of those which bring about periodic swarming.

One way of approaching these questions would be to select on theoretical grounds certain regions suspected of being outbreak areas and to concentrate effort on the study of these. The exclusion, however, of regions which at present, in the imperfect state of our knowledge, appear to be purely invasion areas would be a mistake. Systematic and descriptive literature, rightly or wrongly, contains numerous references to the supposed wide range in Africa of *Locusta danica*, Linn. This locust has in the past frequently been recorded from east Africa, which for the time being may be considered an invasion area. It is possible that transient phases have been confused with the true solitary phase, since the former may prove to persist for a considerable time, after the disappearance of swarms, without giving rise to outbreak areas. In any case, the geographical range of the solitary phase must be reconsidered and reconstructed. This can only be concluded with certainty after ecological study over a wide area, and after the disappearance of phase *gregaria*. That the matter is not easy is shown by the occasional discovery now, during the gregarious cycle, in central Africa of what appear to be on structural grounds very extreme phase *solitaria*. These have occurred in localities which are reported not to have been visited by swarms.

Another important reason for including invasion areas in a scheme aiming at the study of outbreak areas is that, in the former, peculiar opportunities are offered for the study of dissociating factors. By these are meant the phenomena which attend the break-up of swarms and which occupy the intermediate period characterised by phase *dissocians*. These are important as providing a reversal of those processes which give rise to swarms. Such studies can undoubtedly best be pursued in the equatorial and

adjacent regions where two annual broods are normal, and where swarms are present in varying intensity in some stage throughout the year. The countries with one wet season and a long dry period devoid of locusts offer fewer opportunities. In these countries untimely drought and the action of predators may exercise important reducing influences, but it is in those countries of heavier rainfall, which in consequence present a heavier array of competing forces, that the break-up of the swarming phase is more thoroughly accomplished.

The process of break-up of swarms in east Africa is now nearing completion, and there is commencing a period of the utmost value for those who desire an understanding not only of the action of dissociating factors, but of the causes which decide whether a region is purely an invasion area or not.

The remarks which follow refer to east Africa, and more particularly to Uganda, where observations of a more continuous description have been made. The species dealt with is *Locusta migratoria migratorioides* (Reiche & Fairmaire), which, up to the recent outbreak of the Red Locust, *Nomadacris septemfasciata* (Serville), has been the main species concerned. Details will be avoided and subjects both under actual investigation and those considered important to future work will be indicated in broad lines only. It is expected that criticism of a suggestive nature will be forthcoming, as will the experiences and opinions of workers who have anything to offer on these and kindred subjects.

As has been said already, each thread of the investigation in hand should lead towards a solution of questions connected with outbreak areas and outbreak centres. It has been stated above that this involves investigations in invasion areas. Since locust swarming is to be regarded as part of a closed circle, no part of which can be denied attention, phase *gregaria* should be investigated in invasion areas as well as phase *solitaria*. Mention will be made of certain aspects of this later. The work here touched on really commences with the individuals thrown off from swarms either as stragglers or as adults bred from small larval bands. The movements, life habits, and breeding activities of these, particularly towards the end of the gregarious cycle, are of the utmost importance in providing indications of reasons for the selection or rejection of any habitat type as a reservation. Of special interest is the following-out of the narrowing down process, whereby, starting from a widespread occurrence of phase *gregaria*, the occupied areas become only islands in an unoccupied ocean. The definition of each stage in this process, were this possible, would be full of practical interest and importance.

Two possible sources of phase *solitaria* are to be considered. One provides individuals which occupy habitats apart from access by swarms and which, owing to the conditions of their habitat, do not give rise to swarms. The other comprises the descendants of individuals thrown off by swarms, or phase *dissocians*. Whether the

first of these exists in east Africa is very doubtful. Occasional specimens obtained from higher altitudes in certain parts of Uganda faintly indicate the possibility of their existence. These specimens are of an extreme type with a $\frac{E^*}{F}$ ratio of 1·71. They usually occur in short grass "meadow" at an altitude of 7,000 ft. The localities are under investigation. It is with the second class that we are occupied here. The questions to be answered include the following: Can phase *dissocians* lead to the establishment of phase *solitaria* for any length of time in an invasion area? If the answer is affirmative, and if phase *congregans* can be produced from these, that particular region cannot be designated a purely invasion area. If, on the other hand, it is found that swarms leave no permanent impression in the shape of resident breeding phase *solitaria*, what are the causes which lead to the dissolution of the latter and render the region entirely dependent upon immigrant swarms?

It may be remarked here that some uncertainty still accompanies the use of the term "phase *dissocians*," and it is feared that confusion has not been avoided on this occasion. The writer prefers to use the term, at least for the time being, rather to indicate a period of time connecting phases *gregaria* and *solitaria*, and one characterised by locusts of variable appearance, than to designate a definite recognizable insect. Very little work on the lines above intimated soon shows how complicated is the process by which an understanding of the whole subject will ultimately be reached. It is hoped that enough has been said to indicate the main lines of this aspect of the investigation.

Turning to the question of phase *dissocians* as the source of a potential residual phase *solitaria*, it may be asked whether any particular type of habitat has proved suitable for phase *dissocians* and what are its habits in these places. The matter is of too recent date to provide material for generalisation. Two types of habitat have proved to favour the occupation by this phase in Uganda.

From the point of view of locust habitats, the vegetation of Uganda may be divided into seven broad classes: forest, swamp, cultivation, alpine and subalpine, long (elephant) grass, short grass scrub, medium grass bush. As botanical and ecological divisions these are far too indefinite. For the present purpose they will serve. Only two of these have proved of any significance in the present connection, namely, "temporary swamp" and portions of the "short grass scrub." Isolated specimens have been found elsewhere, but up to now these two localities alone have provided considerable colonies.

The term swamp should be confined to ground permanently under water, and bearing a typical vegetation of papyrus and sedge. This type occurs in Uganda in the river valleys and on the edges of

* $\frac{E}{F}$ signifies the ratio of the elytron to the hind femur.

backwaters of lakes. It possesses little importance in the present connection. A habitat which has considerable interest, however, may be called "temporary or seasonal swamps." Individually, these are basins or areas of low ground which, with their adjacent ridges covered with bush of greater or less density, form a prominent feature of a large part of central and northern Uganda. Drainage takes place into these basins, which in the rains become partially or wholly flooded. Between rains they dry, being in this condition to a variable extent in January and February, and again possibly in July. Some never wholly dry up. Few trees flourish. A seasonal succession of grasses takes place, these being normally of from short to medium height, and not closely packed. Open dry and bare spaces may occur where procumbent and creeping grasses flourish. Cattle grazing can be carried on extensively in some of these basins as a result of which the grasses may become sparser and shorter.

The vegetation of the adjacent higher ground is totally different. Here a *Combretum-Bauhinia-Acacia* tree association of varying density, and kept stunted by the annual grass burning, dominates a ground vegetation consisting largely of grasses. These differ specifically from those of the seasonal swamp below, but do not display to the same extent seasonal succession. Soil differences rest largely in the silt and clay content, which in the lower and flooded areas are higher. Moreover, soil moisture content is naturally higher throughout the year in the latter. As regards climatic data, a long period of observations is necessary during at least a year. Present results show that humidity tends to be higher and the minimum temperature lower in the flooded areas.

It is in these seasonal swamps, when not entirely flooded and when in a drying or dried condition, that phase *transiens* may be found. The population density varies considerably from an observed maximum of 126 seen per man per hour to 6 per man per hour minimum. Colour is overwhelmingly green, brown specimens being rare. The biometrical data are those of phase *transiens*, the $\frac{E}{F}$ ratio being between 1·80 and 1·90.

The females are double-brooded, but do not necessarily breed in the low ground. The egg output, judging from field cage observations, is less than that of phase *gregaria*. There is, moreover, a diminution of population during their occupation of the basins chiefly from Nematode worms and birds. It may be remarked that in no case has any tendency towards phase *congregans* been encountered in this type of habitat. Since this particular type of habitat has been under observation for only a short period, it is dangerous to attempt to assign reasons for the facts enumerated above. This much may be said. There appears to be a double migration to these basins in January or earlier, and again in June–July. Breeding can go on there, particularly on the edges which are free from flooding. Grass burning takes place as a rule on the higher bush land in December, whereas in the basins it normally takes place later, in January,

February, or not at all. The bush fires drive numbers from the higher ground. It appears that in many places these basins, if not too humid, offer a suitable habitat throughout the year, being left only for egg-laying, though often occupied during egg-laying.

This case of the basins or seasonal swamps is mentioned at some length not because of its permanent value in relation to the study of reservations, but as an example of the openings offered for field observations in invasion areas. In such cases it is essential to find out in detail the movements of the locusts to and from the basins and the relationship of this to climatic data. The breeding and larval activity must be followed in connection with meteorological work *in situ*, and, above all, it must be ascertained whether all such habitats are merely temporary collecting grounds, or whether phase *solitaria* can inhabit them permanently.

The second type of habitat found favourable to phase *transiens* is the "*Cynodon* short grass association" found in the short grass scrub type of bush. This association is of wide occurrence in Uganda, and probably elsewhere in East Africa. Associated grasses of the genera *Eragrostis*, *Setaria*, *Aristida*, *Sporobolus*, and *Chloris* occur, but the genus most favoured by *Locusta* phase *transiens* is *Cynodon*. In area this grass is locally restricted, but it occurs more or less thickly on roads and paths and in open spaces, sometimes among other taller species. The luxuriance of its growth is always greater on less poor and nitrogenous soils. Nine cases of the connection of *Locusta* with this grass association have been studied. The main features are these: Eggs have been laid by passing swarms usually in bare spaces in the vicinity. The hoppers find themselves in a normal medium grass-bush habitat. If, however, a band in the course of movement finds the *Cynodon* short grass it will remain, become sedentary and alter colour. Here green is not always a predominant colour and brown and other colours largely occur. The adults, again, are of the phase *transiens* structure, $\frac{E}{F}$ being between 1·80 and 1·90. In one markedly interesting case two bands produced almost certainly by the splitting of a larger band, were kept under observation. One meeting with *Cynodon* short grass became sedentary and solitary, whilst the other, owing to a change of direction, moved away into the bush and remained gregarious, producing typical phase *gregaria* adults. In this case the bush vegetation was dying and food was difficult to find, thus accentuating the difference between the two bands in respect of the amount of activity exhibited during larval life.

One important difference between the seasonal swamp and the *Cynodon* short grass habitat is that in the latter no congregation of adults has even been met with. A short time after the last moult the adults seem to scatter. No areas exist there resembling the seasonal swamp to which movement takes place, and with the drying up of the vegetation subsequent to the rains the adults disappear. Their survival rate is at present completely unknown.

It has been mentioned that cases such as these give examples of the sources from which information on the status of phase *transiens* in invasion areas may be sought. Casual and disconnected observations are, however, useless, and only by the continuation of the study of habits with ecological meteorological data can valuable work be done.

Future work on these lines should aim at following the adult phase *dissocians* in the field from egg to adult and subsequent accounting also for the movements of the adults. Migrations from one habitat type to another are important, and the classification of these as permanent or seasonal. Any tendency towards permanent residence or breeding in any particular habitat should be subject to continued observation. Field cage work, if possible in the natural habitat, is of value in ascertaining the particulars of the life-cycle and breeding periods. The writer has found that, though cage experiments are often not without their peculiar difficulties, the results obtained, where these can be compared with field data, are not greatly at variance with the latter. This may be taken to show that locusts are not so adversely affected by confinement as is often supposed.

It may be remarked that field studies of this kind should provide valuable opportunities for settling whether the term phase *dissocians* can be used for an insect possessing certain clear-cut characters, or, in the other extreme, whether it merely represents a period of time connecting the solitary with the gregarious states. The writer is not yet prepared to offer an opinion on this point. The main difficulty rests in not having authentic phase *solitaria* in the region for comparison. As stated above, the adults resulting from dissociation by swarms are in structure intermediate, not reaching the extreme type met with in more isolated habitats. In the former $\frac{F}{\bar{F}} = 1{\cdot}80–1{\cdot}90$, whereas in the latter it is $1{\cdot}70–1{\cdot}80$. Sufficient material exists for the carrying out of careful structural examination and comparison. Whether phase *dissocians* possesses its own temporary habitats differing from those of phase *solitaria* remains uncertain. The requirements of the two phases may differ widely.

A point of importance is the fact that the offspring of a swarm, subjected to dissociating influences, becomes in a period similar to that passed through by a phase *gregaria* brood, typically phase *transiens*, but by no such means have extreme phase *solitaria* been produced such as are found in the isolated habitats.

The passage to phase *dissocians* may be investigated further by inquiring whether any change within the swarms themselves or in their environment gives the first impulse towards dissociation.

One of the early symptoms of dissociation is the reduction in the size of larval bands. In east Africa and the southern Sudan this tendency was evident already in the 10th generation in 1932, and since then the process has been increasingly evident until in the 13th generation in Uganda hardly any large bands were obtainable. One of the main features of the habits of these bands was their

comparatively reduced mobility, apparently largely irrespective of vegetation differences and climatic conditions. Bands continually coalesced and split up, the frequency of this depending on degree of proximity. Study of temperature in relation to these bands showed that, though high temperatures tended to increase the amount of activity of larvae when disturbed and led to short changes of position, it did not lead to extensive marching.

Study of the characters of the adults from small bands has shown a persistence of phase *gregaria* characters. $\frac{E}{F}$ shows as 2·15 to 2·20. No difference could be detected in structural measurements between adults from small bands reared in a humid environment and those from a drier one. Compared with adults from swarms of earlier dates, there appears to be no measurable difference. It must be concluded, therefore, in conjunction with the remarks made above on phase *dissocians* habitats, that the size of the band can be very drastically reduced and yet give rise to phase *gregaria* adults provided a certain amount of activity is maintained throughout larval life. If, however, activity ceases, as happens in the *Cynodon* short grass habitat, phase *dissocians* results.

It is not maintained here that the essential factors governing the change from phase *gregaria* to phases *dissocians* and *solitaria* are fully understood. Further work, particularly exact experimental work, is needed, introducing the possible factors of lowered temperature, food supply (qualitative and quantitative) and mutual proximity in space, &c. It seems, however, borne out that the induction of sedentariness in every case leads to the change. The reduction in the size of bands is an important step in this direction, since the extreme activity of large hopper bands is reduced and the band is more open to disruptive influences of various kinds. Faure has drawn attention to the important place occupied by muscular activity in the passage from phase *solitaria* to phase *gregaria*, and has noted the absence of movement in hoppers kept singly. The facts above mentioned may provide confirmation from the field of conclusions arrived at from cage experiments, namely, that great reduction in movement accompanies the passage from phase *gregaria* towards the solitary phase. The small bands referred to suffer greater or less reduction in many cases from various causes, chiefly birds. Union of the small adult swarms takes place. This depends chiefly on the degree of proximity of the bands. If, however, a small band becomes adult, an attempted migration takes place, but if other swarms are not met with, either scattering takes place or more usually the swarm is reduced by predators, with the same result.

The inquiry regarding dissociating factors does not end with the investigation of small bands, but extends further back to the causes which give rise to these bands, prior to, and apart from, any reduction during the life of the band. Such causes exist either within the parent swarm, or are connected with the reproductive processes and

the environmental conditions under which these processes are carried out.

Among environmental factors the following have been found to operate in greater or less measure :—

1. *Delayed incubation of egg-masses in the ground.*

Evidence from the field has been circumstantial only but of considerable weight. Cases of this kind have been the emergence of hoppers after prolonged drought and in localities from which swarms have been absent. The possibility of such egg-laying having been due to phase *congregans* has been considered and excluded. There is usually some mortality in cases of delayed hatching. Experimental dissociation of egg-masses and their subsequent moistening has reduplicated to some extent, though with difficulty, field conditions. Prolonged incubation would not necessarily lead to reduction in size of individual bands, but to altered distribution over a wide area. A short period of two days has been found to separate the dates of emergence of eggs laid simultaneously in one instance observed. Part were laid on the edge of a cold swamp and part on a warm hillside. In such a case splitting of the hopper bands could occur, though, in fact, this has not been observed.

2. *Scattered disposition of egg-masses in laying sites.*

This primarily depends on the fact that only a proportion of females in any swarm normally lay at one time. Where a large swarm rests during egg-laying, the subsequent scattering of larvae is less likely to take place than where bands result from egg-laying by stragglers thrown off by swarms in transit. Such stragglers frequently separate considerably before laying eggs. In this case the formation of bands will depend on the number of stragglers being sufficient to effect a concentrated egg-laying.

3. *Reduction in number of eggs laid.*

The average given by a large number of examination of egg-masses laid by 10th, 11th and 12th generations in Uganda has been about 45 eggs per packet. This is higher than in certain counts previously made, but is still a low figure. Unfortunately, records of egg-laying in the earliest period of the swarming cycle have not been found for purposes of comparison.

4. *Parasites and disease.*

Cases in which egg-masses have been killed wholly or partially are common, but it is likely that this is a contributory and not

a main cause of dissociation. The dipterous fly *Stomatorrhina lunata* Fab. is important in this connection.

Perhaps the most powerful factor is the fact that, at least as observed in the 10th and 12th generations, the swarms, in many cases seen, do not lay in any sense simultaneously, but eggs are laid consecutively. The route traversed by swarms, particularly in the latter part of their mature life, has been found to be marked by stragglers in greater or less numbers. Among these are to be found sometimes parasitized individuals, but generally the majority are gravid females. An examination of females from mature swarms shows that the maturity of the eggs differs greatly, some being near laying, while others are in a much less advanced state of development. From this it is reasonable to suppose that laying must take place in succession, thus giving rise to a series of small hopper bands in the wake of the swarm.

It is difficult to assign a reason for this lack of uniformity in egg development, or to point to any exact time in the life of the swarm, or in the gregarious cycle, when the process commenced. The union of swarms of various ages would produce this result, or there may be certain causes which lead to more rapid maturation in some individuals than in others. In any case, this is believed at present to be an important cause of the production of hopper bands of much smaller size than would be the case were swarms to lay simultaneously.

Nothing has been said regarding phase *gregaria* in invasion areas. Since attention should concentrate on the fixing of outbreak areas, swarms possess their main interest as links between one solitary period and the next. Two points in regard to swarms, however, deserve study in invasion areas, namely, maturation phenomena, and swarm movement in relation to climate. Both these questions present peculiar features in a country like Uganda, with sharp climatic differences within a comparatively small area. It is probable that swarms from without frequently complete their life in the country. Swarms from the north (Sudan) can be followed southwards. These usually die in a diminished remnant before reaching the equator. A remarkable hiatus exists during the months July to September, when swarms are immature or maturing and when egg-laying and hoppers are entirely absent. This contrasts strongly with the almost continuous occurrences of egg-laying and hoppers from October to June, a short interval of six weeks in the north and nothing in the south separating the autumn and spring broods. This is accounted for by the continuous immigration from outside of maturing swarms during this period. The summer hiatus corresponds with a drier and colder period, but this is hardly sufficient to explain the phenomenon, which remains largely unexplained. The occurrence of a dry period in north-east Uganda, December 1933–March 1934, permitted certain observations to be made on the relationship of swarm movement and climate. It has been found that when the

degree of wetness is less than 1 inch and maximum humidity below 50 per cent. swarms tend to be absent. For egg-laying a higher rainfall than that represented by a degree of wetness of 1 inch is necessary.

Sufficient accurate *experimental* data of maturation phenomena for *Locusta* from east Africa are still lacking. In *Nomadacris septemfasciata* (Serville), however, it has been found that maturation can take place in the presence of humidity and two generations are possible. There are indications also that this maturation can be held up by reducing humidity below 40 per cent. R.H.

Methods in invasion areas.

Turning to the question of methods for adoption in invasion areas, it is difficult to indicate these in the case of an investigation such as the present without precedent and in which methods must be adopted to necessity as the work progresses. Sufficient has been done, however, to enable the broad lines of work to be indicated. It must be repeated that the outbreak areas are the main objective. An invasion area can be so designated only provisionally, and its true status must await the final definition of the range and habits of phase *solitaria*. It may well happen that within what is taken to be an invasion area islands of phase *solitaria* will be found. These may have no significance as outbreak centres, but in such case their investigation must throw light on the outbreak centres by at least revealing factors necessary to permanent occupation by the solitary phase.

Starting with phase *dissocians*, if possible the F_1 generation from swarms, the environment of this phase should be studied, taking into consideration particularly vegetation and climate. In Uganda some idea has been obtained of these habitats. As soon as a general survey has enabled certain habitats to be selected as being favoured by phase *dissocians*, these must be studied from every point of view. Seasonal movements and breeding are of importance. All this can only be done by selecting a few localities and carrying out continuous field studies in them. It is not yet known how far climatic changes directly govern the life of phase *dissocians*, or whether these act through changes in the quality and abundance of food.

A word may be said on the use and value of what may be called field experiments. The difficulty in most cases is to obtain fully controlled conditions, but certain advantages attach to having the experiments in the same area as the field work. A type of large folding cage, measuring 6′ × 5′ × 5′, already in use by the Government Entomologist, Uganda, has been found, owing to its portability and size, of great value in the field work, for closer study of locusts occurring in the vicinity. As an example of field experiment the following may be mentioned. In order to observe the effect of change of environment on the phase *gregaria* hopper, a square of ground occupied by *Cynodon* grass was surrounded by a trench to prevent

exit of hoppers, and another trench on the outside of the first prevented the ingress of hoppers from without. A fixed number of phase *gregaria* hoppers giving a known population density were introduced and their movements recorded by noting numbers caught in the trench. Soil and ground temperatures were recorded, as well as humidity and rainfall. A number of experiments of this kind have been useful in providing data additional to those provided by cage experiments.

APPENDIX 6.

LOCUST DISEASES.

By J. C. F. HOPKINS, D.Sc., A.I.C.T.A., *Senior Plant Pathologist, Government of Southern Rhodesia.*

(Communicated to the Conference by the United Kingdom delegation.)

THE investigations carried out in South Africa upon fungus diseases of locusts have been summarised in Farmers' Bulletin No. 8 of 1911 by Dr. I. B. Pole Evans, and reprint No. 29 of 1925 by S. H. Skaife, both being publications of the Union of South Africa, Department of Agriculture. The information contained in these two papers is distinctly negative in character and suggests that further studies are necessary for a fuller understanding of the natural control of these insects. The fact that epidemic disease can be so destructive warrants the assumption that it is a weapon not to be despised, and it is possible that research may find means of practical application.

Owing to my having recently assumed new and additional duties, I have been unable to devote much time or thought to details of research, but it does appear to me to be desirable for ecological investigations to be made in areas where epidemic disease is rife or has destroyed large swarms. There are so many queries regarding all phases of disease epidemics that our true and certain knowledge appears to be reduced to one fact, namely, that a fungus *is* capable of destroying locust swarms.

I do not profess to have much intimate knowledge of entomogeneous fungi so that I feel somewhat diffident in putting forward suggestions. However, even as a cat may look at a king I will have the temerity to list the ideas which have occurred to me.

1. Field and laboratory work are complementary and cannot be pursued independently.
2. What relationship does population density bear to temperature and humidity in producing epidemics?
3. What is the function of resting-spores? What is their period of longevity (*a*) in dust and plant debris, (*b*) in insect remains?

4. Is there an unknown phase in the life cycle of *Empusa*? What is the sexual stage? Are "resting spores" resting spores?
5. Do resting spores start epidemics or are there always infected insects in existence?
6. Are there tolerant races of insects or is there any difference in susceptibility between swarm phase and solitary phase?
7. Is the disease inherited? To what diseases are the eggs susceptible?
8. Is it possible to produce epidemic disease artificially in permanent breeding grounds? Is the absence of disease the stimulus which initiates the swarm phase?
9. Is *Empusa grylli* (Fresenius) the only organism capable of causing destruction of swarms? It is not the only fungus parasite.
10. Is it not probable that suspensions of conidia or resting spores in a liquid culture medium would bring about infection much more readily than suspensions in water by (*a*) stimulating growth of germ tube, and (*b*) (with suitable medium) protecting germ tube or spore, by a thin waterproof film, from dessication?

    Regarding a suitable medium, it must be borne in mind that a few years ago many fungi which are now grown *in vitro* were regarded as being obligate parasites.
11. By artificially cultivating *Empusa grylli* (Fresenius) it might be possible to produce large numbers of resting spores which could be used to spray on herbage.

As far as I am aware, all the lines which I have suggested could be carried out in Southern Rhodesia, if funds and trained personnel could be made available for this purpose. Certainly, accommodation could be provided at this laboratory for mycological work.

APPENDIX 7.

FUNDAMENTAL RESEARCH ON THE LOCUST PROBLEM

By B. P. Uvarov, *Senior Assistant, Imperial Institute of Entomology, London.*

A thorough understanding of the immensely complex locust problem requires a full knowledge of all the aspects of the structure, physiology, genetics, embryology, and ecology of each locust species. An all-embracing and very imposing programme of such studies could be drafted without great difficulty, but it is not unreasonable to ask whether the fulfilment of such a comprehensive programme is really indispensable for the progress of locust investigations. For an entomologist engaged in investigations there exists a great temptation to try to elucidate all possible details of the locust problem,

merely for the sake of completeness. It must be never forgotten, however, that the international locust investigations in which all of us are engaged, have a definite practical aim in view. This aim is the permanent solution of the locust problem, and the importance of reaching this solution without unavoidable delays is obvious. While realising, therefore, the need for fundamental studies we must restrain our scientific zeal and concentrate our attention in the first instance on those points which would supply data elucidating the results of field studies and thus contribute directly to the solution of the problem. This restriction refers, of course, only to studies carried out in direct connection with the international locust investigations. Research on even the most abstruse aspects of locust anatomy or biology carried out in university laboratories should, of course, be encouraged.

It may be argued that our present knowledge of the locust problem is inadequate for deciding which are the most important of the fundamental aspects of the problem. The fact is, however, that there have already arisen several points, for example, in locust physiology, without the study of which we are unable to interpret certain field results and cannot proceed further. These outstanding points should certainly be given preference over others which have not yet arisen in our work. The present paper is an attempt to indicate briefly the directions in which fundamental research is most urgently required.

The crux of the locust problem as studied at present is the problem of phase transformation. The fascination presented by experiments in which one phase is transformed into another is so great, that entomologists are apt to succumb to the temptation to start them, but this seldom leads to more than a confirmation of the already well known superficial phenomena. The researches by Faure, Zolotarevsky, and others, have demonstrated that the transformation is a metabolic process influenced by the rate of activity and connected with the formation of special pigments. Here, then, are two large fundamental problems for study. The first problem relates to **the rate of activity as regulated by various environmental factors.** This must be studied by the quantitative methods of pure physiology and in a comparative way for the different phases of a species. The environmental factors for study should include not only the physical ones, but also the mutual influence of the crowded hoppers. The second problem is that of **the qualitative differences in the metabolism of the extreme phases,** which can be approached by the study of pigments and of their rôle in the general metabolism. A correlated point is the inheritance of pigments, which should be particularly studied in the hoppers just after hatching and not yet subjected to environmental influences. It need hardly be said that all these problems can profitably be studied only in specially equipped physiological and biochemical laboratories and by trained specialists. At the same time, their solution would materially help in the interpretation of field results.

A further physiological problem is **the resistance of locusts to the physical factors of their environment.** We want to know for each species the degrees of heat and humidity which are tolerated by each stage and phase, and which are injurious or fatal to them. So far, very little work has been done on these lines, but its practical importance cannot be doubted.

Still more important is **the problem of life-cycles.** Studies on this point when carried out on insects other than locusts usually consist in the experiments on the rate of embryonic and postembryonic development under different conditions of temperature and humidity. In the case of tropical locusts with which we are primarily concerned, the greatest interest is attached to the influence of climate on the adult insect, for the variations in the rate of development due to climatic factors in the egg and hopper stages are of subsidiary importance. The annual life-cycle of the tropical locusts is wholly dependent on the climatic conditions causing, or hindering, the sexual maturation of adults. Moreover, recent field studies in the Sudan and in India suggest that the phenomenon of incipient swarming and the beginning of an outbreak may depend on the accelerated maturation induced by certain types of weather. A more exact study of the climatic influences on the maturation process and the diapauses is obviously needed and work of this kind is now in progress in several laboratories. Particular attention is paid to this problem in the locust breeding laboratory of the Imperial Institute of Entomology, where an extensive installation for controlling the temperature and humidity conditions is maintained. The experiments so far carried out were concerned mainly with the influence on the sexual development of constant temperatures and humidities in different combinations. There are some clear indications, however, that fluctuating conditions may be of even greater importance and further experiments are planned on these lines.

The study of the behaviour of locusts may easily fascinate an enthusiastic experimentator to such an extent that their practical purpose is forgotten. Here, again, we must try to select for immediate study the points of greatest value. We want to know, for instance, **the physiological reasons for the interattraction of individuals of the phase** *gregaria* **which appears to be absent in the case of phase** *solitaria*. The formation of hopper bands and of adult swarms and their integrity depend on this presumed interattraction, but we know nothing of its true nature. Merely as a suggestion it may be indicated that the attraction and the mass movements might possibly be studied as conditioned reflexes. The reactions of a hopper placed by chance in a close association with others may conceivably become very different from those of isolated hoppers. Constant irritation by other hoppers may lead to intensive reactions even to their mere presence. This conception has the advantage of being suitable for an experimental study, which would throw light on the obscure phenomenon of gregariousness.

The influence of the physical factors on the behaviour of hoppers

is an interesting subject, but its value for the main problem is not great. A possible exception is **the reactions of hoppers to temperature and humidity leading to a change of habitat.** These may be of importance in the formation of the initial concentrations, leading to incipient swarming.

On the other hand, **the behaviour of adults** is a problem of outstanding importance. With regard to individuals of phase *solitaria*, their reactions to microclimatic and soil factors are also among the possible reasons for incipient swarming, and the physiology of these reactions, as well as the critical values of the factors, must be studied in laboratory conditions. Still more important is the behaviour of adult swarms of phase *gregaria* in relation to climatic factors. A great deal of useful information in this connection can be gained from bioclimatic studies in the field, but a thorough experimental study of the reactions to the main stimuli would undoubtedly assist in the interpretation of field data. This would permit us to approach the problem of the seasonal migrations of swarms, and even to forecast them. The factors to be studied experimentally include different constant degrees of temperature and humidity; the gradients of such temperature and humidity; air-currents of different velocity in combination with the two above factors.

The above survey of the main points in the locust problem which can be solved only in properly equipped laboratories may appear very incomplete. The main idea is, however, to concentrate the attention of the research workers on a few definite problems, the solution of which is urgently needed in connection with the field work. At present, locusts are beginning to gain admittance into university laboratories as very convenient experimental animals. Researches on them are, however, often directed towards such problems as are devoid of interest to locust entomologists. This may be due not only to the fact that pure research workers avoid studying any problems of practical value, but also to the absence of a definitely formulated list of the research problems awaiting investigation. When such a list is produced, steps could be taken to ensure that the various problems in it are referred to particular laboratories for intensive studies. The co-operation of university and similar research laboratories could be best secured if the national locust organisations in each country were to provide some financial assistance towards research in definite problems. In this way, research laboratories would be able to investigate problems of great general interest at the expense of locust organisation, which would benefit by the results attained. A first step in this direction has been made by the Committee on Locust Control of the Economic Advisory Council, who are offering a scholarship for a research student undertaking the study of a selected problem. The number of problems is, however, considerable and it is hoped that a similar course of action will be taken in other countries.

APPENDIX 8.

THE DESTRUCTION OF LOCUSTS IN FLIGHT BY MEANS OF A POISON DUST (SODIUM ARSENITE), DELIVERED FROM AIRCRAFT.

By H. H. KING, *Officer in charge of aircraft experiments in Africa, Imperial Institute of Entomology, London.*

Introduction.

I sailed from Southampton on the 6th, arrived at Cape Town on the 23rd and at Broken Hill on the 26th April. I had informed the Chief Secretary, Northern Rhodesia, of my arrival at Cape Town and an official from the Secretariat met me at Livingstone. On the 27th Mr. Michelmore arrived from Tanganyika Territory and Mr. Allan, Entomologist, Northern Rhodesia, from Mazabuka.

The Hercules aircraft "City of Delhi," with Captain Phillip, pilot, and Mr. Ellis, wireless operator, were awaiting me at Broken Hill. The aircraft was taken up for a short trial flight on the 27th, the apparatus then overhauled, a spare spider fitted to one of the cylinders and the cylinders charged. On the 29th a flight was carried out with the intention of attacking a locust swarm, but the latter being at the time directly and very low over native huts and cultivations, we returned to the aerodrome with the intention of going out again later. On landing, the aircraft collided with the hangar and was seriously damaged. I reported the accident the following morning to the Chief Secretary, Livingstone.

On the 1st May, a Union of South Africa Air Force aircraft, a Wapiti, with Captain Bronkhorst, pilot, and Flight Sergeant Whittaker, mechanic, arrived from Robert's Heights. Captain Bronkhorst asked to be permitted to examine the apparatus on the Hercules and to copy blue prints and instructions for using the apparatus.

On the 3rd May Captain Phillip left on the air mail service for Kisumu, returning two days later with the Hercules "City of Cape Town." The apparatus, which had meanwhile been removed from the "City of Delhi," was then fitted to the "City of Cape Town."

A second Union of South Africa Air Force Wapiti arrived from Robert's Heights on the 10th May, with Dr. Naudé, Chief Entomologist, Union of South Africa, and Lieutenant Faurie, pilot. The Hercules, "City of Cape Town," was ready for use by noon on the 11th May. Five days later Captain Bronkhorst and Flight Sergeant Whittaker left on their Wapiti for Robert's Heights.

The locust swarms in the vicinity of Broken Hill were, by this time, heavily infected with the disease caused by the fungus *Empusa grylli*, and there was good reason to believe that the majority of the

swarms throughout Northern Rhodesia were in a similar condition. As I had heard from Mr. R. W. Jack, Chief Entomologist, Southern Rhodesia, that there were numbers of apparently healthy swarms in that territory, I communicated this information to the Chief Secretary, Livingstone, and asked for instructions. On the 24th May I was directed by the Chief Secretary to proceed to Southern Rhodesia; the Hercules left later in the day with cylinders and air bottle charged, sufficient arsenic and compressed air for a second charge and with Mr. Allan, Mr. Michelmore and myself as passengers, arriving at Salisbury that afternoon. Further supplies of arsenic and compressed air were despatched to Salisbury by rail. Dr. Naudé and Lieutenant Faurie flew to Salisbury on their Wapiti the same day. The following day I called on Mr. Jack, Chief Entomologist, Major H. G. Mundy, Secretary for Agriculture, and the Hon. C. S. Jobling, Minister for Agriculture. A motor car was placed at my disposal and Mr. Jack undertook to obtain news of locust swarms, to aid in keeping in touch on the ground with treated swarms and to co-operate generally.

On the 3rd June Dr. Naudé and Lieutenant Faurie left on their Wapiti for Robert's Heights and Mr. Allan, by train, for Mazabuka.

I had been advised by the Manager, Southern Africa Division, Imperial Airways, Ltd., Germiston, that the contract for the Hercules terminated on the 22nd June and had arranged to return with it to Broken Hill on the 21st. On the 18th June that official wired to the effect that, unless I wished to hand over the Hercules at Broken Hill, he was prepared to take it over at Salisbury. As this would mean an economy of 3½ flying hours, I agreed, but asked whether I could be given a free passage to Broken Hill on either the air mail service on the 20th June or the R.A.N.A. service via Bulawayo leaving on the 23rd. This request was very courteously granted, and, there being no spare berth on the airmail service, I travelled by R.A.N.A., spending the night of the 23rd at Livingstone, and arriving at Broken Hill on the 24th June. I left Broken Hill on the 2nd July to catch the Union Castle Line R.M.S. " Edinburgh Castle," due at Southampton on the 23rd July.

Apparatus.

The apparatus, designed to give a maximum discharge of 300 lbs. of dust in 10 seconds, proved, on the whole, satisfactory, though being, of necessity, rather complicated, a certain amount of trouble was experienced in maintaining it in working order.

During my absence in January and February the pressure gauge had been broken off from the manifold supplied for charging the air bottle in the cabin, and all efforts to seal up the orifice failed. One of the copper pipes from the manifold was, therefore, fitted with a nipple at either end and used in place of the manifold.

The air bottle in the cabin leaked, at first slightly, then seriously, but after several efforts this leak was sealed and no further trouble experienced.

On the 29th May, I had cocks fitted to the two air pipes leading from the reducing valve, to permit of the two cylinders being discharged separately. This was done for two reasons. If the contents of the first cylinder discharged did not reach the swarm the pilot had an opportunity of making a second and more successful shot with the contents of the second cylinder. Secondly, I was of the opinion that the contents of a single cylinder constituted a cloud of sufficient density, and wished to obtain some evidence of this.

The mixture of beeswax and vaseline used to seal the jets of the spiders proved satisfactory, and usually at least thirty out of the thirty-four jets in each would be found to have blown after a discharge. The charge in a cylinder was about 120 lbs. (the contents of two drums), and though by tapping the cylinder the full charge of 150 lbs., for which the cylinder was originally designed, could almost certainly have been got in, the smaller quantity was sufficient to fill it comfortably. Moreover, a ten-second discharge did not empty a cylinder; on the average, I should estimate that approximately 20 lbs. of the 120 lbs. remained. In consequence, I was able to put three separate discharges into a swarm, consisting of a ten-second discharge from the starboard cylinder, a similar discharge from the port cylinder, each consisting of approximately 100 lbs., and a third discharge from the two cylinders simultaneously, consisting, together, of approximately 40 lbs.

After the cylinders had been discharged the discs closing them rarely returned to their seatings owing to dust packing between these discs and their rubber washers.

Sodium arsenite dust.

The condition of the dust in different drums was by no means uniform. In some the dust had caked into one hard lump, in others there were numbers of fairly hard lumps which could be crushed, but the dust had a gritty feeling when rubbed between finger and thumb; the contents of such drums were, after some experience, discarded. In the greater proportion the dust had "lumped" rather than "caked." These lumps were soft and could be broken down readily, while the dust felt smooth. The lumps in the best of the drums could, to a large extent, be reduced by rolling and shaking, but ultimately the best method was found to be that of passing the contents of a drum slowly through a sieve into an empty drum, the lumps being crushed by hand as they went through the sieve. The work of powdering the contents of four drums, blowing out the spiders and resealing the jets, filling the cylinders and, finally, attaching them to the aircraft was a tedious business and could scarcely be accomplished in time to permit of their being discharged the same day.

On the first occasion (the 11th May) when the cylinders were discharged the bulk of the dust cloud was noted to fall, the balance

floating with the wind and apparently not losing height. A trial discharge was therefore made, over the aerodrome at Broken Hill, of approximately 80 lbs. from a single cylinder, at a height of 500 feet. The bulk of this cloud steadily lost height until, when it had drifted some 500 yards, its lower margin was in contact with the ground, while the remainder either maintained height or fell very slightly. Further, numerous small lumps, the largest possibly $\frac{1}{2}$-inch in diameter, could be found on the ground below where the discharge had been made. At the time I was inclined to attribute this fall of the cloud to the thinness of the air at an altitude of 4,000 feet above sea level, but later observations led me to modify this opinion. If only dust which felt smooth when rubbed between finger and thumb were used the clouds appeared to maintain height. Although small lumps of sodium arsenite were not invariably found below where a cloud had been ejected there is reason to believe that such lumps actually fell to the ground from each discharge for it was not possible to crush them all by hand.

When the scene of the experiments was transferred to Salisbury, I was particularly asked by the Southern Rhodesian authorities whether any risk of poisoning to farm livestock would be involved. In view of the tendency of the clouds to lose height and of small lumps of arsenic to fall direct to the ground, I was compelled to give it as my opinion that there would be such a risk—though I believed the risk to be a slight one—if the dust were discharged over occupied farms. To obviate this risk Mr. Jack, and usually also Mr. Pawley, Native Commissioner, accompanied me in the Hercules on all flights in Southern Rhodesia and indicated whether the land over which a locust swarm was flying formed part of an occupied or of an unoccupied farm.

Bases.

The bases selected were in Northern Rhodesia, Broken Hill, and in Southern Rhodesia, Salisbury. The services of a ground engineer were required for the aircraft, and these were available at both the above stations. In the opinion of Mr. Jack, Salisbury was the most convenient base in Southern Rhodesia from which to work from the point of view of keeping in touch on the ground with treated swarms.

Occurrence and behaviour of locust swarms.

There were locust swarms in Northern Rhodesia at the end of April and until the middle of May, but all seen were infected with the disease caused by the fungus *Empusa grylli*. At first, there appeared to be a general tendency for the swarms to move westwards, but, later, owing possibly partly to the low temperatures prevailing and partly to the incidence of fungus disease this tendency to move in a definite direction was less apparent, and a swarm

might reappear in an area it had occupied two or three days previously. This favoured the rapid spread of fungus infection, and swarms which included relatively large numbers of diseased and dying locusts were obviously unsuitable for experimental purposes.

The locust swarms which I saw in Southern Rhodesia were almost if not entirely free from fungus disease. Most were of fair to considerable size; the area covered by a swarm at rest might occupy anything from one to several square miles. They were not migrating, but cruising, the direction of their flight being influenced, apparently, by the wind prevailing at the time. Rarely did a swarm move more than three or four miles in a day and rarely was the whole of a swarm on the wing at the same time. The swarm might be said to "roll" along, for groups of individuals at the rear would rise and fly to the front, followed by those which then found themselves in the rear. Moving in this way the locusts rose to no considerable height above the trees, in fact many would fly actually among the trees. I understand that it is customary for the red locust to behave in this manner during the cool "winter" months, but that later in the year—September and October—the swarms become more active and fly in a definite direction throughout the greater part of the day and at a height of two or three hundred feet. I further understand that the weather experienced at Salisbury during most of my stay there was unusually cold and wet, and that had normal climatic conditions prevailed the locust swarms would have displayed rather more activity.

Information regarding the occurrence and movements of locust swarms.

Although a considerable amount of news as to the occurrence and movement of locust swarms could be obtained by telephone and telegraph, where such services were available, far more accurate information could be got by the use of aircraft. Scouting flights were carried out almost daily by the Union of South Africa officials on one or other of the two Wapitis, until the second left for Robert's Heights on the 3rd June. The Hercules was a very unsuitable aircraft for scouting purposes and, further, I had been warned by Mr. Ramsey, A.I.D., that it would be inadvisable to land it often with cylinders charged, while I could not afford to discharge the cylinders unnecessarily. I therefore arranged on the 5th June with the Manager, Rhodesia and Nyasaland Airservices, Ltd. (R.A.N.A.), for a Puss Moth aircraft to be available, piloted by Captain Phillip. The Puss Moth proved a very suitable aircraft for scouting purposes.

Following swarms on the ground.

In order to get into touch from the ground with a locust swarm, motor transport is usually required, and in neither Northern nor Southern Rhodesia can motor transport be made use of in the

absence of roads. Except in the farming areas roads are few and far between. Broken Hill is not situated in a farming area, but in the immediate vicinity of the town there are a number of tracks over which a car may be taken. These served for the single experiment made from this base. When Salisbury was used as a base there was little difficulty in approaching by car any spot within a reasonable distance, but unless the observer actually camped and lived with the swarm he was very liable to lose touch with it. On one occasion a swarm was lost and only refound the following day from the air; it had moved only a short distance, but in the bush was very difficult to find by an observer on foot.

Mr. Allan and Mr. Chorley, Entomologist, Southern Rhodesia, shared the arduous duty of observing and following swarms from the ground, aided sometimes by Mr. Michelmore and myself.

Methods employed in the carrying out of an experiment.

News having been received of a swarm in a suitable locality, the ground party would set out in an endeavour to reach it. Sufficient time having elapsed to permit of the ground party arriving at its objective, the Hercules would go up carrying, when operating in Southern Rhodesia, in addition to what may be described as the crew—Captain Phillip, Mr. Michelmore and myself—Mr. Jack, and usually Mr. Pawley, who were familiar with the country. On the Hercules approaching the swarm the ground party would fire one or more Verey lights to let us know its position. Mr. Jack would then indicate whether the land over which the swarm was passing was used for grazing and therefore whether it was permissible for dust to be discharged over it. Permission having been given, Captain Phillip would manœuvre into position and give me a "stand by" signal which I, sitting next him in the wireless operator's seat, would pass on by means of a whistle to Mr. Michelmore who was in charge of the release. A few seconds later Captain Phillip would shout "go" and I would again pass on the signal to Mr. Michelmore. On the occasion of the first experiment at Broken Hill Mr. Ellis, wireless operator, was in charge of the release.

The position relative to the swarm at which the release should, if possible, be made was indicated to Captain Phillip before starting the flight.

THE EXPERIMENTS.

Experiment 1.—11th May.

A locust swarm was located in the vicinity of Broken Hill and Mr. Allan went out to it on the ground. As it was resting in trees, Captain Bronkhorst, with Dr. Naudé, went up in a Wapiti and by flying low, backwards and forwards, over it induced it to fly, or rather rise and circle. The Hercules was then taken past it at a

distance of 200 yards or more upwind and at an altitude of about 100 feet, and the contents of the two cylinders discharged simultaneously. The greater part of the dust cloud would appear to have fallen fairly rapidly into the trees, but the remainder floated with the wind. and, as a very thin cloud, passed through a portion of the swarm.

The swarm was followed on the ground for three days. Many sluggish and apparently sickly locusts were seen in the path of the swarm, which was moving only two or three miles daily. Of these sickly specimens a large number developed fungus disease, but others exhibited symptoms similar to those of arsenical poisoning. The Manager of the Broken Hill Mine very courteously permitted me to submit some of the latter to his Chief Chemist for examination; a trace of arsenic was found in some only. Further material was sent by Dr. Naudé to the Division of Chemistry, Pretoria, with similar results.

Experiment 2.—28th May.

A number of locust swarms had been reported in the neighbourhood of Salisbury and the Hercules went up, accompanied by a Wapiti with Dr. Naudé on board. After passing several swarms which were over occupied farms we sighted one entering a native reserve. It was flying low, the lower part of the swarm being among the trees, but the top possibly 100 feet from the ground. An attempt was made to deliver the contents of the two cylinders, simultaneously, immediately above the swarm and at a height of 250 feet. Owing to a delay in the release only a part of the cloud was discharged over the swarm, the remainder being ejected beyond its limits. Most of the dust released above the swarm appeared to fall into the swarm, but some rose and hung; I noted a column of dust extending to a height of 300 feet or more some three or four minutes after the discharge. The portion of the cloud ejected beyond the swarm appeared to hang until it dissipated. Messrs. Allan and Chorley endeavoured to find and follow the swarm the next day, but connected with another swarm. Owing to the distance (some 70 miles) from Salisbury to the native reserve it was decided to leave this swarm and look for one nearer our base, but I arranged for the Native Commissioner, Sinoia, to send out a native to follow the swarm and obtain specimens of dead or sick. Some days later the native returned with five specimens, said to have been picked up in the path of the swarm. One of these was submitted to the Chief Chemist, Southern Rhodesian Government, and found to contain arsenic.

Experiment 3.—31st May.

A large swarm of locusts was reported from Warwickshire farm and Messrs. Allan and Chorley went out to it on the ground. When we reached it in the Hercules it was flying strongly over and along some rocky hills. Messrs. Allan and Chorley were on a railway line

under part of the swarm. The dust was ejected in three discharges, all in approximately the same place, over a grassy valley between the railway line and the hills. The Hercules crossed the line of flight of the locusts, passing through the upper and thinner part of the swarm, at a height of about 150 feet. Messrs. Allan and Chorley noted that the first half of the discharge from the starboard cylinder fell while the second half and the whole discharge from the port cylinder maintained height. They did not observe the third discharge. The clouds were visible for seven minutes after which they drifted over a hill.

The passage of the aircraft through the upper parts of the swarm had no noticeable effect on the locusts. The swarm showed no tendency to break or change direction. Further, no attempt on the part of the locusts to avoid the cloud, even when it was dense, could be detected.

Messrs. Allan and Chorley noted some thousands of locusts falling with wings closed, from the swarm as it passed through the cloud. These locusts hit the ground hard and, except for a certain amount of leg movement, were helpless when picked up. Unfortunately, no specimens were obtained for subsequent examination.

Numerous small pellets of sodium arsenite could be found on the ground immediately beneath the position at which the dust had been discharged. It is believed that these fell from the first half of the starboard discharge.

The swarm was followed on the ground for three days. Owing to its size—it covered several square miles—only a small part of it could possibly have passed through the dust clouds while they were at all dense, and the ground being covered with thick grass, sick locusts had every opportunity for concealment. Nevertheless numbers of sluggish specimens could be found in the path of the swarm, many of them exhibiting symptoms typical of arsenical poisoning. Of those collected at spots from three to six miles from the scene of dusting and which died within two days of collection, thirteen were examined by the Chief Government Chemist. He reported finding arsenic in nine of these specimens. He failed to find arsenic in two sluggish but living specimens. Of two locusts which lived until the 14th June (fourteen days), one was found to contain a trace of arsenic, the other none.

Messrs. Allan and Chorley stated that on the 2nd June, when the swarm was approximately 6 miles from the spot where the dust had been discharged two days previously, the number of sluggish specimens appeared greater than on the previous day, since when it had travelled about 3 miles.

Experiment 4.—7th June. 11th June. 12th June.

A medium-sized swarm of locusts having been located at Darwendale farm on the previous day, Mr. Chorley left by road, in

the morning, to make contact with it. The Hercules went up in the afternoon and found the swarm flying downwind among rocky hills. The three discharges were put out across the wind, the Hercules passing through the swarm. All three clouds appeared to maintain height or rise, but, later, pellets of sodium arsenite were found on the ground.

It had been my intention to put dust into this swarm, which covered about a square mile when at rest, on three successive days with the object of poisoning a sufficiently large proportion of it to arrest its flight, but weather conditions rendered this impossible On the 8th and 9th the weather was so dull and cold that the swarm remained almost stationary; on the 10th it moved about a mile The following day, Mr. Chorley, who had gone out to it by road, reported by telephone that it was on the wing. On hearing this, we went up in the Hercules and put the contents of two cylinders, in three discharges, into the swarm. The aircraft passed just over the trees and through the thickest part of the swarm. On the 12th the swarm was found resting in trees, but a brief gleam of sunshine, aided by the noise of the Hercules, induced it to take wing. A ten-second discharge from each of the two cylinders was put into it at a height of about fifty feet from the ground, but the third discharge, consisting of the balance left in the two cylinders, could not be made. The engines were so plastered with the bodies of locusts that Captain Phillip advised returning without delay. Flying through the densest part of the swarm had resulted in locusts being driven into every crevice of the aircraft, and it was seven days before the Hercules was again ready for service.

The discharges on the three days (the 7th, 11th and 12th) were observed by Mr. Chorley from the ground. He reported that it was always difficult actually to watch the behaviour of the clouds owing to the foliage of the trees intervening and to the sunlight shining on the locusts' wings. He detected no effort on the part of the locusts to avoid passing through the cloud, but found many small lumps of sodium arsenite on the ground. No locusts were seen to fall headlong from the cloud, but sluggish locusts were picked up within five minutes of the discharge on the first day. Sluggish specimens were found in the path of the swarm on the 8th and again when it was visited on the 11th. On the night of the 11th part of the swarm settled in trees over which dust had been discharged that afternoon. Specimens collected after this date may therefore have ingested arsenic. Similarly, after being dusted on the 12th, part of the swarm settled in trees which must be assumed to have been contaminated with arsenic. From this date the swarm scarcely moved, and when Mr. Chorley visited it on the 4th August it was resting over exactly the same area it had occupied on the 12th July. This extreme sluggishness may have been due to a large proportion of the swarm suffering from poison, but, equally, may have been due to cloudy skies and low temperatures. Numbers of specimens were

collected on various days for examination. Three specimens collected on the 12th and found dead in the cages on the 13th were submitted to the Chief Chemist; he reported finding a trace of arsenic in each. It should be noted that the cold, even wet, weather made the selection of sickly locusts difficult. The vast majority were sluggish and may have been exhibiting cold torpor.

PHOTOGRAPHS.

I regret that no photographs of any value were obtained with the camera provided. The design of the Hercules did not permit of photographs being taken from the wireless operator's seat, and those who very kindly undertook to use the camera from the cabin of the Hercules and from the Wapiti met with no success. I hope, later, to be able to submit a few photographs taken by Dr. Naudé, and possibly also some taken by Mr. Michelmore, with their own cameras.

CONCLUSIONS.

A large amount of material in the form of dried locusts is being brought to England. The majority of these were sluggish or sickly when collected in the paths of treated swarms, while the remainder were apparently healthy locusts from untreated swarms. The whole of, or a selection from, this material should be examined for arsenic by a chemist.

The minimum quantity of arsenic required to cause the death of a locust, when ingested, has, I believe, been ascertained. It is possible that the quantity which, when inhaled or absorbed through the cuticle, will cripple by paralysis, if not directly kill, may be smaller.

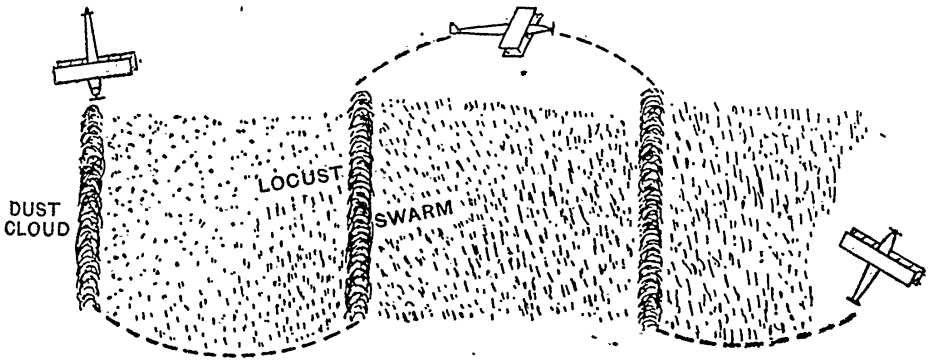
A note on the difficulties attending the recovery of poisoned locusts from a swarm which has been dusted may not be out of place. The ground is, almost invariably, covered with tall thick grass; a locust suffering from arsenical poisoning and unable to fly endeavours to hide, and grass tussocks constitute excellent cover. A sickly locust may be seen to creep into a tussock and yet escape capture. A dead or dying locust is soon removed or consumed by ants, while sickly locusts fall an easy prey to various species of mammals, birds and reptiles. With the apparatus used only a part —and in the case of a large swarm only a very small part—of the swarm could be treated. A swarm covers a considerable area of ground, and during the cold season is continually "mixing"; sickly locusts must be sought for over the whole area covered by the swarm.

What happens to a locust which, suffering from temporary, partial paralysis or sickness, drops out from the swarm? I imagine that, even if it does not fall a prey to its many natural enemies, it will never regain a swarm unless, after it has recovered, a swarm should happen to pass directly over it.

It is obvious that, before the results of these experiments are finally considered, the analyses of the material referred to above should be available. In the meantime, it may be desired that I should give the opinions I have formed from field observations. My instructions as regards the scientific conduct of the experiments are contained in communication No. 4056/33 of the 14th November, 1933, from the Under-Secretary of State, Colonial Office, to which I now refer.

Paragraph 5 (*a*). Locusts in flight make no effort to avoid a cloud of sodium arsenite dust, even when the cloud is dense, but instead pass steadily through it. Further, the passage of an aircraft through a locust swarm and across its line of flight does not cause the swarm to change its course.

Paragraph 5 (*b*). The dust cloud should be discharged as close as possible to the front of the swarm and, except in the case of swarms smaller than any met with, other clouds would need to be discharged into the swarm as indicated in the sketch.



Paragraph 5 (*c*). With the data obtained it is impossible to state with any certainty what proportion of the individuals composing a swarm ultimately die from arsenical poisoning as a result of the swarm passing through a cloud of sodium arsenite dust. The swarms experimented with were all large in relation to the dust cloud, and consequently only a proportion of any swarm could come into contact with the dust. From the numbers of locusts showing symptoms which I associate with arsenical poisoning seen in the paths of dusted swarms, I am led to believe that the majority of those which pass through the cloud ultimately drop out from the swarm.

Paragraph 5 (*d*). Under normal atmospheric conditions I am confident that a cloud resulting from a discharge of 10 lbs. of sodium arsenite dust per second remains of sufficient density to be toxic to locusts flying through it for at least three minutes, and anticipate that further experiments would show that this toxic density is maintained for considerably longer, possibly five to ten minutes.

Paragraph 5 (*e*). For how long will locusts which have passed through a cloud of sodium arsenite dust and acquired a lethal dose remain in flight? Although it has not been possible to ascertain definitely the cause of the fall of locusts from the swarm dusted on the 31st May (Exp. 3), the probability of its being due to paralysis brought about by inhalation of the dust must be admitted. Such a fall was not detected on any other occasion when a swarm was dusted, but, apart from the fact that the ground observers were probably in a better position to see it on that day than on any other, it may be noted that the locusts dusted on the 31st May were flying strongly, while those dusted on the 7th, 11th, and 12th June were flying for short distances only. Neither I nor any of the entomologists with me had ever witnessed a similar fall from a swarm in flight. Should a swarm on steady migration flight pass through a cloud of sodium arsenite dust, I should expect a considerable number of the individuals composing it to fall within a few seconds of entering the cloud and during the ensuing half hour, with wings paralysed as a result of inhalation of arsenic.

Dr. Naudé, Chief Entomologist to the Union of South Africa, has informed me that he has found that adult locusts which have been dusted with a lethal quantity of sodium arsenite may live for as long as ten days, but I do not think they could keep with a migrating swarm for longer than, possibly, five days.

Paragraph 5 (*f*). As regards the possibility of destroying locust swarms resting in trees or on the ground. I understand that Dr Naudé, in the Union of South Africa, has been experimenting recently in the use of aircraft for distributing sodium arsenite dust over resting swarms and has met with a considerable amount of success. His methed has been to distribute the dust in the early morning, before the swarms take flight. In the winter season in Southern Rhodesia, and particularly during spells of cloudy weather, I should imagine that sodium arsenite dust, possibly not quite as fine as that needed for swarms in flight, could be distributed with great effect from aircraft both in the early morning and the late afternoon. Dust distributed over resting swarms acts not only as a contact poison, but also as a stomach poison, as it settles on the foliage on which the locusts are about to feed. I cannot, on the data available, form an opinion as to whether sodium arsenite dust would prove more or less efficacious when used against a resting swarm than when used against a swarm in flight.

Paragraph 5 (*g*). Provided that the sodium arsenite dust is uniformly fine (entirely free from lumps) and that the locust swarms are on migration flight, and therefore well clear of the tree tops, I believe there to be little or no risk to the inhabitants of the country, their livestock or crops attached to its use from aircraft against such swarms. There would be very definite risk of poisoning to both livestock and crops if sodium arsenite dust were used from aircraft against resting locust swarms, but this risk could be reduced to a minimum by the taking of suitable precautions.

It must be emphasised that the above are merely the opinions I have formed from field observations, unsupported as yet by an appreciable number of chemical analyses of the bodies of locusts believed to have been crippled or killed by means of the dust.

Paragraph 9. If it were decided to extend the use of aircraft against locusts, I consider, in the light of experience gained, that the discharge apparatus should be of an entirely different type to that which served excellently in the experiments. The aircraft should be capable of carrying at least 1,000 lbs. of poison dust, and the discharge apparatus so designed that the dust could be ejected in a continuous or interrupted stream at the will of the operator and at a rate of from 5 lbs. to 10 lbs. per second. The charging of the apparatus should be simple and occupy, at the most, thirty minutes. The aircraft itself should be of a design which would permit of its being flown repeatedly through dense locust swarms without serious risk of being put out of action. The pilot should have as clear and uninterrupted a view as possible, together with a ready means of cleaning his glass screens when they become covered with the body contents of locusts.

In addition to the aircraft carrying and discharging dust, a scouting aircraft would be required. For this purpose a small high-wing monoplane, such as a Puss Moth, would be most suitable.

ACKNOWLEDGMENTS.

My thanks are due to every official, whether in Government employ or on the staff of Imperial Airways, Ltd., who had it in his power to help in the carrying out of the work. Captain Bronkhorst and Lieutenant Faurie, of the Union of South Africa Air Force, were always ready to go out on scouting flights in their Wapitis, while Dr. Naudé, when not scouting or observing from a Wapiti, was prepared to assist in the very unpleasant task of charging the cylinders. Mr. Allan and Mr. Chorley worked tirelessly in following locust swarms on the ground; without their assistance I should have had great difficulty in obtaining data as to the effects of arsenic dust on the swarms. Mr. Jack not only permitted Mr. Chorley to spend much of his time following swarms, but himself collected news of the whereabouts of swarms and accompanied us in the Hercules in order that he might indicate where dust might be discharged. Mr. Michelmore's services were invaluable, both in the charging of cylinders and in the actual release of the dust. Further, all the above entomologists were prepared to help by means of advice and constructive criticism.

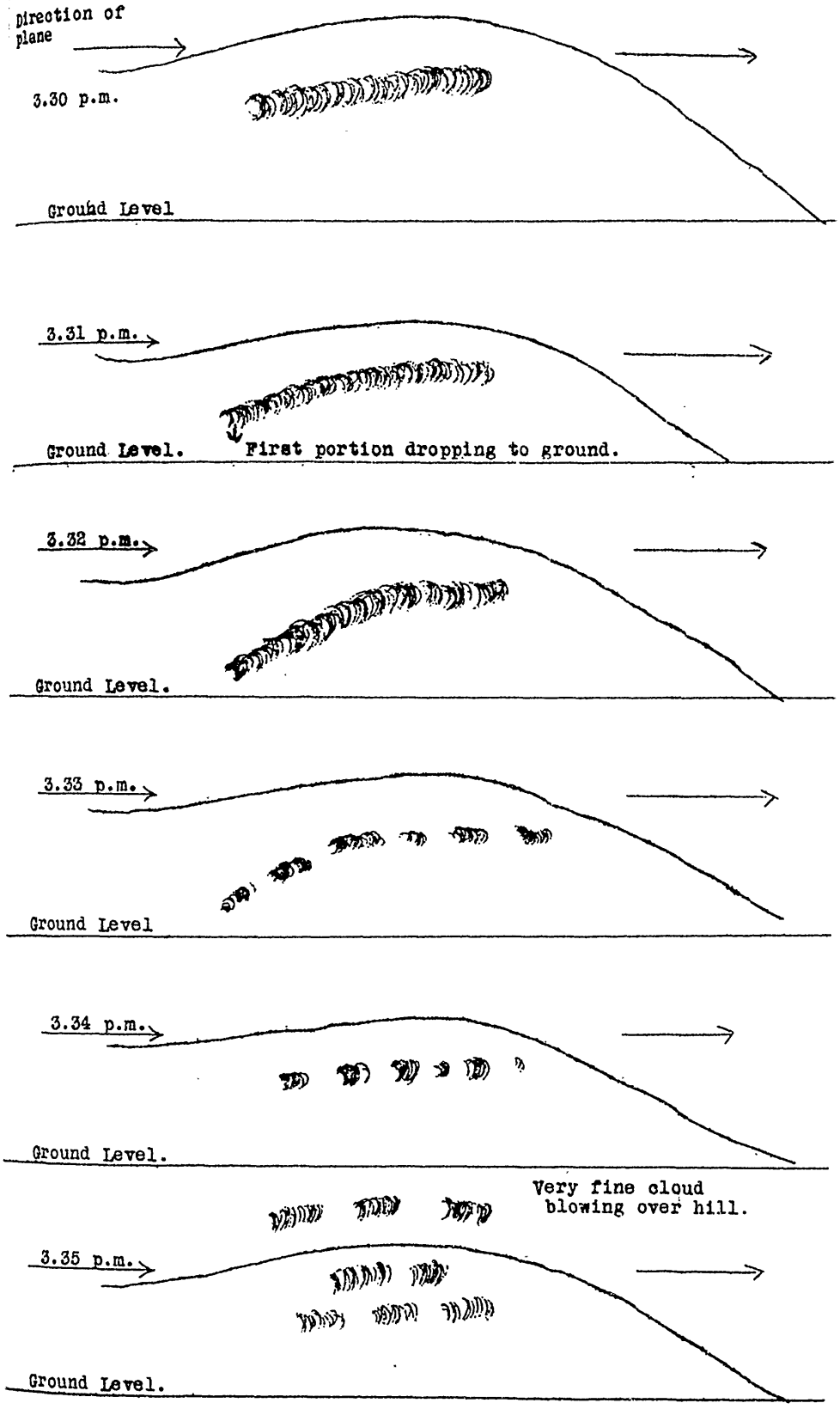
From Mr. Solomon, Station Superintendent, Broken Hill, I received innumerable courtesies. Similarly, when I went to Salisbury, Mr. Billborough, Acting Station Superintendent, and Mr. Manton, Assistant Station Superintendent, were always ready to render any assistance. Mr. Wookie, Ground Engineer, Broken Hill, and Mr. Wilson, Ground Engineer, Salisbury, had a lot of extra

work thrown on them—and did it as if they enjoyed doing it. As already mentioned, seven days' work on the Hercules was needed after it returned on the 12th June, and Mr. Wilson was the responsible engineer. Finally, Captain Phillip not only carried out his duties as pilot most skilfully, but also undertook to help in charging cylinders whenever his help was needed, to charge and attach the air bottle and to be responsible for attaching the cylinders to the planes.

ANNEXES.

I attach, as annexes, observations by Mr. Allan (annex 1) and Mr. Chorley, who were responsible for most of the ground work (annex 2).

CHARACTER OF FIRST DISCHARGE MADE 31st MAY, 1934.



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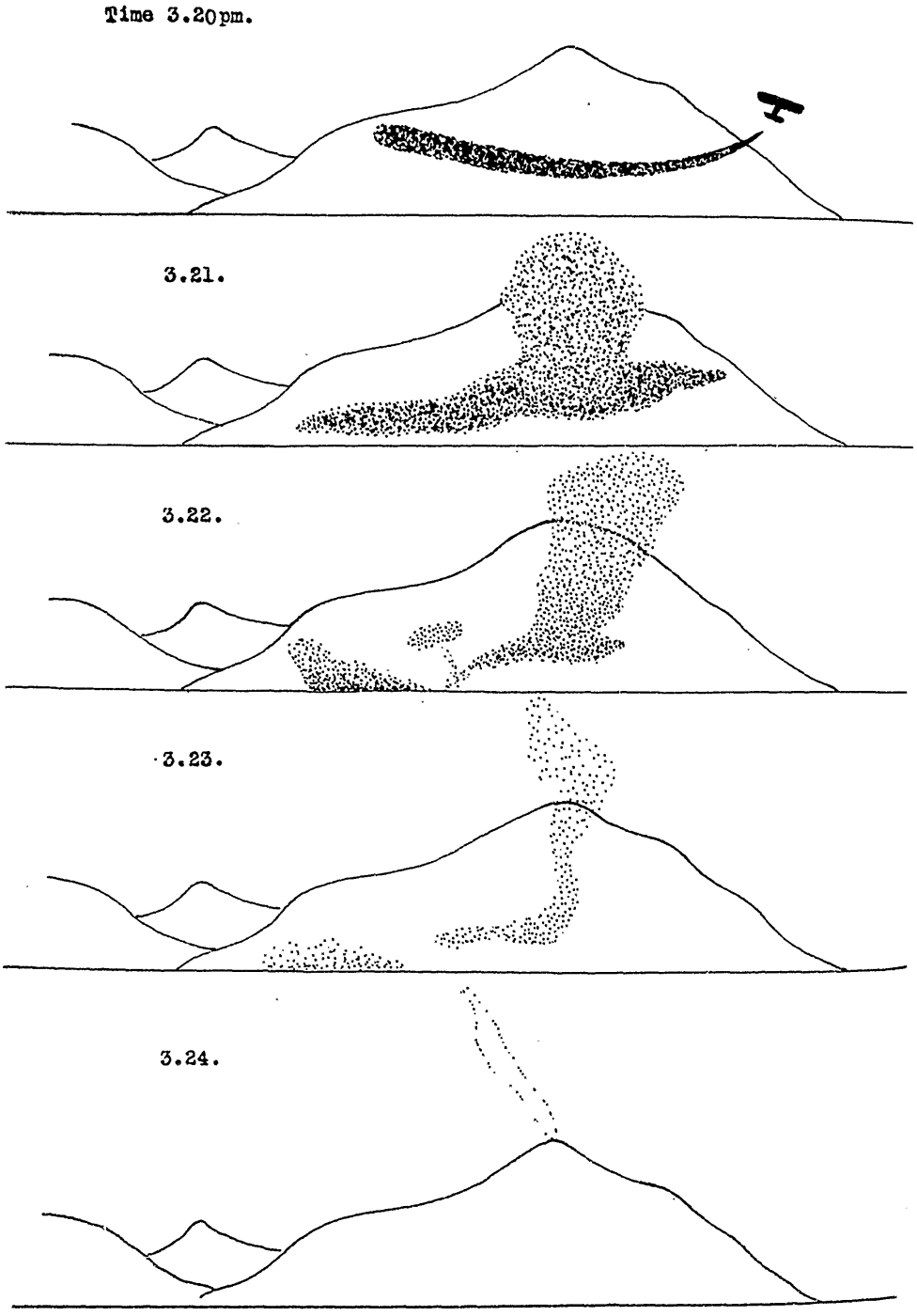
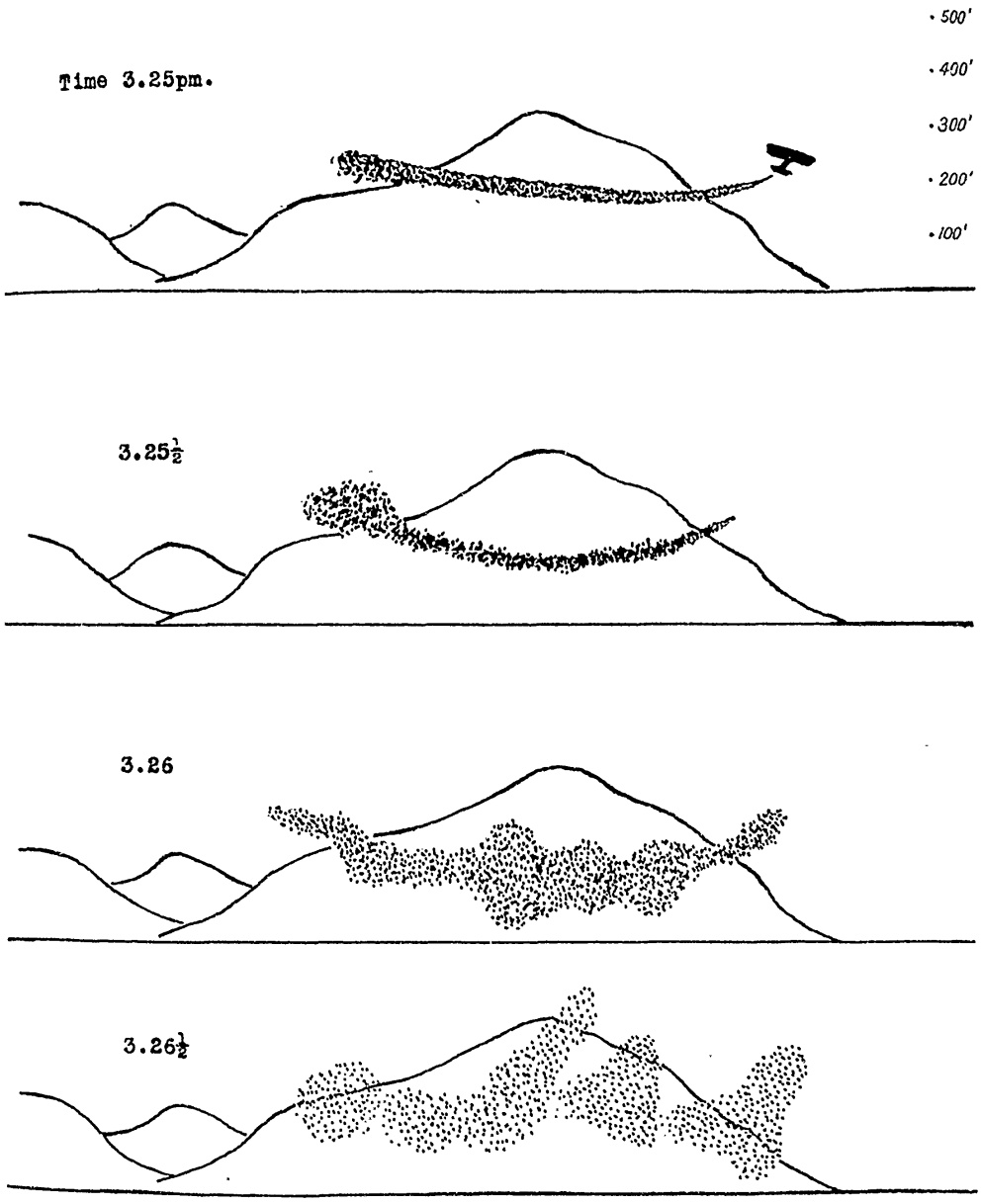
Malby & Sons

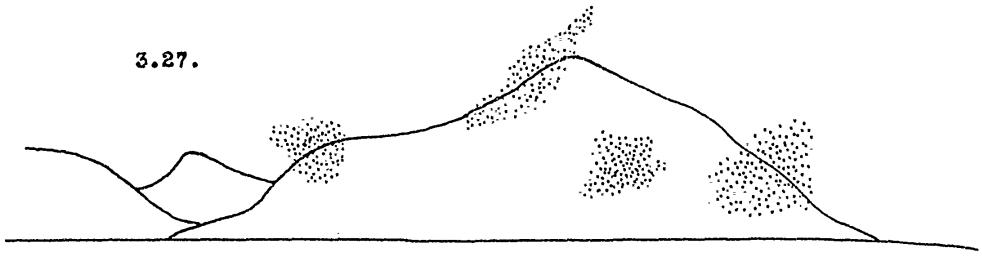
Discharge of the first cylinder.

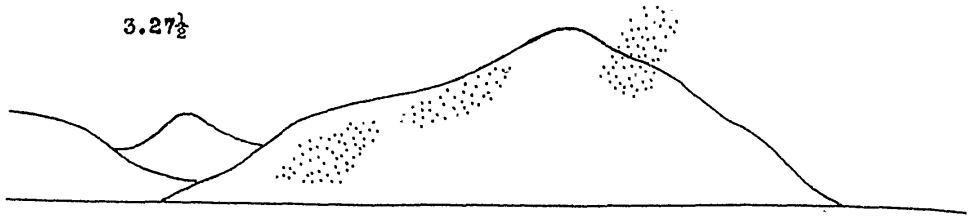


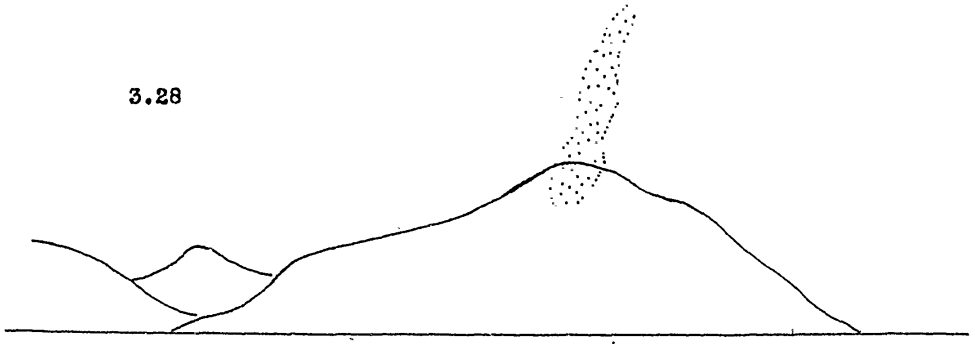
Discharge of the second cylinder.

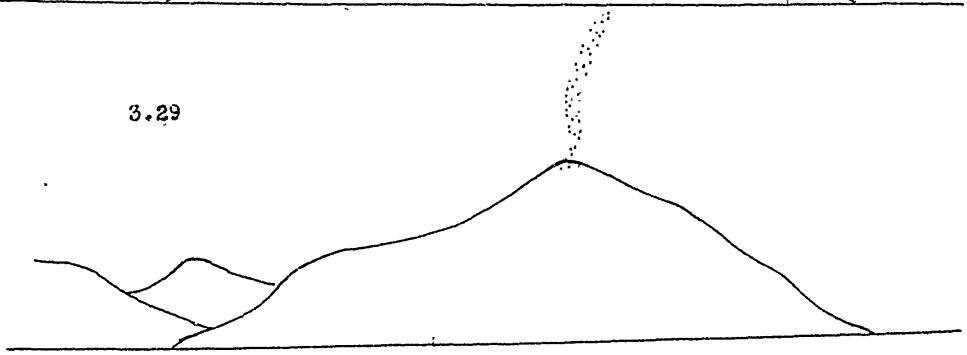
Approximate scale I cm. = 100 feet.

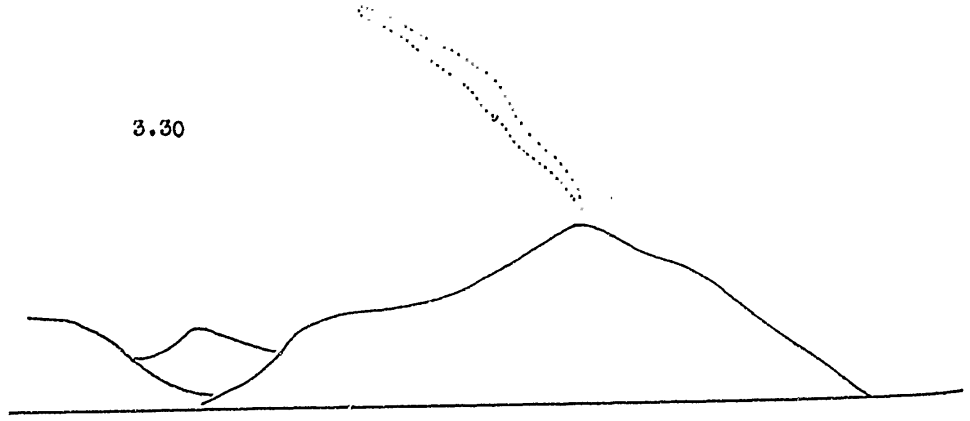












ANNEX 1 TO APPENDIX 8.

NOTES BY MR. W. ALLAN, ENTOMOLOGIST, NORTHERN RHODESIA, ON AIRCRAFT LOCUST EXPERIMENTS.

May–June, 1934.

(a) Trial discharge at Broken Hill, May 11th.

The only material available within range of Broken Hill consisted of very small thin swarms containing a high proportion of diseased individuals. The chief disease affecting the swarms (there may have been others, not yet identified) was that caused by the parasitic fungus *Empusa grylli*. Large numbers of sick and dead locusts could be found in the track of any swarm.

The flight of these swarms was very weak and generally during flight less than half the swarm was in the air at any one time, the remainder being settled on the trees. While this lack of movement may have been partly due to the proportion of diseased individuals, I am of opinion that the low temperatures and over-cast weather conditions experienced were important factors. During the few brief spells of warmer weather flight was very markedly stronger.

The swarms near Broken Hill were examined from the air. I selected the largest and most active as material for the experiment, established contact with it and observed the operations from the ground. It had been decided that the South African Air Force machine should, by circling over the swarm, endeavour to raise the locusts resting on the trees. The presence of the aircraft certainly resulted in raising practically the whole swarm, but a further effect was to alter the direction of flight and set up a milling movement. Consequently, since there was no definite flight direction, it was impossible to determine where the dust would be discharged and I took up a position on the highest available point, indicating the position to the aircraft by firing a Verey Pistol. I was unable to see the dust cloud, although subsequent inspection showed that it had been discharged within half a mile of my position.

Examination of the swarm on the 12th.

On the evening of the 11th the swarm settled close to the point at which the experiment had been made. On the morning of the 12th a large number of sick individuals were collected.

The majority showed signs of infection with *Empusa* and were discarded. Six individuals of this collection developed a dark diarrhœa after capture and died on the afternoon of the 13th, approximately forty-eight hours after the experiment. These specimens were examined by the Chemist to the Broken Hill Mine, who reported that a slight trace of arsenic was present.

A further collection of sick and dead locusts left behind after the swarm had taken to flight was made between 3 and 6 P.M. on

the 12th. All the dead individuals showed signs of *Empusa* infection and were discarded. Several of the sick locusts died the following day, but in a moist atmosphere these too developed *Empusa* symptoms.

The remainder of both collections made on the 12th were still alive after nine days when they were killed (by crushing the thorax) and dried.

Examination of the swarm on the 13th.

During the previous day the swarm had moved a distance of one mile. About 1 o'clock it took to flight leaving a large number of sick individuals behind. In the case of a considerable proportion of the sick the fæces, when expressed, were found to be dark brown to almost black in colour, suggesting the diarrhœa which usually follows arsenical poisoning. Dr. Naudé, who has had considerable experience of the effect of arsenic on locusts, was impressed by the similarity of the symptoms.

A collection of individuals showing these symptoms was made and samples were examined by the Mine Chemist at Broken Hill and by the Division of Chemistry, Pretoria. Arsenic was not found in either sample. The remainder of the collection were alive after eight days.

Examination of the swarm on the 14th.

The resting place of the swarm during the night of the 13th–14th was some four miles to the west of the point at which discharge had been made. This resting place was visited on the morning of the 14th. Messrs. King, Naudé and Michelmore accompanied me on this occasion.

Numerous apparently sick locusts were left behind after the swarm had risen and a collection of individuals which did not show signs of *Empusa* was made. The number of specimens with liquid, dark coloured fæces appeared to have increased.

Five individuals in the collection of sick locusts died within two days of capture and were sent to Pretoria for chemical examination. A trace of arsenic was found in this sample. The remaining individuals in the collection were alive after seven days.

Examination of the swarm on the 15th.

Large numbers of apparently sick individuals were again left behind by the swarm, and of the collection made a sample of twelve was sent to Pretoria for chemical examination. No arsenic was found in this sample. The locusts collected were still alive after six days when they were killed and preserved.

On the afternoon of the 16th the swarm flew fairly rapidly and steadily over dense bush country through which progress on foot was slow and difficult. Consequently contact with the swarm was lost.

(b) Experiments in Southern Rhodesia.

Condition of the swarms.

A considerable number of very large and active swarms were present near Salisbury. In all of the swarms seen, while a few individuals infected with *Empusa* could generally be found, the proportion of diseased locusts was negligible.

An examination of the fæces of individuals collected at random showed that in the case of many apparently healthy locusts a liquid drop could be expressed varying in colour from pale amber to dark brown, the more extreme types of dark drown exudation resembling the condition observed in sick locusts at Broken Hill.

Experiment near Hunyani Tank, May 31, 1934.

The discharge.

The first cylinder was discharged at a distance of approximately three quarters of a mile from my position, but an excellent and uninterrupted view was obtained. A hill some 300 feet in height provided a background and enabled moderately accurate sketches of the changes in the visible part of the dust cloud to be made. These sketches are reproduced. The first part of the discharge (apparently rather less than half) fell rapidly to the ground. The remainder appeared to expand and dissipate, the total time from discharge to the complete disappearance of the cloud being between five and six minutes.

While observing the first discharge I approached as rapidly as possible and the sketches of the discharge of the second cylinder were made within a distance of half a mile. In this case no part of the cloud could be seen to fall. It expanded, broke into four separate parts and disappeared. After five minutes a faint column was visible extending high above the top of the hill, but no part of the cloud was visible after six minutes. The discharge of the remaining dust from both cylinders was not visible from my position.

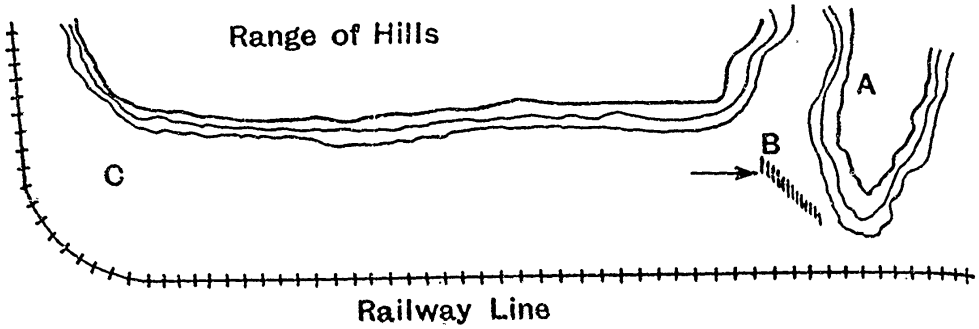
Behaviour of locusts in relation to the dust cloud.

It was, unfortunately, impossible even at a distance of less than half a mile to observe the reaction of the locusts to the dust cloud. The cloud was apparently discharged over a thick mass of locusts and about the level of the upper part of the swarm. I saw nothing to suggest that the main mass avoided the cloud either by circling back or by flying round it.

At 3·40 (about 10 minutes after the disappearance of the last part of the cloud) Mr. Chorley and myself were at the place where the dust had been discharged. We experienced some irritation of

the throat and nose, which indicated that particles of arsenic were still present in the air.

The following description will be more readily understood with the aid of a diagram.



The position of the discharge is shown by the shaded area at B, and the direction of the flight of the locusts at the time of discharge is indicated by the arrow. At 3·40 a dense mass of locusts, probably that which had been in flight when the dust was discharged, was settled on the hill A. These took to flight in the direction of the arrow some ten minutes later. Between the points A and C (a distance of about one mile) a thin mass of locusts was flying actively and circling between the railway line and the range of hills. At 3·45 our attention was attracted by the behaviour of the locusts between B and A. Individuals flying strongly suddenly dropped vertically, sometimes from very considerable heights. We continued observations at the point B until 4·15. During this time the number of locusts falling increased rapidly until it became a continuous shower, and in any field of view a considerable number could be seen falling at any one moment. I am unable to explain this behaviour except as the effect of inhalation of the dust. Diseased locusts falling from a swarm do not, in my experience, behave in this way. The effect suggested, rather, a sudden and complete paralysis of the wings.

On our return we observed locusts falling as far behind the position at which the dust had been discharged as the point C (approximately one mile). Since, however, locusts were continually flying in all directions and circling between A and C after the discharge, it may reasonably be supposed that individuals affected by the dust circled back as far as this point. Furthermore, we had opportunities of observing the swarm both before and subsequent to the discharge, and on no other occasion were locusts seen falling in the way described.

Samples of the paralysed locusts were collected. Although unable to use the wings, and in some cases the hind legs, they made active movements with the fore and mid legs and were able to crawl fairly rapidly. These individuals were still alive two days later.

Examination of the swarm on June 1st.

After the experiment had been carried out the swarm became divided into two parts by a range of hills. On the morning following the experiment I went to one part of the swarm, which when settled covered an area about three miles in length and probably some two miles in width. I could find no unhealthy locusts (with the exception of such as might have been injured by traffic on the road) except at the end of the swarm. Here there were many individuals which failed to take flight with the swarm and which made no attempt to escape capture. The wings, and in many cases the hind legs, of these locusts appeared to be paralysed, one wing sometimes remaining half-extended while the locust was at rest. Two dead locusts were also found. These showed no signs of disease and had obviously been dead for only a few hours. They were found hidden in the centre of grass tussocks. One of these dead locusts was examined for arsenic by the Division of Chemistry, Salisbury. Arsenic was found to be present and the quantity estimated at 0·0105 g.

These observations were made some 20 to 24 hours after the experiment and about three miles distant from the place at which the dust was discharged.

Examination of the swarm on June 2nd.

On the previous day the swarm had moved only about three miles. On the afternoon of the 2nd (*i.e.*, 45 to 48 hours after the experiment) very many semi-paralytic locusts were found at the end of the swarm, and these remained behind after the swarm had taken to flight. Comparisons of this nature are difficult to make, but I am of opinion that the number of sick locusts was considerably greater than that observed on the previous day. One dead locust was found, again in the centre of a grass tussock.

The failure to find dead locusts in any numbers is not surprising, since the country through which the swarm was followed is covered with long thick grass. Even had locusts died in considerable numbers, it is improbable that more than a few would have been recovered. The occasional movements of sick locusts made it comparatively easy to find them.

CONCLUSION.

If the examination of samples of the sick locusts collected shows appreciable quantities of arsenic (and assuming that they die within a reasonable period), I should have no hesitation in describing the results of the experiment as very satisfactory. The number of sick observed immediately following the experiment and on the two subsequent days was, in my opinion, commensurate with a very high mortality in the part of the swarm which could have been affected by the discharge.

ANNEX 2 TO APPENDIX 8.

Notes and observations on some experiments in dusting locusts from the air.

By J. K. Chorley, Entomologist, Department of Agriculture, Southern Rhodesia.

The following notes and observations are taken from my field note book with few alterations. Naturally they are somewhat disjointed, necessarily very terse, and may not be very illuminating. One thing, however, they should bring out very clearly, viz., the difficulties encountered by the ground staff in following a flying swarm in bush country, in keeping in touch with headquarters, and in manœuvring, so as to be underneath a dense portion of the swarm when the discharge is made. Some comments—not to be taken as criticisms—will be added at the end in order to clarify certain points which may be obscure or which need explanation. I do not wish here to make any suggestions as to how the experiments should have been carried out or for improvements that could be made in future experiments, as the most obvious defects are clear to all who have been connected with these preliminary experiments and have been fully and freely discussed in conference.

May 28th, 1934.

Left by car with Allan at 10·30 A.M. following the old Gatooma Road from the aerodrome. Located a large swarm flying east over "Warwickshire Farm." Collected specimens—none showing visible evidence of Empusa. Phoned headquarters and instructed to return to Salisbury. (42 miles.)

Left with Allan at 2 P.M. to locate a swarm sighted in the morning north of main Gatooma Road. Signalled to aeroplanes with mirrors at 3·30 P.M., but failed to attract their attention. Planes circled over swarm on "Lilfordia" Farm and then flew west. Phoned headquarters from Nyabira and informed swarm at "Lilfordia" not dusted, but another swarm further west dusted. Returned to Salisbury 6 P.M. (50 miles.)

May 29th, 1934.

Left with Allan for Kutama Mission, Zwimba Reserve with instructions to locate swarm and collect specimens from swarm stated to have been dusted somewhere in the locality of the Mission. Located a swarm on Hunyani River within one mile of the Mission. Collected specimens from swarm which was resting (2 P.M.). None of the specimens looked sick. No local natives saw swarm dusted. Visited nearest farmer ("Gungurubi"), and told planes flew over farm in a westerly direction, but no dusting observed. Swarm flew west down Hunyani at 2·30 P.M. Returned to Salisbury 8 P.M.

after arranging with Father O'Hea to collect further specimens, if possible. Later received a letter from Father O'Hea stating he had collected some specimens and had used March test, but could not find arsenic. (151 miles.)

May 30th, 1934.

Remained in Salisbury. From information secured at Mission and at farm decided that swarm was dusted 8–10 miles further west.

May 31st, 1934.

Left with Allan 10 A.M. to locate swarm seen by Naudé and Faurie on "Glanrhyd." Failed to locate by 2 P.M. and returned to phone on "Idaho Farm" where another swarm flying north was found. Phoned position to aerodrome 3 P.M. and informed plane leaving immediately.

Lighted flares on railway line and on road and followed swarm along the railway. Planes sighted 3·20 P.M. Planes circled over swarm, crossed the Hunyani Range—recrossed and discharged first cloud at 3·30 P.M. on "Maryvale." We were about one mile away with a perfect view of the cloud, with the hills as background. First portion of cloud dropped heavily to the ground, but the second portion floated nicely, began to split up and finally rose over hills (see diagrams). Still visible at 3·36 when second discharge made. This discharge appeared to be perfect, well in the main locust stream and made at same spot. Cloud floated nicely, slowly split up, became less dense, rose with the wind and drifted away slowly over the hill. Visible as a good cloud for five minutes. Locusts did not appear to alter direction of flight, but to fly right through the discharge and over the hill. Five minutes later arrived at spot where discharge made and collected until 5 P.M. Numerous locusts seen falling like a stone from a great height with wings folded and legs outstretched. Never observed anything similar before (nor afterwards when other swarms dusted). A considerable quantity of arsenic found on ground from $\frac{1}{8}$ inch to 1 inch across, presumably from portion of first discharge which fell to the ground. No dead picked up and specimens collected contaminated with arsenic from my fingers. A considerable number of stragglers left behind—cannot tell if hit with arsenic. Locusts continued dropping out as described above until 5 P.M. both on spot dusted and even $\frac{1}{2}$ mile up wind. Allan suggests some affected locusts doubled back—not observed.

Direction of flight N.-N.N.E. following wind, locusts flying strong through treees on east side, full of settled locusts. Weather bright, warm, clear, gentle breeze.

Later, 5·15 P.M., went to Ganger's Cottage, Hunyani Tank, and informed swarm divided by planes, half going over "Warwickshire Farm," half on to Government Reserve and "Porta Farm." Actually swarm divided by hills. Passed locusts settled for night on "Porta" and "Kilworth" Farms. (85 miles.)

June 1st, 1934.

Left 10 A.M., with King, Naudé, Allan and Michelmore, to inspect swarm dusted 31st. Dropped Allan at 20-mile peg and went on with others. Left car at Hunyani Bridge and walked on to spot where dusted. A considerable number of stragglers left behind and collected a few specimens. No dead found and few that I should call really sick. Climbed hill over which swarm flew and dust was carried, and then back to car. No sick on hill. Followed up portion of swarm on "Sublime" and "United" Farms east of Hunyani Range. Now dull—cloudy—intermittent sunshine. Locusts showing symptoms of cold and settling in trees and grass in vlei. Difficult to tell sick from cold specimens. No signs of arsenical diarrhœa. Returned to Allan on west side of Range and collected more specimens, these looking sickly, or at least sicker than the others. At 5 P.M., gave over collecting, *i.e.*, twenty-five hours after dusting. End of swarm now resting where front of swarm rested 31st. (74 miles.)

June 2nd, 1934

Went up with Faurie in "Wapiti," 6·30 A.M., to locate a smaller swarm. Several small swarms seen on "Whitecliff," "Gillingham" and "Parkridge." Consider these would join up when they fly. Also flew over swarm dusted 31st now covering very large area, dense on "Kilworth," "Saffron Walden" and "Stonehurst." Swooped at swarm with plane—did not stir them.

Later, 10 A.M., went out with Allan to collect sick specimens at 18–21 mile peg, Hunyani Road. At 12·30 P.M., swarm just leaving, flying west. Collected more specimens which I consider to be definitely sick. Fairly easy to collect in short grass, but impossible to find in long dense grass. Sick specimens when approached dropped on the ground and completely disappeared under one's nose. Camouflage colouration perfect. Returned Salisbury 3·30 P.M., R. W. Jack and party just leaving on a reconnaissance flight. (62 miles.)

June 3rd, 1934.

Naudé and Faurie returned to Pretoria and Allan to Livingstone.

June 4th, 1934.

Public Holiday and Post Offices closed. Attended to locusts at Laboratory with King and Michelmore. Some dead specimens in cages completely eaten by ants, *Dorylus sp.*, and went out to "Lilfordia Farm," Nyabira, Nkomo and Wellesley to trace swarm and to be present if King decides to dust. Could not locate swarm. Weather in morning cloudy and cold—cleared later. Jack and King did reconnaissance. (118 miles.)

June 5th, 1934.

Went up with King, Jack, Pawley and Michelmore in "Hercules" over "Passaford," lower portion Barwick Estate, south along east side, "Great Dyke," "Wellesley," Hunyani–Norton–Kent Estate, Warehouse to Salisbury, but saw nothing. Weather cold and dull. Could see no swarms.

June 6th, 1934.

Went up in Puss Moth with Pawley and Phillip. Located a very big swarm settled on "Welston Farm," known to have been previous day on Glenara and Komani. Circled over swarm. Followed Gwebi River to Darwendale. Located another—what appeared to be a compact isolated swarm on Eclipse Block, Darwendale. Locusts settled on trees and flying over Gwebi River on to Darwendale. Returned to Salisbury and reported.

June 7th, 1934.

Collected Verey Light Pistol and cartridges from aerodrome and left for Darwendale 11 A.M. Arrived 12 noon. Locusts just beginning to rise. Weather bright, clear and warm in sun. Saw Mr. C. Rawson and then left for swarms on Gwebi River. Later, 1 P.M., swarm commencing to fly N.-N.N.W. towards Darwendale. Phone Headquarters at 2·10 P.M., swarm heading for "Fishponds Farm," Puss Moth not required. Took up good position on hills at 3 P.M., after picking up a Native Constable at Police Camp. Posted Messenger Beaton on west side of hills and remained on east with Native Constable. First sighted plane at 3·30 P.M., and fired Verey Light. Plane changed course and circled north over hills. Locusts now rising and crossing hills. Could not tell which side of hills they were going to dust. Fired another light as plane passed over me second time. Too close. Dashed over to west side of range. According to Messenger first discharge of poison had been made, but air so full of locusts could not see dust for glinting wings. Plane now to north heading direct at me—one mile away—fired third Verey light. Second discharge made 3·45 P.M., and I think a very good cloud right in swarm as locusts seen above and below plane, but could not see too well as plane right in front of line of sight, very close and on same level; air full of locusts and sun in my eyes.

Third discharge made at 3·49 P.M., from both cylinders. Very light discharge, but floated well and right in middle of swarm. Did not see any powder falling from either discharge seen by me.

Collected numerous sickly looking locusts in vlei and at edge of vlei below. No arsenic seen on ground. No locusts seen falling like a stone as seen by Allan and self on 31st. Later, 5 P.M., locusts all flown over and settled in "Dyke." Messenger Beaton states all three discharges good and in middle of swarm. Turning cold. Returned to Darwendale and went on to "Maryland," but

could get no information about swarm. Now dark. Stayed night Darwendale Police Camp. (69 miles.)

June 8th, 1934.

Left 9 A.M. Maryland and picked up a native guide at farm and went on foot to spot in centre of "Dyke" where swarm rested night. At 10·45 A.M. most on ground, but still many in trees. No definite flight commenced. Collected numerous sickly looking specimens, but may be still cold. All tested by throwing up into air three times before putting in box. Three dead collected by self, others by Messenger. By 1 P.M. swarm rising and flying N.W. over "Dyke" towards "Abercorn Farm." Weather clear, but cold out of sun. Commencing to cloud over. Returned to car and located swarm.

Later 2 P.M. phoned aerodrome giving position of swarm on "Abercorn" near Chrome Line on west side of "Dyke" and returned to swarm. Weather now dull and cold. Hills covered with locusts also trees near line. Later, 3 P.M., some of swarm moving N.N.W. across vlei, most still settled in hills. Very overcast and cold. Later 4·15 P.M., sighted plane coming over "Dyke" and fired Verey Light—started veld fire. Plane circled north and then turned south towards me—fired second Light—failed to burn in air—started another fire—fired third Light. Plane overhead—very high, visibility from plane must be poor—no sun—cold. Plane returned to Salisbury without dusting. Too cold to collect specimens so returned to Salisbury. (78 miles.) Left swarm in hills and in trees on both sides of Chrome Line. Towed disabled car from Gwebi River to Wellesley.

June 9th, 1934.

Very cold and overcast; stayed in Salisbury.

June 10th, 1934.

Went out with King, Michelmore and wife to "Abercorn Farm," arriving 1 P.M. Went to spot where swarm left on Friday night and where I fired Verey Lights. No sign of main swarm. Numerous stragglers in bush and in vlei. Drove five miles north along "Dyke" and climbed kopje. No sign of dusted swarm, but sighted two other swarms, one towards Banket and one towards Hunyani River north of Sinoia. Latter swarm very big. Very high cold wind. Thought swarm seen near Banket, fifteen miles north, might possibly be dusted swarm. Returned and inspected ground on foot on west of vlei. Made no proper collection. Returned Salisbury. (134 miles.)

June 11th, 1934.

Morning cold, overcast and raining. Went up in Puss Moth at 2·30 P.M. with Phillip and Michelmore. Located dusted swarm still

flying N.N.W. on "Stratham Farm." Returned Salisbury 3·45 P.M. through heavy rain and phoned headquarters. "Hercules" prepared for flight, Jack arrived 4·15 P.M. and plane left. Swarm had moved a little towards main road, appeared to be settled on trees, but rose as plane circled over.

1st Attempt: Discharge failed to go off—handle slipped.

2nd Attempt: Good, right in middle of swarm, floated well, many locusts seen between wings of plane.

3rd Attempt: On same spot, first cloud still visible blowing to N.W. This cloud blew over main road and Sinoia railway line. Possibly high, *i.e.*, above main body of swarm.

4th Attempt: Both cylinders, very good but light; plane low in middle of swarm. Saw many locusts between wings. Arrived Salisbury just at dark; plane covered with dead locusts.

Do not think swarm will travel far, if at all.

June 12th, 1934.

Left for Maryland 9 A.M. Visited Mr. O. C. Rawson, Darwendale, and D. J. Robertse, "Cowley," informing them where swarm dusted; advised them to keep cattle away. Commenced collecting 11 A.M. at spot where swarm dusted. Locusts still on ground and trees, no definite flight commenced. Weather bright, clear, but cold. Picked up six locusts killed and smashed by plane and being eaten by ants (*Pheidole*). Could not find any trace of arsenic on ground. Collected many sickly looking specimens—ones that could not fly—were lying hidden in the grass or showed symptoms of paralysis in their hind legs. Swarm commenced to fly N. to N.N.W. at 12 noon. Many still in trees. Left at 1 P.M. to locate swarm. Found swarm very scattered at 2·30 P.M. on "Cleen" and "Stroud" Farms (P. Lamb). No phone—returned to Trelawney and phoned aerodrome 3·20 P.M. Plane just leaving—too late to deliver message. Waited 20 minutes to get connection; returned "Stroud" 3·40 P.M. and waited for plane at edge of old tobacco lands. Heard plane at 3·50 P.M.—sighted—and fired Verey Light—then another. Most of swarm on trees or on vlei in grass.

Plane turned—circled overhead—then flew overhead very low—40–50 ft. and circled round over swarms. Lost sight of plane—flying very low over bush. Native Messenger says saw dust cloud, heard hum of plane decrease and spotted through trees—ran towards plane through bush and saw discharge about 100 yards away. Plane passed overhead very low—visibility extraordinarily poor owing to dense bush. Impossible to see what happened unless stationed right under swarm—then impossible for pilot to locate position. Second discharge about 4 P.M.—most of swarm settled on trees, dense just above trees—no definite flight. Weather very dull—locusts rose for short circular flights with each burst of sunshine—cold generally, conditions poor.

Collected some sickly looking specimens, including a number hit by machine. Did not see any poison on ground, but could smell it and feel "ticklish" sensation in throat and nostrils. Collected until 5 P.M., when swarm definitely settled for night on and around spot where dusted—possibly one square mile. Returned Salisbury. (129 miles.)

June 13th, 1934.

Left 11 A.M. with Michelmore to collect at site where dusted on Monday, the 11th, and Tuesday, the 12th. Arrived 12·30 and collected until 2 P.M. Sickly and dead specimens more numerous on "Cowley" than on previous day, and more numerous than found at other positions. Between us obtained quite a good collection of definitely sick specimens, including about 10 dead, partially destroyed by ants (*Pheidole*). The strong cold wind of Saturday and Sunday had dropped.

Later, 2 P.M., went on to where swarms dusted Tuesday, the 12th, on "Stroud." Locusts still thick in trees and grass where dusted previous day, but some had moved N.W. over homestead and in gum plantation. Lunch. At 3·10 P.M. locusts still thick on trees. Occasionally, when sun appeared, there was a partial rising and a tendency to fly N.W. Difficult to explain, as bright and warm in sun but cold in shade. Did some collecting, but difficult to tell cold from sick specimens. Swarm—main body—had moved a little during night, as tail end on spot where dusted, the rest a little further N.W. Visited P. Lamb. Returned to Salisbury at 5·30 P.M., arriving 7·30 P.M. Assisted disabled motorist on road at Gwebi River. (118 miles.)

June 14th, 1934.

Stayed in Salisbury.

June 15th, 1934.

Left Salisbury 11·30 A.M. for Marylands and Trelawney to collect at spot on "Strathearn" (Cowley) where swarm dusted the 11th June, and on "Stroud" the 12th June. On "Strathearn" still found a number of dead, dying and sickly looking locusts on ground. Probably easier to collect at this spot, the grass being fairly short. Some healthy looking stragglers also present. Weather very cloudy and cold—some rain in east. More dead found than at previous collections.

Later, 2 P.M., went on to "Stroud Farm," Trelawney, to spot where collections made the 11th and 12th. Swarm had moved away about ½ mile to the south and were settled on trees on both sides of a narrow vlei with stream running east to west.

Did some collecting at point where dusted and picked up a number of dead and dying, exhibiting typical symptoms of arsenical poisoning. Locust stragglers very numerous in vicinity. Visited

main swarm. When the sun was out they would fly round a little, but the majority remained on the trees. Some movement from one side of vlei to the other and *vice versa*, and a certain amount of mass movement up and down the vlei—fairly dense. Up wind with a straggling return movement at a lower level. Many locusts in grass. Weather overcast with short bursts of sunshine, cold. Returned to Salisbury 6 P.M. (115 miles.)

June 18th, 1934.

Went out with Michelmore to inspect swarm on "Stroud," King suspecting that general movement of this might have been slowed down owing to a big proportion of the swarm having arsenical poisoning. Found, 1 P.M., that swarm had moved back again across old tobacco lands, and were resting in trees surrounding these lands, including the spot where dusted on Tuesday, 12th. A few sickly specimens exhibiting typical symptoms of arsenical poisoning, and two dead picked up where swarm rested Friday. Weather completely overcast—no sun, cold. Returned Salisbury 5 P.M. (114 miles.)

This swarm has been dusted three times, once on the 7th on "Fishponds," once on the 11th on "Strathearn" (Cowley), and on the 12th on "Stroud." On the evening of the 7th the swarm rested 1-2 miles from the spot where dusted, but on the evenings of the 11th and 12th the swarm or some of it, rested on the spot where dusted, while from the 12th to the 18th, the swarm remained within half a mile or a mile of the same place, and on the 18th actually returned to the spot where dusted. The probability that some of these locusts have eaten foliage with arsenic on it is a pretty big one.

This swarm was first sighted on Eclipse Block about 3 P.M. on the 6th. On Wednesday the 7th, it commenced flying N.W. with the prevailing wind to "Fishponds Farm" where it was first dusted and settled for the night in the middle of the "Great Dyke," having flown approximately 4 miles. The next day, the 8th, it flew to "Abercorn Farm" about 5 miles. Between the 9th and the 11th, it flew to "Strathearn" (Cowley) about 4 miles. The weather conditions on the 9th and 10th were abnormally cold and windy, with rain in Salisbury on the 9th, 10th and 11th. On the 12th it flew to "Stroud Farm" about 2 miles and remained there until the 18th. During the thirteen days it was under observation, it flew in all about 15 miles in a north-north-westerly direction following the prevailing wind from the S.S.E.

One difficulty is the limited time during which it is possible to dust the swarm, *i.e.*, between 3 P.M. and 4·30 P.M. as, owing to the prevailing atmospheric conditions, the pilot did not consider it safe to dust before 3 P.M. During the present cold weather, the swarm does not as a whole take to the wing before 1 P.M. and commences to settle between 3–4 P.M. even on bright days. On really dull, cloudy days, the period during which flight occurs is

even shorter and, as has been observed on occasions, no flight may take place, the swarm remaining at approximately the same place. It is a pity that it was not possible to keep another swarm under observation over the period 6th to 18th June so that the behaviour of the two swarms, one dusted and one as control, could have been compared. As it is there is no definite proof that the very short flights—usually not more than half a mile, which this swarm made between the 12th and 18th—were due to the effect of arsenical poisoning, whether received from the dust cloud or from poisoned foliage. Much as one would like to believe that these short flights were due to a large proportion of the swarm suffering from arsenical poisoning and therefore acting as a drag on the others, the cold weather conditions which prevailed may be entirely responsible.

With regard to the actual cloud discharged from the 'plane, I only had a really good view of the two discharges made on the 31st May. Of these, the first discharge was a partial failure, the first half falling heavily to the ground, although the second half floated nicely. The second discharge appeared to be perfect in regard to position, timing, height, relation to direction of flight, time it remained in the air (visible for over 5 minutes), suspension and dispersion. Owing to the known defects of the design of the apparatus used, the cloud is too heavy in proportion to the area covered, possibly 150–200 yards during the period of the discharge.

Of the other discharges, I had a fair view of the second discharge made on the 7th. Owing to the nearness of the plane, its position, the number of locusts present in the air and the fact that the sun was in my eyes, it was difficult to tell exactly what happened. The third discharge from both cylinders appeared very good but light. No arsenic was found on the ground where the discharges were made, so they were probably very good. It is, in fact, reasonable to assume that all three clouds were good, certainly they were well timed and nicely gauged as regards position, height and direction of flight.

The three discharges seen from the "Hercules" on the 11th I should judge to be good although one's range of vision from the plane was extremely restricted. The clouds appeared to float well and were discharged in the densest portion of the swarm. I doubt, however, if any real flight movement was taking place at the time. No arsenic was found at this spot.

Two discharges were made on the 12th. I only saw one at a distance of about 150 yards through the trees. It was impossible to see how the cloud behaved owing to the dense bush. Although I could smell and feel the arsenic afterwards; nothing was found on the ground.

The behaviour of the locust swarm during the discharge is rather difficult to judge, but my impressions are as follows:—

On the 31st the swarm was flying strongly with a following wind and bright sun—it appeared to pass clean through the cloud without changing direction or height. On this occasion numerous locusts

were observed falling like a stone from a height with wings folded and legs outstretched. This may have been due to paralysis following inhalation of the arsenic during rapid flight accompanied by maximum respiratory effort. This phenomenon was not observed afterwards.

On the 7th the swarm was flying fairly strongly over the "Great Dyke," but had only just commenced to fly, the swarm having rested on the tree clad hills from about 2 P.M. to 3 P.M. Actually, many of the locusts were disturbed by the plane when circling above the swarm. They continued to maintain the direction of flight regardless of the plane or the dust cloud.

I did not see clearly what happened on the 11th and 12th. Definitely, a portion of the swarm rested for the night at the spot where the discharges were made, and I believe that no real flight was in progress at the time. I should probably be right in saying that the plane and the dust cloud cause some excitement in the swarm, causing it to circle round and round over the spot where it obviously intended to rest the night.

In conclusion, I would add that three dustings made on the 7th, 11th and 12th have had no apparent effect on the size of the swarm.

The above notes and observations have been compiled in the hope they will assist all connected with these experiments to draw reliable conclusions from them. Faulty, disconnected and incomplete as they are, I probably saw more of what actually happened than the observers in the planes.

APPENDIX 9.

THE USE OF AEROPLANES IN LOCUST CONTROL.

By DR. T. J. NAUDÉ, *Chief Entomologist, Union of South Africa.*

THE idea of using aeroplanes in South Africa against the redwing locust originated from a field study of the roosting and flying habits of this species in December 1931. The compactness of a roosting swarm, its prominence as an object on the veld, its helplessness during the early morning hours, and the fact that the dusting of forests and field crops has been successfully done from aeroplanes indicated a strong likelihood of the success of this method against the redwing locust. The compactness of the flying swarm at certain times of the year suggested the possibility of even dusting some swarms in flight, whereas the great mobility of the swarms render the most rapid form of transport necessary to keep in touch with them.

For the Union of South Africa an aerial attack on this species would have as its main object the interception and destruction of invading swarms on our borders. The idea underlying such a scheme

is the prevention of an otherwise unavoidable hopper campaign in the interior of the Union, the saving of crops and grazing from both the invading fliers and their progeny, and the elimination of arsenical poisoning of stock in our most important stock-raising areas.

The first trials in this direction consisted of experiments with a de Haviland 9 aeroplane in March this year. Using an old model Venturi tube and hopper, the machine was first rendered dust-proof to protect the pilot and operator. Then experiments were conducted to develop a technique in applying the poison, and 5th and 6th stage hoppers of the redwing locust were used to get an idea of the lethal dosage necessary and attainable by this method. Fair mortalities resulted and an idea could be formed as to the technique to be followed and the approximate dosage per acre likely to prove effective.

Field trials were then conducted both near Pretoria and further afield on flier swarms of the same species. It was soon proved that swarms settled on the bush are very readily visible at considerable distances, and that if the right time of the day is chosen flying swarms can be detected with certainty at long range and with surprising ease. It proved quite easy to fly over the swarm where it roosts and to deposit arsenite of soda powder in suitable clouds to achieve satisfactory theoretical distribution of the poison. Various brands of powder were tried. All of these were not equally successful, but given an effective brand, the finest possible particles seemed to work most satisfactorily. The addition of medium fine powder of the same brand to the finest powder available would, however, appear to cause an acceleration of mortality.

It proved practicable to treat roosting swarms effectively at the rate of 10 pounds per acre, flying at a height of approximately 80 to 100 feet from the ground. At this dosage very heavy mortalities were obtained within 48 hours, although locusts in some instances kept on dying for at least 10 days after treatment, these being presumably individuals which had received a light dosage. In the later trials the venturi arrangement was discarded for a curved windshield, which worked equally well and had the advantage of being very simple, practicable and accessible.

Towards the end of April, however, the swarms encountered were so large that even though within easy range they could not nearly be covered in a morning's work with the D.H. 9 machine. It was, therefore, most difficult to follow up results as the swarms were definitely migrating. Enough information had, however, been gained to prove aerial attack on flying swarms definitely practicable and effective. It has, however, been considered desirable to confirm the impression by repeating the tests on an extensive scale using a machine of greater carrying capacity. More work is also necessary towards the evolution of a definite technique and the establishment of the minimum and optimum effective dosage, 10 pounds per acre being definitely higher than necessary judging by results obtained and definitely dangerous to livestock.

The advantages of this method if finally successful would be:—

1. probable prevention of wholesale invasion of the territory concerned by flying swarms.
2. obviating of an otherwise unavoidable hopper campaign.
3. great saving in actual expenditure.
4. reduction of area over which stock would be lost.
5. transfer of the use of dangerous poison to hands of a few disciplined workers instead of thousands of untrained and undisciplined labourers.
6. quick and efficient action.
7. more economical use of poison.
8. greatly enhanced possibility of avoiding campaign against young fliers, which involves greater danger and difficulty than hoppers.
9. reduction of danger of poisoning workers and other humans.
10. greatly enhanced possibilities of eventually controlling locusts like the redwing within their permanent breeding grounds before the surrounding territories become overrun with the insect in the swarming phase.

As far as the Union is concerned, distinct preference is given to treating swarms only while they are roosting. This gives ample time to operate for three to four hours at the best flying time of the day, without any change in the position of the swarm. This makes complete coverage easily attainable, while the compactness of the swarm reduces the area poisoned and brings the amount of poison needed for dusting swarms within the carrying capacity of large aircraft.

APPENDIX 10.

FURTHER INVESTIGATIONS ON THE DESERT LOCUST, *SCHISTOCERCA GREGARIA* (Forskål); DRAFT PROGRAMME SUBMITTED BY THE UNITED KINGDOM DELEGATION.

The following programme, which the United Kingdom delegation have prepared for the consideration of the Conference, has been prepared in the light of the results of the field investigations already accomplished, and of the inferences which can be drawn from the annual surveys of the present locust outbreak. It is further supplemented by indications of certain regions which come under suspicion as possible outbreak areas on general geographical and ecological grounds.

The programme may appear to be rather ambitious, but its main aim is to provide a basis for discussion. This discussion should

help to formulate a clear conception of the scope of the work confronting the international locust investigations. It is only after a complete stock has been taken of what remains to be done, that a definite plan of future investigations can be settled. Such a plan, accompanied by suggestions for the allotment of different parts of the work to the respective governments, would, it is felt, be helpful to governments in making the necessary arrangements.

I.—The Moroccan–Senegambian region.

(a) *Mauritania.*—Summer breeding of swarms in Mauritania appears to be a common occurrence. The ecology of the country is little known, but the littoral and the sub-littoral dunes* present an aspect closely similar to that of known breeding areas. A reconnaissance would be of very great value.

(b) *Rio de Oro.*—No data at all are available with regard to Rio de Oro, which is certainly covered by swarms passing from Mauritania to Morocco and back. It is not impossible that some parts of the littoral present conditions suitable for the permanent breeding of locusts. A reconnaissance is urgently needed in the interests of Morocco.

(c) *The Draa valley.*—The Draa valley situated in the extreme south of French Morocco may possibly represent a winter refuge for locust swarms. It is not impossible that locusts may be able not only to survive, but also to reproduce there. A reconnaissance is necessary during the winter and early spring.

II.—The Algerian–Nigerian region.

(a) *The Nema area.*—The Nema area has already been surveyed by French investigators.

(b) *Adrar des Iforas.*—This region has also been surveyed.

(c) *The Tegama (east of the Niger bend, south of Air).*—According to descriptions (Chudeau; Abadie), the northern parts of the Tegama present conditions under which permanent habitation by the Desert Locust is highly probable. The region of Azaouak, adjoining the Tegama on the west (south-west of Air and north of Tahoua) also deserves attention. A reconnaissance of the whole area is necessary.

(d) *The area north and north-east of lake Chad.*—At some distance from lake Chad (about 16° N.), low sandy ridges separated by depressions appear to offer conditions suitable for the Desert Locust. The Kanem, north-east of the lake, presents similar conditions. The reconnaissance of this area should be extended eastwards to link up with the investigations in Darfur.

III.—The Sudanese–Arabian region.

(a) *Kordofan.*—The Kordofan region has already been investigated by a British entomologist.

* See illustrations in Chudeau, 1909, *Sahara soudanaise*, pl. 23.

(b) *Darfur.*—A reconnaissance of Darfur by a British investigator is now in progress.

(c) *The African coast of the Red Sea.*

(i) *The Sudan coast.*—A reconnaissance of the Sudan coast was carried out by a British investigator in the winter 1933–34, and some outbreak areas were located. Stationary work is planned for the winter season of 1934–35.

(ii) *The coast of Eritrea and Abyssinia.*—A reconnaissance in winter of the coast of Eritrea and Abyssinia is necessary in order to see whether the same conditions obtain there as on the Sudan coast.

(d) *Arabia.*

(i) *The coastal plains of the Yemen and Lahej.*—The type of country in the coastal plains of the Yemen and Lahej is very similar to that on the Sudan coast. A reconnaissance in winter is necessary.

(ii) *Nefud.*—The Nefud is a sandy desert in north-eastern Arabia where the breeding of locusts in early spring is a common occurrence. A reconnaissance is necessary.

(iii) *The Batina plain (northern Oman).*—The Batina plain in northern Oman is a probable winter and early spring breeding area of swarms which may affect Persia and perhaps Baluchistan. The country is of a suitable type for solitary locusts. A reconnaissance is necessary.

IV.—The Somali region.

Italian Somaliland, particularly Jubaland, presents conditions under which permanent habitation by the Desert Locust is very probable. It is possible that this region is of importance as a source of infestation of east Africa. A reconnaissance is necessary.

V.—The Indian region.

Investigations in the Indian region are being carried out by Indian entomologists.

VI.—The South West African region.

The presence of the Desert Locust in South West Africa and its ability to form swarms there has been established recently and a detailed survey of outbreak areas is necessary.

APPENDIX 11.

SUMMARY OF RESULTS AND PROGRAMME OF FURTHER INVESTIGATIONS ON THE RED LOCUST, *NOMADACRIS SEPTEMFASCIATA* (Serville).

By A. P. G. MICHELMORE, *Member of the field Locust Staff in East Africa of the Imperial Institute of Entomology, London.*

Two main objects have been kept in view (i) the working out of the factors affecting migrations, and (ii) the study of outbreak areas and outbreak centres.

I.—Factors affecting migration.

This side of the work will eventually be less important than the other, but it is the more urgent, since its solution would be of great use in the campaigns against the present outbreak. Unfortunately, the problem has proved to be very complex, and data are still far too scanty for an attempted analysis of them to be of any value. For the present all that can be done is to continue to collect information about swarms and about the nature and the climate of the country in which they are found.

II.—Outbreak areas and outbreak centres.

A. *Habitats of solitary Red Locusts.*—Wide travels in Tanganyika, Northern and Southern Rhodesia and Nyasaland have revealed the following as the only obvious limiting factors in the distribution of solitary Red Locusts in the districts visited:—

1. presence of trees or bushes, unless widely scattered.
2. permanent flooding.
3. absence of grass of more than about 1½ ft. in height and of moderate density.

Within these limits, that is to say in all open grassland which is neither very arid nor heavily grazed, isolated Red Locusts can be found. No direct climatic limits have yet been discovered. Doubtless parts of these areas are not permanently inhabited and have only been colonised temporarily by swarms. The outbreak areas can only be marked out by surveys covering the whole and gradually eliminating the temporary habitats as the locusts disappear from them.

B. *Outbreak centres.*—1. The sources of the present outbreak were almost certainly confined to (*a*) Lake Rukwa in south-west Tanganyika, (*b*) Mweru wa Ntipa or its neighbourhood, and (*c*) the Masanka plain in the Mweru–Tanganyika Lowlands of Northern Rhodesia.

2. These three known outbreak centres differ from each other in vegetation and other characteristics, but other places resembling some of them more closely than they do each other are known not to have produced swarms recently.

3. Lake Chad in the Sudanese region and the Kafue Flats and perhaps the Lukanga swamp, both in Northern Rhodesia, had rudimentary outbreaks at about the same time as the main area.

4. The 1918 outbreak in Uganda did not originate from any of the known centres.

5. The great outbreak at the end of last century originated, at least in part, in the Mweru–Tanganyika lowlands. What was either a second rise in the same swarm cycle, or else a new outbreak starting from the solitary phase before the previous one had finished, began in Mozambique in the early years of the present century.

Conclusion.—Although only three outbreak centres are known, it is certain that others exist. At present no criterion, by which one can tell whether a given place can or cannot be an outbreak centre, is known. Therefore, all habitats of phase *solitaria* have to be suspected as possible outbreak centres until the contrary can be proved.

III.—Work recommended for the future.

A. *Botanical survey.*—Vegetation maps to show the position and character of open grass country and grass dotted with bushes or trees would be easy to make for most countries in central and southern Africa and would be very useful in the study of the Red Locust. In default of actual maps, any information on the subject would be of value.

B. *Entomological reconnaissance.*—In south-central and south Africa a stage has been reached when little can be gained by continuing general reconnaissance, like that done during the past year, until intensive work has given some test for distinguishing at a glance temporarily colonised habitats, habitats of the solitary phase, and the outbreak areas. In the *equatorial regions* such survey is needed, since nothing is known of the distribution and behaviour of the solitary Red Locust in areas with two annual rainy seasons. In the *northern tropical regions* also reconnaissance would be of value in defining permanent habitats, if done before swarms spread across from East Africa.

C. *Intensive work.*—Lake Rukwa, a known outbreak area, is to be the subject of special study during the next year by an entomologist of the Imperial Institute of Entomology. The area next most in need of examination is the grass plains of the lower Limpopo, Sabi, Zambesi and Shire rivers, and this should be studied first, if the Union of South Africa sends a man to work on this locust. It is suggested that the Kafue Flats in Northern Rhodesia should be watched from time to time by the entomologist of the Northern Rhodesian Government, and that the Nyasaland Government should

be asked to do the same with Zomba Mountain, as typical of "mountain grassland," and lake Shirwa (Chilwa), which is very similar to a known outbreak area at lake Rukwa.

D. *Other work.*—In other countries such general observations on the changes in distribution of isolated locusts during the later stages of the swarm cycle as other duties of the Government entomologists permit should be made.

The following areas are suggested as the most important for future study, apart from those already mentioned:—

1. the Lualaba valley in Katanga Province of the Belgian Congo.
2. the Usinge swamps, Wembere steppe and Kilombero valley in Tanganyika.
3. the great sandy "grass deserts" of western Northern Rhodesia and eastern Angola, including the Lunda plateau.
4. the Mossamedes and Huila districts of southern Angola (swarm phase).
5. the swamps and pans of northern Bechuanaland and South West Africa, including the Caprivi strip.
6. the eastern grasslands of the Union of South Africa (influence of cold on the distribution of the solitary phase).

APPENDIX 12.

RESEARCH CARRIED OUT UNDER THE AUSPICES OF THE ITALIAN GOVERNMENT ON *DOCIOSTAURUS MAROCCANUS* (Thunberg) AND ON *CALLIPTAMUS ITALICUS* (Linn.).

Memorandum by Professor Filippo Silvestri, Professor of General and Agricultural Zoology, Royal Superior Institute of Agriculture, Portici, and Director of the Entomological Laboratory, Portici.

THE Italian delegation is glad to be able to inform the Conference that their Government is in perfect agreement with the programme laid down by the first and second International Locust Conferences held at Rome and Paris, and that the Ministry of Agriculture has provided the Laboratory of Entomology, Portici, with the necessary staff and other means for the study of locusts infesting Italian territory and especially *Dociostaurus maroccanus* (Thunberg). Dr. Jannone, who is in charge of these researches, has published a preliminary report—"Osservazioni ecologiche e biologiche sul *Dociostaurus maroccanus* (Thunberg), *Calliptamus italicus* (Linn.) e loro parassite," printed copies of which have been distributed direct to the delegations attending the present Conference in London, together with other papers on *Dociostaurus* and *Calliptamus* by Drs. Melis, Paoli, and Gravini, published by the Ministry of

Agriculture. At the present time an additional entomologist, Dr. Ricchello, has been charged with the special study of the Moroccan Locust in Sardinia also. We can, therefore, assure the Conference that research concerning this locust will be carried on in the best manner possible, in the field, on the mainland and in Sicily by Jannone; in Sardinia by Ricchello; and in the laboratories of Portici and Cagliari. The results will be communicated to the Imperial Institute of Entomology and also to other institutions and entomologists interested in the problem.

APPENDIX 13.

THE ORGANISATION FOR THE COLLECTION OF INFORMATION ON LOCUSTS IN THE UNION OF SOUTH AFRICA.

By JACOBUS C. FAURE, *Director of Locust Research, Department of Agriculture, Union of South Africa.*

UNDER the provisions of the Agricultural Pests Act of 1911, as amended by Act 15 of 1934, occupiers of land are expected to report to the nearest magistrate the appearance of flyers or hoppers, and the laying of eggs on their land. Occupiers are also under obligation to destroy all bands of hoppers which appear on their land.

Police officers are under instructions to be on the lookout for, and to inquire about locusts, and to submit monthly reports. Railway servants, and other government officials, have also been instructed to report the appearance of locusts.

Local locust officers fill in weekly reports, in the form of diaries, showing the farms visited and locusts found on them. Senior locust officers are under instructions to send in monthly reports, and at the end of each campaign they submit a general survey of the events of the season, accompanied by maps showing the distribution of locusts. Districts in which the outbreaks are small may be left in charge of the magistrates, without the services of senior locust officers, and in such cases the surveys are submitted by the magistrates.

A weakness in the system of reporting by locust officers is that they work only when there are locusts to destroy. During the intervals between outbreaks they are apt to lose interest and consequently the first signs of swarm formation are often not reported. No senior locust officers are permanently employed, but during the swarm-free periods two or three of them are retained on semi-active service and sent out to scout from time to time when it is suspected that locusts may be increasing.

In general it may be said that the farming population does not fulfil its obligations to report locusts as promptly as is desirable, especially in the case of incipient swarms of the brown locust. One reason for this is that most farmers do not recognize the brown locust in its solitary phase, and pay very little attention to the early stages of incipient swarming.

The Department of Agriculture intends to place an entomologist in charge of the central locust reporting office in the near future; it will be his duty to improve the reporting system in general, to keep complete records of all aspects of locust outbreaks and campaigns, and to provide the information desired by neighbouring States and the Committee on Locust Control in London.

APPENDIX 14.

SUMMARY OF LOCUST RESEARCH WORK CARRIED ON IN NORTH-WEST INDIA UNDER THE AUSPICES OF THE IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH, SIMLA.

By Rao Sahib Y. Ramachandra Rao, *Locust Research Entomologist, Imperial Council of Agricultural Research, Simla.*

In accordance with the recommendations of the Board of Agriculture that met at Pusa in December 1929, a Locust Advisory Committee composed of the government entomologists and various agricultural and administrative officers of the Indian Provinces and States affected by the depredations of the Desert Locust was formed for advising the Imperial Council of Agricultural Research on locust matters, and at the same time a Locust Bureau was created under the Imperial Council for collecting and circulating information periodically in regard to locust movements and for giving advice as to locust destruction. In December 1930 a scheme of locust research in India, as recommended by the Locust Committee, was inaugurated, with Mr. Afzal Husain, M.Sc., M.A. (Cantab), I.A.S., Entomologist to the Punjab Government, as the Locust Research Entomologist in charge of the whole scheme, with headquarters at the Punjab Agricultural College, Lyallpur. Under him, Rao Sahib Y. Ramachandra Rao, M.A., Entomologist to the Madras Government, Coimbatore, was appointed Deputy Locust Research Entomologist in charge of locust survey work in Baluchistan, Sind and Rajputana, with headquarters at Quetta. (From April 1933, Mr. Ramachandra Rao was appointed Locust Research Entomologist, with headquarters at Karachi, in the place of Mr. Afzal Husain on his reversion to the Punjab Agricultural Department.) At Lyallpur, a detailed investigation of the bionomics of the Desert Locust was to

be undertaken, with special reference to points of practical importance bearing on control work. The staff stationed under the Deputy Locust Research Entomologist, Quetta, was to conduct a detailed survey of various parts of Baluchistan, Sind and Rajputana for determining if any outbreak areas of this locust actually existed on these desert areas. In addition, if oviposition and hatching of hopper bands were to occur, experiments in regard to the best and most economical methods of control were also to be undertaken by the staff.

Anatomy and morphology.

The following points in the morphology and histology of the Desert Locust were studied, mostly by research students of Indian Universities under the personal guidance of Mr. Afzal Husain: respiratory system: oogenesis and spermatogenesis; the digestive system; the muscular system; blood and blood corpuscles; the micropylar apparatus; embryonic development, &c.

Bionomics.

The following points were exhaustively investigated by the research staff at Lyallpur under the personal guidance of Mr. Afzal Husain during 1931, 1932 and 1933:—

Longevity of adults under various conditions: pairing: oviposition under different conditions: parthenogenetic breeding: period of incubation under different conditions: soil moisture and incubation: emergence of larvae from the soil: colour of hoppers as influenced by (1) temperature, (2) carbon-dioxide, and (3) fatigue: amount of food taken by hoppers: food plants of *Schistocerca* in India: number of broods in a year (1) under natural conditions and (2) under conditions of high temperature: duration of larval instars under different temperature conditions: the effect of different tropisms: ascent and descent on plants: &c.

The detailed results of the work done on the above points are being submitted by Mr. Husain for publication to the Imperial Council (see Ind. J. Agr. Sci., August 1933).

Results of survey work.

During 1931, as a result of survey tours conducted in Baluchistan, it was found that a sedentary and non-gregarious form of the Desert Locust was existent in certain sandy areas containing fairly dense xerophytic scrub vegetation, known locally as "reks," present along the coast of southern Baluchistan. From January 1932, a field laboratory was opened by the Imperial Council at Pasni, a typical centre on the Mekran coast, under the charge of Dr. K. R. Karandikar, for carrying out detailed ecological and bionomic studies of what was presumed to be the solitary phase of the locust in the midst of its natural breeding grounds, the

ultimate object of the investigation being the determination of the exact conditions under which a transformation into the migratory phase would take place in nature under the Indian type of environment.

During 1932 survey work was carried out with the aid of a motor lorry provided by the Imperial Council all over the Indus valley, in Sind and south-west Punjab, and in Lasbela and Mekran, and on camel-back across the Indian desert in parts of Sind and Rajputana, and led to the discovery of the locust in its non-gregarious form in various isolated localities in the desert regions. It was, however, felt that it would not be safe to consider these places as the permanent homes of the locust unless they were kept under observation for some considerable time for noting the seasonal distribution of the locust. Living, as it does, in a desert habitat subject to long periods of drought, *Schistocerca gregaria* (Forskål) is essentially a nomad in its constitution and has presumably to shift from place to place, even in its solitary phase stage, for maintaining its race. A scheme of more intensive survey work was, therefore, adopted during 1933 and 1934, whereby the regions of southern Baluchistan, Sind and Rajputana in which the non-gregarious form of the locust had been found were divided into definite areas, each being in the charge of a survey unit. It was arranged that all the more important localities in each area should be visited three or four times during the different parts of the year in order to make observations on the seasonal distribution and activities of the locust. Fairly interesting results have been obtained, but require to be confirmed before any generalizations can be made. During 1933, which proved to be a favourable year in regard to rainfall, there was evidence to show that in certain parts of Sind, Mekran and Rajputana two broods of the non-gregarious locust had developed during the year, the first one in spring, and the second in summer, and that the solitary type of locust was capable of making general, though limited, movements from one type of habitat to another, somewhat like the migratory form of the locust.

In order to study these points in detail and get definite information on them, the Imperial Council have sanctioned the starting in 1934 of two observation posts in typical centres of the Indian desert, one at Chachro, representative of the southern type of desert, and the other at Sardarshahr, in Bikaner State, typical of the northern desert. Work in these stations was to be restricted to the recording of meteorological data and the carrying out of intensive surveys throughout the year for getting definite data on the activities of the non-gregarious forms found in the desert.

Ecological studies on the Mekran Reks.

As already stated, the solitary phase type of the locust has been known to be existent on some of the sandy areas, known as "reks," in the neighbourhood of Pasni and Gwadar on the Mekran coast,

since April 1931, and it appears to be justifiable to consider them as some of the outbreak areas of the Desert Locust. From January 1932 regular ecological studies of the locust in its solitary phase have been in progress at Pasni and a great mass of data has been collected. The life-history of the locust has also been kept under observation in cages under semi-natural conditions for following under controlled conditions the course of breeding in nature.

Prominent among the results of the ecological work at Pasni is the fact that timely rainfall is a very important and indispensable factor in the life-economy of the locust. It is only after a good fall of rain that all the conditions necessary for its well-being come into existence, the most essential ones being the presence of sufficient soil-moisture requisite for egg-laying and the springing up of rich vegetation for food. Breeding almost always follows rainfall, giving rise to a new generation of the locust, but in case the rainy season is specially good and prolonged, more than one generation might come into existence. At Pasni, rains occur mostly in spring or early summer, but occasionally heavy rains may be received even in the summer months, as in 1930 and 1932, in which case summer breeding would also take place. In 1931 there was a spring brood following good spring rainfall, but in 1932 winter rains failed and there was no breeding in spring, while summer breeding occurred in July–August 1932 in the wake of heavy summer rainfall. In 1933 spring rains began rather late, but were copious and continued, so that locust-breeding extended over a long period. There were no summer rains and no breeding. In the spring of 1934, the rains failed utterly and the locust population has been diminishing steadily.

While Pasni and Gwadar, forming part of the western portion of the Mekran coast, are areas of winter rainfall, the region to the east of Ormara—comprising the greater part of the Lasbela coast—is pre-eminently an area of summer rainfall. Most of the rainfall occurs between July and September, and consequently the locust breeds only in summer. As the conditions of this area differed greatly from those of Pasni, a small field station, somewhat on the lines of Pasni, was started at Ambagh, a few miles to the south of Sonmiani, on the Lasbela coast, and the results obtained so far have shown that there is usually one generation in the year, which occurs in the summer months.

Another point of importance that emerged from the observations made at Pasni during the 1933 season was that, on the Pasni Reks, there were existent a few isolated areas where the soil-moisture persisted for a much longer time than in other parts of the reks, and the clumps of xerophytic vegetation remained green for quite a long time. In 1933, it was observed that freshly emerged first stage hoppers were to be seen on these clumps up to the middle of September, indicating that breeding had been in progress in these special areas, though it had ceased by the end of June in the rest of the reks. While at least two generations had been produced on the reks in general at Pasni in 1933 (between February and June), as a

result of a good season, it is certain that an additional generation (possibly even two) had come into existence on these special areas. It is possible, therefore, that these moist spots may serve as points of concentration for the solitary locusts during times of over-multiplication, and thus serve to bring about their transformation into phase *gregaria*.

Study of old records.

Special attention was paid to the collection and study of all existing old records from every available source in India. Valuable information has been obtained from various Administrations and States, of which the records lent by the Kalat and Jaisalmer States may be specially mentioned. Very important data have also been gathered by a study of the season and crop reports in the Provinces of Punjab and Sind, dating as far back as the year 1869. The information found therein, in regard to locusts, has been extracted and compiled, and it is proposed to map these out for the various years and study them before attempting to draw definite conclusions from them as to the general trend of locust movements in India. It may, however, be stated that, in regard to the years 1930 and 1931, detailed mapping of movements has already been done, firstly, by Rai Sahib G. R. Dutt, formerly Locust Bureau Entomologist under the Imperial Council, and later on by Mr. Afzal Husain at Lyallpur, but a study of the full cycle of movements recorded during the last outbreak of 1926–1931, as a whole, has yet to be made.

On the whole, however, it may be observed that there is general indication to the effect that in years of infestation locust swarms had been migrating from regions of winter rainfall, such as Baluchistan and Persia, to those of summer rainfall, such as Sind, Punjab, and Rajputana, during the summer months. During winter and autumn the trend of movements would appear to have been from east to west, from Rajputana and Sind towards Baluchistan, thereby bringing the swarms into regions where winter or spring breeding would be possible.

General information in regard to the last great outbreak in India is obtainable in the following publications: (1) "Desert Locust in India in 1929–1930," by Burt and Dutt, 1930, Agr. J. India, 25: 417–425; (2) "Mekran—Possibly the Country of Origin of the Locust Invasion of Sind in 1926," by R. Rao, Oct. 1933, Ind. J. Agr. Sci., 3; and (3) "Survey of the locust outbreak in Africa and western Asia in 1925–31," by Uvarov, London, Jan. 1933. A fuller and more complete account is, however, a desideratum so far as India is concerned.

Recent swarm movements.

During 1931, locust swarms were active in Baluchistan, Sind, and Rajputana, and parts of the Punjab, but almost everywhere the flights were weak and very little breeding occurred in summer, except in

parts of Rajputana in August–September. No movements were reported in 1932, except for a few swarms noted in Bahawalpore, Rajputana and Kathiawar. During 1933, there was heavy rainfall all over Rajputana and Sind during the monsoon months, and observations made by the survey staff in those areas showed that there were evidences of multiplication all over this region, though hoppers of the gregarious type were not noted anywhere. Towards the end of the year there were several reports from Montgomery (Punjab), Muttra (U.P.), Suket (Kotah State), Bhicangaon (Indore), and Katosan (Kathiawar), to show that swarms had been moving about in these areas between October 1933 and February 1934. Although in no instance could samples be collected, it is probable that these swarms had actually occurred and that they were possibly the result of over-multiplication in the Rajputana area (mostly in Bikaner and Jaisalmer).

APPENDIX 15.

SUMMARY OF THE WORK DONE ON THE DESERT LOCUST, *SCHISTOCERCA GREGARIA* (Forskål), AT LYALLPUR DURING THE YEARS 1931 TO 1933.

By AFZAL HUSAIN *(Communicated to the Conference by the Indian delegation).*

ANATOMY.

WITH the co-operation of some university students, particularly those of the University of the Punjab, the digestive, respiratory, and muscular system have been studied. The cogenesis and spermatogenesis have also been worked out. A preliminary study of the blood corpuscles of the locust has been made.

One of the features, by which the solitary phase is distinguished from the gregarious phase, is the colour of the eyes. In the gregarious phase the colour of the eye is uniform, while in the solitary phase the eyes are distinctly striped. Histological studies have shown that the pigment cells which separate individual units of the compound eye are more or less devoid of pigment in the unpigmented stripes. The physiological significance of this arrangement remains to be studied. It is not unlikely that this " defective " pigmentation is the main reason of the solitary hoppers not venturing into the bright sunshine of the desert.

A study of the micropyler apparatus has shown that it consists of a ring of elongated funnel shaped canals just behind the posterior pole of the egg. For a comparative study of the micropyler apparatus

in the ACRIDIDAE, see Afzal Husain and Mithan Lal Roonwal (1938, Ind. J. Agric. Sci. 3).

BIONOMICS.

Pairing.

Once a pair is *in coitu*, disturbances, unless very violent, do not separate the couple. Sounds, strong winds, rainfall, flooding of the area, approach of moving objects, even freezing, do not separate the copulating pairs. The loss of both the antennæ in males and females does not interfere in pairing. Similarly the loss of any one pair of legs does not disable males from performing this action.

Polygamy and polyandry are both common, and the males do not make any choice between virgin females and females which have already copulated.

Oviposition.

The chief factor which determines the choice of female in the selection of site for oviposition is suitable soil moisture conditions. Eggs are never laid in dry soil. As long as moisture is available, the eggs are laid in any type of soil which can be penetrated by the ovipositor of the female. In soils with stones and boulders the eggs are laid if the ovipositor can work under the stones.

The usual number of egg-clusters laid by a female varies between 2 and 4. The potentiality, however, is very high. The best performer laid as many as 11 egg-clusters in the laboratory, and the total number of eggs was 853. The average number of eggs per pod is 66, and the highest recorded is 120.

It has been ascertained that a female can lay eggs in the soil the temperature of which varies between 20° to 42° C.

Incubation period.

The influence of temperature and humidity on the incubation period has been studied. In presence of suitable soil moisture the duration of incubation is determined by temperature. At 20° C (constant temperature) it was 30 days, while at 44° C, which is near the highest vital limit, it was only 9 days.

It has been stated that the eggs of the Desert Locust, kept in dry sand, may remain unhatched for a prolonged period, which may extend to years. In nature the temperature of the soil where eggs may be laid hardly ever remains below the developmental zero (18° C) for any considerable time. That being the case, lack of soil moisture would be the retarding factor in such instances. This very important question could not be studied fully for want of sufficient material. The proliminary observations made tend to indicate that at a suitable temperature the prolongation of the incubation period can be connected with moisture deficiency in the soil. It has been possible to prolong the incubation period through

moisture deficiency up to 81 days, while the control, at the same temperature, the incubation period was only 10 days.

Emergence of larvæ from the soil.

As against the suggestion that positive phototropism or negative goetropism influences the movement of the larvæ out of the soil, it has been proved that neither light nor gravity plays any part. Hatching may take place in a dark room and the larvæ work their way up to the surface of the soil. It has been established by actual experiments that hoppers follow the path of least resistance. They move upwards, downwards or side ways, wherever the resistance is the least. In the case of the pod in the soil the frothy plug provides the necessary outlet, where the larva finds the path of least resistance.

Intermediate moult.

The contention that a dry atmosphere is necessary for the occurrence of the intermediate moult has not stood the test of experiment. The larvæ exposed to a fully saturated atmosphere shed the skin normally. Nor is light essential because the skin is shed in perfect darkness.

Colour variation in freshly hatched hoppers.

Soon after hatching the first stage hoppers assume the colour which they retain throughout the first stage. In this colour they show variations, and in the same batch there may be all the different types present. There are some hoppers which are green without any pigmentation; there are others which have light markings; and the third type consists of hoppers which are fully pigmented or black. In a general way the gregarious type of parent yields black progeny, the solitary type green progeny, and the intermediate type mixed progeny. But this is only generally true, because from the same female one may obtain a batch of eggs giving green hoppers and then a batch giving mixed hoppers and yet another batch giving pure black hatching.

Longevity of the life of adult.

The temperature of the atmosphere plays an important part in the duration of the life-cycle of the locust. At higher temperatures all the life processes are quickened and the life span is shortened. Thus for the brood which appears in spring the adults of which are present during summer, the longest life of an adult male in the laboratory was 79 days and that of a female 69 days. On the other hand the longest life of the adults that acquire wings in September–October, and over winter may extend till the following May. The maximum recorded in the laboratory was 236+10 days for the male and 230+10 days for the female. There is hardly any doubt

that in nature there are two broods, and that the broods overlap, *i.e.*, some of the adults of the previous brood are still alive when the hoppers and even adults of the next brood have made their appearance.

Influence of food on life-cycle.

It has been found that the quality of food has great influence on the duration of the life-cycle. Hoppers bred under identical conditions, but fed on cotton leaves and maize leaves showed great variation. While those fed on cotton reached the adult stage in 25 to 28 days, those fed on maize did not advance beyond the third instar within this period.

Food.

Over three hundred different plants were supplied to the Desert Locust and of these it refused to feed on about one dozen.

Outside the vegetable kingdom the locust feeds on its own dead or dying or even moulting comrades, on the flesh of animals and even on wool. Experiments have been performed to determine the reason why locusts eat such a substance as wool, which cannot provide any nourishment. It has been found that locusts eat wool for the sake of the moisture contained in it, and that they refuse to eat dry wool, though they greedily devour wet wool particularly when the atmosphere is dry. This shows the significance of moist baits.

The amount of food eaten varies with the temperature. At higher temperatures the locust eat more per day, but the total quantity consumed during each instar, and hence during the whole of life, is more at low temperature, within certain limits.

The coloration of hoppers.

The tremendous variation in coloration that occurs among hoppers bred under different conditions of association, temperature, &c., have been fully described and coloured plates prepared. It has been ascertained that high temperatures retard the development of pigment, and that hoppers bred at 40° C. are almost white. At low temperatures the colour is almost black, *i.e.*, pigmentation is intensified. In association, pigmentation is developed intensely and the hoppers born green turn black. Contrary to this in solitude the black hoppers turn green.

The green ground colour develops from the plant pigment. Hoppers bred entirely on rose petals or wheat bread did not develop green ground colour.

It has been possible to develop in hoppers bred in isolation the black pigmentation of the crowded condition by maintaining an excess of carbon dioxide in the atmosphere. Similarly an isolated hopper, given proper exercise, also develops pigmentation.

APPENDIX 16.

A BRIEF SUMMARY OF INVESTIGATIONS ON LOCUST PROBLEMS IN THE UNION OF SOUTH AFRICA.

By JACOBUS C. FAURE, *Director of Locust Research, Department of Agriculture, Union of South Africa.*

(a) Red Locust. *Nomadacris septemfasciata* (Serville).

LABORATORY and field observations carried out during 1933–34 by A. Lea, D. H. Botha, and the writer, have shown—

Egg-laying apparently takes place mainly at night, from about 1 A.M. to about 6 A.M. during summer nights, in which the temperature does not fall below about 18° C. The females oviposit together in groups. The males do not sit on the females during oviposition. The females do not cover the holes in which they have laid with earth. Copulation on a large scale indicates that egg-laying is about to take place.

One female lays from 2 to 5 packages of eggs. The minimum incubation period at 35° C. in moist sand was 21 days. Exposure to 0° C. and 10° C. for 5 to 8 days does not prevent hatching. Submergence under water for 5 days at 26° C. can be endured. Eggs can endure considerable dessication when kept in sand. Ordinarily, the incubation period is about 30 days, but after partial dessication some eggs were found to hatch about 3½ months after they had been laid, when kept moist at room temperature.

Attempts to produce a second generation in incubators:—

(1) At 35° C. constant and about 40–50 per cent. relative humidity, adults changed from chocolate brown to pale yellow in about 16–20 days and copulated after 29 days; no eggs were obtained.

(2) At 21° C.–36° C. and relative humidity of about 70–90 per cent. all the adults were dead after 45 days without assuming a pale coloration; no copulation observed.

Solitaria coloration of hoppers observed in the field showed great variety of colours and colour patterns. Painted-background experiments showed that *Nomadacris* does not imitate background colours as readily as *Locustana* or *Locusta;* several good resemblances to black, white and yellow were, however, obtained.

Wohlfahrtia cuvittata Vill. was bred from adults of *Nomadacris* from South West Africa. Two undetermined species of *Sarcophaga* and a species of *Blaesoxypha* (TACHINIDAE) were also obtained from the red locust, but the infestation by all these fly parasites was very light.

(b) Desert Locust. *Schistocerca gregaria* (Forskål).

Incipient swarms of hoppers of this species were destroyed in Warmbad, South West Africa.

(c) Tropical Migratory Locust. *Locusta migratoria migratorioides* (Reiche & Fairmaire).

Small swarms of hoppers definitely reported in the Union for the first time.

(d) Brown Locust. *Locustana pardalina* (Walker).

The events of 1933–34 are summarised in the Pretoria report. Observations by S. J. S. Marais have shown:—

The species occurs during minimum abundance mainly on Karroo type veld, but also in smaller numbers in pure grassveld bordering on the Karroo areas. Within the boundaries of the natural home (the Karroo areas), certain areas can now be recognised as outbreak areas; some of these are capable of producing swarms at short intervals, others only after longer intervals. Rainfall is a very important factor in determining the status of reservations.

Within the outbreak areas, certain localities do not serve as places for increase and congregation of *solitaria* to form swarms; poorly drained depressions or vleis, heavy clay soils and hill-tops fall into this group.

Suitable swarm-building spots have shallow, well-drained soil, many open spaces, and short vegetation consisting of *Pentzia* and other scrub bushes and certain grasses which are usually only a few inches in height.

The species increased with amazing rapidity in 1933–34; the exceptionally heavy and widespread rains probably enabled it to breed with great efficiency in all classes of outbreak area. In such a season almost all the known outbreak areas in the Karroo and of South West Africa must be expected to produce swarms owing to the rainfall, which in 1933–34 reached 21 inches and more. In ordinary seasons, with about 12 inches, or less, only some of the outbreak areas which offer the most favourable conditions will produce swarms.

Feeding experiments were carried out in outdoor cages in the Karroo; hoppers were reared on exclusive diets, consisting in each case of one species of grass growing in the cages. Five common grasses from the outbreak areas all proved suitable as food, but three of these species gave somewhat better results than the other two. It is intended to continue this work and to study the effect of each grass on the reproductive powers and to note whether several generations can be bred on these exclusive diets.

APPENDIX 17.

THE OCCURRENCE OF THE TROPICAL MIGRATORY LOCUST, *LOCUSTA MIGRATORIA MIGRATORIOIDES* (Reiche and Fairmaire), IN THE UNION OF SOUTH AFRICA IN 1933–34 AND IN SOUTH WEST AFRICA IN 1931–34.

By JACOBUS C. FAURE, *Director of Locust Research, Department of Agriculture, Union of South Africa.*

THE Tropical Migratory Locust, *Locusta migratoria migratorioides* (Reiche and Fairmaire) has been known in the Union of South Africa for many years in its solitary phase. The first invasion by flying swarms of which definite records exist is that of April 1932, when several dozen large swarms entered the Union, crossing the Orange River from South West Africa. The swarms turned eastwards and proceeded as far as Queenstown in the eastern Cape Province. Probably owing to unfavourable weather conditions, they disintegrated, and no swarms of hoppers are known to have resulted from this invasion.

This invasion of April 1932 is of great interest. There are sound reasons for believing that the locusts invading the Union actually travelled all the way from Kenya and Tanganyika, south-westwards through Northern Rhodesia, then southwards through South West Africa, and eastwards again through the Karroo. The swarms travelled at great speed and often at a great height; it is recorded that some of them travelled as far as 150 miles in one day. Such a flight into regions quite unsuitable for breeding, and even into the ocean, can only be described as migration gone mad.

This headlong flight occurred during the ninth generation developed since the beginning of the series of outbreaks of 1928–32, and it resulted in a decided decrease in the intensity of the outbreaks in east Africa. No doubt many similar "mad migrations" have occurred in the past, since swarms have often been encountered far out at sea. It seems probable that the extreme mutual stimulation to activity obtaining in dense swarms, repeated through successive generations, finally results in such an irresistible urge to migrate, that the insects do violence to their normal reactions to the factors which determine the direction and duration of their more usual migrations. Possibly such excessively long migrations may produce physical exhaustion resulting in inability to reach sexual maturity.

It is clear that this type of migration can be an important factor in bringing a huge invasion to an end, the locusts simply flying out of the territories suitable for them to breed in. The writer has suggested in a former paper (Faure, 1932)* that the high rate of

* Faure, J. C., 1932—The Phases of Locusts in South Africa. Bull. ent. Res., 23: 365.

metabolism obtaining in locusts living in dense swarms may resemble the condition known as fever in a vertebrate. The " mad migration " under discussion lends further support to the idea that the extreme phase *gregaria* is an expression of a semi-pathological condition and that the phase *solitaria* is to be regarded as the more normal state of existence of the species.

The Union of South Africa, 1933–34.

In December 1933 one adult of the phase *gregaria* of *Locusta* was found by the writer near Pretoria in a swarm of Red Locusts. Further north in the Transvaal the presence of fair numbers of fliers of *Locusta* in the swarms of *Nomadacris* was reported.

Early in January 1934 reports appeared in the newspapers to the effect that the eggs of the Red Locust were hatching 14 days after they had been laid, instead of after 30 days as the official reports had led people to believe would be the case. Investigation showed that these reports were due to the presence of several small swarms of hoppers of the Tropical Migratory Locust in the northern Transvaal. Only three or four farms are definitely known to have been infested, about 40 to 50 miles due north of Pietersburg, both in the Pietersburg and Zoutpansberg districts.

The swarms seen by the writer on the 4th January, 1934, only covered an area of about 10 by 10 yards when resting in the heat of midday; they consisted of hoppers in the second instar, all uniformly of the *gregaria* type of coloration. It is probable that small swarms may have occurred in other localities without being reported.

During the campaign against the hoppers of *Nomadacris*, January–March 1934, several reports were received, with specimens, of hoppers of the phases *solitaria* and *transiens* occurring in the swarms of *Nomadacris* in the north-eastern lowveld of the Transvaal.

During April and May 1934, the writer found the phase *solitaria* of *L.m. migratorioides* in many different localities in the districts of Vryburg, Kuruman, Hay, Kimberley and Hope Town, and also in the north of Gordonia district in the Kuruman and Molopo river-beds. Locusta was found mainly in vleis and in cultivated lands, but in some places also on the veld.

It is difficult, in the absence of continuous field observations made in the same areas, to decide whether the specimens of *Locusta* found were the progeny of insects that had bred in those localities for many generations, or whether they were the descendants of the fliers which came in with those of *Nomadacris* in 1933–34. The latter hypothesis is most probably correct, since *Locusta* was found in almost every case on farms on which *Nomadacris* also occurred.

South West Africa, 1931–34.

In November 1931, flying swarms invaded the districts in the extreme north of South West Africa; eggs were laid by them and

between December 1931 and February 1932 swarms of hoppers were reported at Tsumeb, Outjo and Otair. The invasion by flying swarms which occurred in April 1932 has been referred to above. Egg-laying was reported from several localities in May and June 1932, but no hoppers are known to have hatched from these eggs.

In May 1934 the writer and Mr. D. H. Botha found *L.m. migratorioides* phase *solitaria* on a number of farms in the Keetmanshoop and Aroab districts, usually in vleis or pans, and in every case in association with *Nomadacris*. On a number of farms the brown, red, tropical migratory and desert locusts were taken in close proximity to one another. A few hoppers of *Locusta* of the phase *transiens*, with a sprinkling of phase *gregaria*, were found in a pan with a tall, dense growth of grass near the farm Kukanebib Oos. *Nomadacris* adults were also present, and it seemed probable that the *Locusta* hoppers had developed the *transiens* and *gregaria* types of coloration because they grew up in a swarm of *Nomadacris* hoppers.

APPENDIX 18.

THE SWARMING OF *SCHISTOCERCA GREGARIA* (Förskål) IN THE UNION OF SOUTH AFRICA AND IN SOUTH WEST AFRICA IN 1934.

By Jacobus C. Faure, *Director of Locust Research, Department of Agriculture, Union of South Africa.*

In discussing the distribution of the Desert Locust, Uvarov (1932) stated in 1928 "there are numerous records of both the solitary and swarming phases from the Cape Province and South West Africa," but no swarms of this species have apparently been definitely reported in the Union or South West Africa in the last thirty to forty years, since economic entomologists have been working in South Africa.

The solitary phase was collected by the writer in various localities in the north-western Cape Province between 1917 and 1929. Breeding experiments carried out on a small scale in 1929–31 showed (Faure, 1932) that hoppers bred from solitary phase parents developed the *gregaria* type of coloration when reared under conditions of crowding.

In 1931 Dr. T. J. Naudé and Mr. S. J. S. Marais found this locust present in considerable numbers in the Karibib district of South West Africa, but not in sufficient numbers to warrant reporting the presence of incipient or loose swarms.

Early in May 1934 the District Locust Officer for Gordonia showed the writer some specimens of *S. gregaria* taken in the dry course

of the Molopo river about 100 miles north-west of Upington from an incipient swarm on the farm Witkop. On visiting this area on the 6th–8th May, the writer found considerable numbers of adults on the farm Vrouenpan in the Molopo-bed, from 200 to 2,600 per man-hour being counted* in some localities.

The adults were only about a week old, and a few hoppers were still present, therefore I assumed that the adults were found on or very close to the locality in which they had lived as hoppers. They were found among the dunes of greyish-white sand that are characteristic of the dry courses of the Molopo and Kuruman rivers near their confluence. To the uninitiated it is difficult to make out when one is in the river bed and when one is out of it, but those familiar with the country know that the white dunes are characteristic of the course of the river.

In May 1934 the dunes on Vrouenpan were covered with a rather dense growth of grass, about 12″ to 18″ high, in which sweet grass, *Eragrostis porosa* Nees, predominated, followed by sour grass *Schmidtia kalahariensis* Stent and Bushman grass *Aristida obtusa* Del. The grass-cover was so luxuriant that it largely obscured the scrub bushes such as *Monechma genistifolium* C.B. Cl. that occurred in scattered formation, and of which a great many were dead. Succulent low growing plants (*Tribulus* sp. and *Zygophyllum* sp.) were also present as well as Tsama melons, *Citrullus vulgaris* Schrad, the last-mentioned plant mainly on the dunes.

In the surrounding red-sand dunes of the Kalahari desert the predominant grass was sour grass (*Schmidtia kalahariensis* Stent), and there were very few of the low-growing succulents such as *Zygophyllum*, although melons were common on the dunes. On the red sand *Schistocerca* was also present, but in much smaller numbers, only about 5 to 20 per man-hour.

The few hoppers found were yellow and greenish in colour, with black markings. They were not as black as the hopper illustrated on plate xix, fig. 55, of the writer's paper on the phases, but resembled figure 56, except that there was less black on the head.

The adults were very similar to those bred in cages in 1929–31 under conditions of crowding, being largely bluish-grey in colour, with some pink and yellowish markings. There was no evidence of the reddish colour seen in young adults of the phase *gregaria* in north and east Africa. The biometrical ratios of these adults have not been studied, but one's general impression from superficial examination is that they will be found to represent a slight variation from extreme *solitaria* towards *gregaria*.

About 40 miles north-west of Vrouenpan another incipient swarm was found on the farm Witkop, also among the white-sand dunes of the dry course of the Molopo. Here the dunes are further apart,

* The number of locusts per man-hour refers to the number that can be counted in one hour by one man walking at about three miles per hour.

and somewhat lower than on Vrouenpan, and the grass was not as dense. On a typical dune patch Bushman grass (*Aristida* spp.) predominated, with many driedoring bushes (*Rhigozum trichotomum* Burch.) and scattered vaalbos (*Lebeckia linearifolia* E. Mey) about 5 to 6 feet in height. In addition, there were various low, creeping succulent plants, such as *Tribulus* and *Zygophyllum*.

The population of *Schistocerca* was similar in density to that found on Vrouenpan, from 700 to 2,000 adults being noted per man-hour in an area about one mile wide by one mile long. The locusts were not evenly distributed over this area, but were much denser in some patches than in others. To the south a very hard, stony type of soil adjoined the sand, but on this only 10 to 20 *Schistocerca* could be found per man-hour.

A vlei adjoining the sand dunes, and densely covered with driedorings (*Lycium* sp.) and grass such as *Setaria verticillata* Beaur. and *Chloris virgata* Sw. also showed a fair population of *Schistocerca* adults, but not nearly as many as the sand dunes. Fair numbers of hoppers were present on the dunes, but none were found in the vlei.

The vlei harboured a scattered population of grey and green hoppers of *Locusta migratoria migratorioides* (Reiche and Fairmaire), as well as a few adults.

The hoppers and adults of *Schistocerca* taken at Witkop were very similar to those found at Vrouenpan.

Warmbad, South West Africa.

In the Warmbad district of South West Africa approximately 100 incipient swarms of *Schistocerca* were destroyed during April and May 1934. According to the District Locust Officer, the infested area was mainly in the western part of the Bondels Reserve, and extended about 20 miles from east to west and about 40 miles from north to south, reaching practically to the Fish river in the west.

This area is apparently located in a transition zone between the winter rainfall area on the coast and the summer rainfall area further east. The soil is largely sandy with some gravelly sand. Bushman grass (*Aristida* spp.) predominates, with klaver (*Indigofera alternans* D.C.) and dubbeltjie thorn (Tribulus) in addition to other plants such as *Limeum* sp., *Trianthema parvifolia* E. Mey., *Sesamum capense* Burm., and *Polygala armata* Chod. There are a few scattered bushy trees about 8 to 10 feet in height known as luni trees, *Boscia foetida* Schinz.

On the 10th May, 1934, the writer saw an incipient swarm on the Bondels Reserve. About 80 per cent. of the insects had reached the adult stage about a week previously, but many were still undergoing the last moult, and a sprinkling of hoppers was present, mainly in the 5th, but also in the 4th instar. The swarm covered about 300 by 50 yards, but was by no means a dense swarm. About 10 to 20 adults camped together for the night in a bush 18″ tall

and 6″ in diameter, but on some of the luni trees they roosted together in large numbers.

The hoppers found on the Bondels Reserve were green, yellow or slate blue with black markings. They showed more black than those taken in the bed of the Molopo, but were not as black as figures 55 and 56 (Faure, 1932). One hopper was almost as green as figure 53, but it had some black markings on the hind femora and the abdomen.

The adults were more decidedly bluish in colour with distinct pink and yellowish markings.

Wohlfahrtia parasites.

The swarm on the Bondels Reserve was very severely infested by the larvae of *Wohlfahrtia euvittata* Vill. About 50 per cent. of the young adults were lying dead or dying as a result of the attack of this parasite.

The *Wohlfahrtia* adults were present in considerable numbers, and were noted as being strongly attracted by human faeces, although no case of deposition of larvae on faeces was observed.

One *Wohlfahrtia* female was observed in the act of depositing a larva on the side of the abdomen of an adult *Schistocerca* that was so weak from parasitism that it could barely walk. The larva penetrated the body wall of the locust through one of the intersegmentalia of the abdomen, within one minute after it had been deposited. On dissection the locust was found to contain three nearly full-grown larvae, and about five small dipterous larvae.

According to various locust officers, the *Wohlfahrtia* female deposits its larvae mainly on freshly moulted adults, when they are still moist immediately after emerging from the exuviae. Judging by the large number of young adults found to be parasitized this view seems quite acceptable. The sick and dying adult locusts were very attractive to the adult *Wohlfahrtia*; this fact, together with their occurrence on faeces, shows that these flies are evidently strongly attracted by odours emanating from decaying matter. It is probable that a locust in the act of moulting would emit a stronger odour than one not moulting.

There were large numbers of healthy adult *Schistocerca* within 50 yards of sick and dying locusts, but the flies did not appear to be attracted by the healthy locusts at all.

Small swarms of *Schistocerca* were reported in April 1934 by Mr. J. F. Rorich from about 20 miles north of Keetmanshoop, and near Koes to the north of Aroab. Swarms were also reported from the districts of Kenhardt and Namaqualand, and a small swarm of fliers appeared in the town of Worcester in the western province of the Cape in May 1934.

Scattered solitary adults of *Schistocerca* were very common in the districts of Aus, Bethanie, Keetmanshoop, Warmbad and Aroab in South West Africa in May 1934, and they probably occurred in

other districts further north as well. In parts of Aroab and Keetmanshoop the population varied from 40 to 200 and even 1,200 per man-hour on different types of veld, but the largest numbers were found among sand dunes or on sandy soil.

Travelling east from Aroab we found *Schistocerca* very common in and near the course of the Molopo, which we crossed at Inkbospan, and on this farm a swarm of hoppers was seen by the owner early in May. Beyond Witdraai in the Kuruman river no specimens of *Schistocerca* were found on the trip eastwards to Kuruman.

Adults of the solitary type were very common early in May between Putzonderwater and Upington, east of the railway line, as many as 100 per man-hour being seen in some places. They were also found between Upington and Zwartmodder and further north towards Vrouenpan.

One specimen was taken in a maize field about seven miles west of Hope Town. It is of interest to note that all four South African species of migratory locusts were present in this field on the 2nd May, 1934. The Tropical Migratory and Desert Locusts were represented by phase *solitaria*, the brown by phase *transiens*, and the red locust by phases *gregaria* and *solitaria*.

In June 1934, Mr. S. J. S. Marais reported that he had found isolated adults of *S. gregaria* amongst the swarms of *L. pardalina* in the region of Middelburg, C.P. It is probable that these adults migrated eastwards with the Brown Locust fliers, possibly from districts like Calvinia or Victoria West. In July adults of the solitary phase of the Desert Locust were sent in for identification from Piquetberg in the western Cape.

The number of generations.

In view of the fact that the eggs of *Schistocerca* cannot, as far as we know, survive long periods of drought, it is surprising to find this species increasing so rapidly in a few months after good rains. Warmbad, South West Africa has an annual rainfall of only 3 to 4 inches. From 1925 to the end of 1933 there was a very severe drought; showers fell on strips of the country here and there, but there was not sufficient growth of vegetation to feed the sheep and goats. The first good rains fell between the 15th and 20th December, 1933, and after that there were frequent showers, at fortnightly intervals, until about March 1934.

Allowing about 60 days from egg to adult, and assuming that eggs were laid by the over-wintering adults at the end of December 1933, the adults of the first generation could have appeared about the 1st March. If sexual maturity were attained by the 15th March, and eggs laid on that date, the second generation could have reached the flying stage by the 15th May. When the writer visited the Bondels Reserve on the 10th May, 1934, about 80 per cent. of the swarm had just reached the winged stage. It is therefore probable that the adults present on the 10th May represented those

of the second summer generation, and if this is correct, it is easier to account for the great increase in numbers after a period of severe drought.

In the Warmbad district winter showers are expected in normal seasons, so that certain types of vegetation remain green throughout the winter, and this no doubt facilitates hibernation of the adults maturing towards the end of the summer.

According to the District Locust Officer of Warmbad the hoppers of the desert locust prefer various succulent plants to grasses, and they are strongly cannibalistic.

The rainfall of the summer 1933–34 was quite exceptional. So much water came down the courses of the Auob and Nossob rivers, from South West Africa, that a great lake said to be 20 or 30 miles wide was formed in the Molopo some 30 miles below its junction with the Kuruman River. No such accumulation of water has been known in the Molopo in living memory.

The status of *Schistocerca gregaria* as a pest in South Africa remains uncertain. If the season of 1934–35 should prove favourable for its increase, there seems to be no reason why large migrating swarms should not be formed, unless *Wohlfahrtia* should prove to be capable of keeping it under control.

I am indebted to the National Herbarium for the identification of the plants mentioned in this paper.

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APPENDIX 19.

DÉCLARATIONS ET VŒUX SOUMIS PAR LA DÉLÉGATION BELGE.

LE Gouvernement du Congo belge, se conformant aux propositions et résolutions adoptées aux conférences antiacridiennes tenues à Rome et à Paris, a organisé dans toute la Colonie, selon les moyens dont il disposait, un service de renseignements possédant actuellement au Laboratoire de Bambesa (Province Orientale) un bureau centralisateur des observations élémentaires. L'entomologiste du Gouvernement, M. Bredo, est chargé, non seulement de réunir tous les documents congolais concernant la question acridienne, mais de donner des directives générales aux autorités administratives des différents districts grégarigènes ou susceptibles de le devenir.

Au Congo belge, le problème acridien conserve toute son acuité dans les régions d'élevage où l'apparition d'essaims ou de bandes

d'acridiens diminue considérablement les disponibilités en herbages nécessaires à la bonne tenue du bétail.(1)

Les Territoires sous mandat Ruanda-Urundi et le sud de Katanga, reconnus dangereux, sont particulièrement surveillés et deux entomologistes, respectivement MM. Lejeune et Seydel, sont attachés en permanence aux services agricoles de ces provinces.

Dans les chefferies où des foyers grégarigènes—endroits de ponte —sont repérés, des moniteurs indigènes, chargés de leur surveillance, avertissent les autorités administratives dès l'apparition de bandes d'acridiens.

Pour prévenir les cas de disettes locales résultant des invasions acridiennes, le service de l'agriculture s'occupe activement de propager, chez l'indigène, la culture des plantes alimentaires et économiques généralement délaissées par les criquets. D'excellents résultats ont été obtenus en ce sens.

Les échecs subis dans l'étude des maladies bactériennes et fongiques des acridiens ne doivent pas rebuter les chercheurs; le champ d'investigations est vaste et à peine exploré.(2)

En plus des notes de vulgarisation publiées précédemment par MM. Schouteden, Pynaert, Vrijdragh et Bredo, un mémoire, émanant de l'Entomologiste du Gouvernement, M. Seydel, sur *Nomadacris septemfasciata* (Serville) est paru dans le Bulletin Agricole du Congo belge du 2ème semestre 1934.

Le délégué belge, tout en se ralliant au nom de son Gouvernement aux différents vœux admis au cours de ces séances, émet le vœu suivant(3) :—

> considérant que l'étude biologique des acridiens migrateurs locaux d'importance secondaire pourrait fournir de précieux renseignements et contribuer à augmenter nos moyens d'action sur les grands migrateurs, souhaite que, parallèlement aux divers programmes arrêtés à cette Conférence, des recherches soient entreprises sur les migrateurs secondaires tels *Tylotropidius* sp., *Acrotylus* sp., &c.

(1) Les populations pastorales du Ruanda-Urundi déclarent même que les épidémies de peste bovine suivent toujours les grandes invasions acridiennes. Le fait s'est réalisé ces dernières années.

(2) Nous avons déjà signalé la découverte d'un nouveau bacille spécifique de *Nomadacris* par le Dr. Bouvier (Lab., Lufuta-Kasai).

(3) Au Lomami (Nord du Katanga) sur un front de 5 km. environ, un vol local très dense d'acridiens migrateurs secondaires composé principalement de *Tylotropidius* sp., accompagnés d'*Acrotylus* (*patruelis* Sturm.,?) *Berengueria* (*obliquifrons* Bol.?) et *Heteropternis* sp., a été observé dans les savanes situées entre Kabinda et Pania-Matumbo, direction Est-Ouest 10 heures A.M. 1°. élevée, vent faible Est-Ouest (obs. J. Ghesquière 20 août 1924—détermination, B. Uvarov).

A noter aussi un vol migrateur peu dense de sauterelles *Homorocoryphus assimilis* Karny (CONOCEPHALIDAE) (the long-horned locust) observé à Luluabourg (Kasai, sud du Congo-Belge) sur un front de 500 m. environ, direction Est-Ouest, 8 heures A.M. T. 20° C. vent très faible Est-Ouest (obs. J. Ghesquière, 26 avril, 1928).

APPENDIX 20.

LOCUSTS IN SOUTHERN RHODESIA.

By RUPERT W. JACK, *Chief Government Entomologist, Southern Rhodesia.*

(Communicated to the Conference by the United Kingdom delegation.)

General.

SOUTHERN Rhodesia is not known to contain any outbreak areas from which swarm cycles of any species of locust originate. It has, however, definitely afforded a temporary breeding ground for three species of swarm locusts from time to time, viz. :—(1) The Red Locust, *Nomadacris septemfasciata* (Serville), (2) The Tropical Migratory Locust, *Locusta migratoria* (Linn.) phase *migratorioides* (Reiche and Fairmaire), and (3) The Brown Locust, *Locusta pardalina* (Walker).

The first and last named species have so far proved to be the most important as far as Southern Rhodesia is concerned.

The following short account of locust invasions of the colony since the Entomological Branch was constituted in the year 1909 may be of interest. Records previous to that date are scanty, except in so far as they are recorded in the reports of the South African Central Locust Bureau, 1907–1910.

By 1909 a great swarm cycle of locusts, including the Brown and the Red Locusts, and probably also at one time the Tropical Migratory Locusts, was near its end, only a few small swarms remaining in the colony. The last swarms of this cycle were recorded in 1910.

1. The Red Locust, *Nomadacris septemfasciata* (Serville).

The swarm cycle of the Red Locust which terminated in 1910 apparently commenced about 1892, but reliable records concerning the prevalence of this species year by year in the colony during the intervening period are apparently lacking. Whilst the Red Locust seems to have been particularly prevalent in Natal in 1906 and 1907, it is not clear that it was particularly abundant in Southern Rhodesia at that time, although swarms were certainly present. In 1907, at any rate, the Brown Locust seems to have overshadowed the Red Locust in the colony, but the differentiation of the species in reports may have left something to be desired.

As is well known, the Red Locust did not again experience a swarm cycle until the commencement of the present outbreak. During this outbreak the Red Locust is not known to have bred anywhere in Southern Rhodesia until the 1932–33 season. The great invasion took place from the north in December 1932,

commencing during the last few days of November. Great swarms swept over the Zambesi, flying fast in a southerly to south-easterly direction, until they reached the Limpopo valley, which was little penetrated and apparently not crossed. The swarms then commenced to circle and laid eggs over most of the colony in December and January, about six districts out of the thirty-two being omitted. The hoppers commenced to hatch from the middle of January and to mature in March, most, however, obtaining wings during April.

The direction of flight of the newly matured swarms was, in general, westerly, possibly owing to the direction of the prevailing wind. Swarms came into the colony from Portuguese East Africa, and others left the colony, passing into Bechuanaland. It is not clear, however, that this movement was due to a definite migratory impulse, and the impression gained was that the swarms were more or less drifting with the wind.

Flying swarms continued to be prevalent in the colony throughout the dry season of 1933, the direction of flight being more or less irregular but with a tendency to a westerly drift. Swarms inclined to haunt the eastern border throughout the dry season flying backwards and forwards to and from Portuguese East Africa. The swarms generally favoured the high veld and hilly country.

During the first three weeks in November 1933 a definite pre-breeding migration commenced, this flight taking a southerly direction as in the case of the first invasion. Swarms already in the colony flew south towards or over the Limpopo river, and great swarms, in some cases associated with a comparatively small proportion of the Tropicaf Migratory Locust, again swept down from the north.

Breeding in the 1933–34 season occurred several weeks earlier than in the previous year. Egg-laying commenced in November, hatching in December, and the great majority of hoppers matured during March. Egg-laying was very prolonged, extending from November to February.

The direction of flight in April 1934 again showed a westerly tendency as in the previous year. There was also a definite indication of the flying swarms deserting the low veld for higher altitudes, although for breeding purposes the low veld seems to be greatly favoured.

The direction of flight became more irregular in May and has continued irregular to August.

Swarms have been prevalent in the colony during the present dry season, but in the cooler months have not moved about much nor attracted a great deal of attention. The winter has been uncommonly mild and has in fact created a record in this respect. June was unusually humid. Enormous swarms were reported in the Inyanga district during the second week in August flying north-east. Elsewhere the swarms reported have been described as from "small" to "large."

Reverting to the question of a westerly or north-westerly migra-

tion of flying swarms shortly after obtaining wings, it would seem that there is certainly a suggestion of such a movement in the colony, but that it is not very definite nor long continued. It is not sufficiently marked seriously to deplete the number of swarms in the colony; nor apparently does Northern Rhodesia suffer heavy invasion from Southern Rhodesia, at this time. Swarms kept under aeroplane observation in May and June 1934 definitely changed direction with the wind.

2. The Tropical Migratory Locust, *Locusta migratoria migratorioides* (Reiche and Fairmaire).

Mr. E. R. Sauer, Assistant to Secretary for Agriculture, Salisbury, mentioned the presence of a third species of locust in the northern districts of Southern Rhodesia in a pamphlet entitled "Locust Destruction" (Cape Town, 1906). This species may have been and presumably was the Tropical Migratory Locust. The first definite record of this species in swarm formation south of the Zambesi river seems, however, to have been obtained in September 1932, when swarms of this species circled over several of the more eastern districts of Southern Rhodesia, returning to Portuguese East Africa without laying eggs or doing any damage. A swarm cycle of this species had been in evidence in central Africa and elsewhere for several years, and had even resulted in an abortive invasion of the Union of South Africa in May 1932, before the Tropical Migratory Locust again appeared in Southern Rhodesia. This occurred in September 1932 when a number of swarms entered the colony from the north-east, and flew completely across into Bechuanaland. These swarms were not in egg-laying condition and did no serious damage. By the end of October 1932 the colony was again apparently free from locusts.

In late November and December 1932 swarms again appeared from the north-east and laid eggs in several of the north-eastern districts, and also in one district at least (Gwelo) in the centre of the colony. The first hoppers were reported in the Zambesi valley on the 15th December, and fliers were reported in February.

There appears to have been no second brood of this species in Southern Rhodesia in 1933, although adults collected in the field commenced copulating in cages during the first half of April. No flying swarms were recorded in the field after the 4th April.

Nothing more was heard of this species in the colony until November 1933, when invading swarms of the Red Locust from the north were found to have this species in association.

The Tropical Migratory Locust was, of course, separated out from the Red Locust swarms by the shorter periods occupied in incubation of the eggs and maturing of the hoppers. A few winged swarms of no great magnitude were reported at the beginning of February 1934, but again nothing further was heard of this species until April, when invading swarms of Red Locusts from Portuguese East Africa

were found to contain an admixture of the Tropical Migratory Locust.

Eggs were definitely reported to have been laid in the Victoria district during April, but it is not known if the deposit hatched. Development of hoppers during May and June in this district appears unlikely, owing to the falling temperature and humidity and the drying up of the grass.

It would appear that the Tropical Migratory Locust under normal conditions can rear only one brood in Southern Rhodesia, and that the second brood must be reared elsewhere. Adults which have matured in the colony have laid eggs of the second brood in cages during May at Salisbury (1933), and it would, therefore, appear that the climate does not prevent sexual development at this time of the year.

On the whole this species appears to be comparatively ill adapted to the Southern Rhodesian climate, although capable of rearing successfully one generation during the wet season.

3. The **Brown Locust,** *Locusta pardalina* (Walker).

Southern Rhodesia appears to constitute something approaching the extreme limit of spread of the Brown Locust and has apparently only been invaded after a swarm cycle in the Union of South Africa, South West Africa, and Bechuanaland has been in progress for some years.

Previous to 1909, there was danger of some confusion with the Red Locust or Tropical Migratory Locust, but it seems certain that the Brown Locust invaded the colony on a large scale in 1906 and 1907. In 1908 and 1909 the occurrence of all species was negligible and the few reports of hoppers received may not be reliable.

Whilst early in 1924 breeding of this species slightly overlapped our western border, it was not until the dry season of that year that the next serious invasion occurred. From late April onwards swarms poured in from Bechuanaland and, holding a general easterly direction quickly overran the greater part of the colony. Egg-laying apparently commenced in June and extended well into October. The eggs hatched shortly before the first heavy showers, in one district as early as the 24th September. Hatching mostly occurred during October.

The hoppers which escaped the ensuing campaign became fully matured in December, and near Christmas day large swarms were observed flying in a westerly direction into Bechuanaland. Within two or three weeks, the whole colony was apparently free from locusts.

This westerly migration of the newly matured swarms was forecasted by some of the older natives and is in fact reported to have occurred in the colony in 1906–7 and 1907–8 (reports of South African Locust Bureau). It seems therefore that this is the normal sequence of events.

It seems noteworthy that the invading swarms avoided the humid elevated districts of the eastern border and that no egg-laying took place in these parts. During the period of the prebreeding invasion the remainder of the colony is dry, and it appears that zones with a relatively high humidity are avoided at this season. When the adults obtain wings in December and January they find themselves in a generally humid environment and promptly fly west, where conditions are usually drier.

Unfortunately for the locusts, Northern Bechuanaland in 1924–25 experienced an unusually high rainfall. Disease, particularly *Empusa grylli* (Fresenius), seems to have wrought havoc amongst them during the second generation and the last that was heard of the Brown Locust, as affecting the Southern Rhodesian borders, was that at the end of 1924–25 wet season, small swarms were flying southwards in Bechuanaland towards the dry zone of the Kalahari and the Karroo.

Since that time until the present day there has been no further threat to Southern Rhodesia from the Brown Locust, due apparently to the success attending the efforts of the Union Government to keep this species controlled in its reservations in the Union. Reports at present suggest, however, that further trouble may be experienced, due to weather conditions having apparently favoured swarm development in South West Africa and the Kalahari.

REMARKS.

It would appear that, of the three species of swarm locusts recorded in Southern Rhodesia, the Red Locust is more nearly at home than the other two species. Both the Tropical Migratory Locust and the Brown Locust apparently leave the colony after one generation has been passed through at a time of year when conditions are favourable. The Red Locust, however, remains continuously from one breeding season to another, although the actual position seems to be that the swarms tend to migrate southward immediately before breeding, and that other swarms from the north take their place at this time.

It is not improbable that solitary specimens of the Red Locust are continually present in the colony, although this remains to be proved. Some solitary specimens were collected in the Umtali district in 1915, five (5) years after the last swarms had disappeared (in 1910). There is as yet no suggestion, however, that any true outbreak areas of this species exist in the colony.

CONTROL MEASURES EMPLOYED AGAINST THE RED LOCUST.

Operations have to date been directed almost exclusively against the hopper stage, although some destruction of eggs in cultivated lands has been carried out by private individuals and winged swarms

have been destroyed to some extent before they have attained full vigour.

Spraying with arsenite of soda in solution has been relied upon almost exclusively. **Dusting**, without suitable distributing apparatus, has proved unsatisfactory and in fact dangerous to the operators, not to speak of livestock. With the development of more reliable dusting machinery of a suitable type dusting is likely to be more extensively practised in the future.

Baiting has proved unreliable up to the present, the attractiveness of bait being apparently greatly influenced by the humidity of the surroundings. Lack of a cheap carrier at some central point is also a great difficulty in regard to extensive manufacture of bait. Ground maize cores have proved as satisfactory as anything, but the supply is distributed over the farms and not concentrated anywhere.

Some experiments have been carried out with **galvanised iron barriers** with rather indeterminate results. This method may prove useful under certain conditions, but the barriers will apparently need skilful handling for the purpose of actually destroying hopper bands. **Ditches** have been used to protect crops.

Soap solution has been employed to some extent to destroy very young hoppers hatching out in the midst of crops.

Beating has also been employed in many instances when the bands have been sufficiently small. **Firing the grass** has also been possible on a few occasions.

RESULTS OF TWO SEASONS' CAMPAIGNS.

No claim is made that anything approaching complete extermination of hoppers throughout the colony was effected either in the 1932–33 or the 1933–34 season.

Destruction of hoppers was, however, achieved on a vast scale during both seasons and the main crops of the colony were successfully protected in spite of the severity of the invasion.

Southern Rhodesia has legislation in force similar to that of the Union of South Africa, making it obligatory on the part of the occupiers of land to destroy hoppers on their holdings. The response in the agricultural districts has left little to be desired, but the ranchers naturally have not exhibited the same enthusiasm. The danger to livestock from the use of this virulent poison, even if reasonable care is exercised, is a very great hindrance to securing whole-hearted co-operation on the part of farmers and the public generally.

Whilst an attempt has been made to collect a record of the number of hopper bands destroyed it is judged that this basis of reckoning is too unreliable to be of any real value as an indication of the destruction brought about. In the 1932–33 campaign poison was used to a total, which, if properly diluted would amount to 4,500,000 gallons. In the 1933–34 campaign the amount of poison used should

have made over 9,000,000 gallons of spray. In the 1932–33 campaign bucket spray pumps were used to a total of 4,000. Last season the total was raised to approximately 7,000.

The primary object of the campaign has been to protect the crops, but in actual practice the hoppers have been destroyed wherever it has been possible to attack them.

During the last campaign the district controllers of locust operations were instructed to attempt to clean up all occupied areas and as far back (say 10 miles) from such occupation as possible. The newly matured adults of the Red Locusts do not seem to move very far for about two weeks after obtaining wings, but they feed voraciously. In these circumstances if swarms are not allowed to mature in the neighbourhood of crops the latter have a further period for maturing before the menace from winged swarms develops.

In a few of the more populous districts the hopper bands were approximately exterminated, but this, of course, could not be achieved in the more undeveloped areas.

The result of the policy adopted is that in neither season were the summer crops as a whole appreciably affected by the heavy locust invasion, although individual farmers suffered to a greater or lesser extent.

The amount of protection afforded to native crops has depended very largely on the attitude of the natives themselves and the accessibility of the locality concerned. The 1932–33 was a drought year in many parts of the colony and the crops were doomed to failure in any case. Some districts, however, were favoured with exceptionally good weather and here the crops were successfully protected by the continued efforts of the officials and the natives.

In the 1933–34 season three districts suffered heavy loss of native crops, owing to an overwhelming outbreak of hoppers and later visitations by winged swarms. In general, however, the native crops were more or less successfully protected.

THE RED LOCUST'S CAPACITY FOR DAMAGE IN SOUTHERN RHODESIA.

During the actual pre-breeding migration, swarms of the Red Locust seem to fly fast and high, and to do little feeding, but as soon as they commence to circle and to lay eggs they feed freely and their capacity for damage is great.

In 1932, the invading swarms appeared in December, whilst the maize and the summer crops were very young. Some crops were destroyed by these swarms, but in most cases sufficiently early to admit of replanting.

The growing period of summer crops in Southern Rhodesia has corresponded in the main with the egg and hopper stages of the Red Locust, although the correspondence is unfortunately very far from complete. It was more nearly complete during the 1932–33

than in the 1933–34 season. In the former season eggs were laid mostly in December and the locusts obtained wings in late March and April. In the latter season eggs were laid nearly a month earlier and the resulting adults matured in February and March, considerably before the maize crop was safe. The egg-laying period was also more prolonged in the 1933–34 season, extending over three months from November until February, whereas in the 1932–33 season it covered only about six weeks, namely, from mid-December to the end of January.

Defence of crops from the hopper stage is, of course, comparatively easy.

The newly matured adults, as already stated feed voraciously, but with the advent of colder weather the appetites of these insects appear to decrease and not much damage has been sustained in May, June and July. Swarms are even reported to have settled on green wheat at this time without feeding to any great extent.

Swarms may, however, do considerable damage to trees during this period, both by chewing the leaves, possibly to obtain moisture, and by breaking down the branches with their weight.

With the advent of warmer weather about September, the appetites of the winged locusts appear to develop greatly and winter crops which have escaped attack up to that time may be totally destroyed, as has in fact occurred in more than one district. From this time until they have completed egg-laying they constitute a serious menace, except apparently during the short period of active pre-breeding migration.

In districts where winged swarms are particularly prevalent during the dry season, as for instance the Melsetter district, young grass is liable to be eaten off repeatedly, and this seriously affects the farmers' arrangements for the early grazing for their livestock.

Although the feeding habits of locusts are notoriously capricious it would seem to be the general rule that the hoppers of the Red Locust feed mainly on gramineous crops, whilst the adults seem to have more catholic tastes.

The hoppers have been reported as attacking the following non-gramineous crops at times, viz., tomato, cabbage, turnip, ground nuts and cotton. Tobacco is generally not attacked by the hoppers, but the newly matured adults may attack this crop to a serious extent, chewing the midribs of the leaves and sometimes the laminae. The adults will chew the leaves of a wide variety of trees and shrubs.

ENEMIES AND DISEASES.

One of the more important enemies of the eggs has proved to be *Stomatorhina lunata* Fab., which was found to be active during the first deposition of eggs in the colony in 1932. Although not a specific parasite of locust egg-pods, it has apparently increased greatly during the present locust swarm cycle.

Cantharid beetle grubs have been found associated with the egg-pods in the soil, but no adults have been bred. A species of mite has also been recorded as attacking the egg-pods freely.

A very small Tachinid fly was first recorded as infesting the fat bodies of the winged locusts, when the females were nearing the laying stage in 1933, and towards the end of the breeding season in March, sixth stage hoppers and newly matured adults were found to be infested to an appreciable extent. These parasites caused the death of their hosts. Another, but apparently unimportant, Tachinid has also bred out from sixth stage hoppers.

A species of Sarcophagid which may be of some importance was bred in some numbers from sixth stage hoppers in March 1934.

Numerous verbal reports were received in the latter part of the wet season of 1934 and the early part of the dry season concerning prevalence of maggots in the winged swarms, but specimens were not obtained sufficiently frequently to enable a decision to be made as to which species was mainly responsible. The mortality caused by maggots of one species and another, seems to have been very considerable.

Threadworms have been to some extent in evidence throughout the invasion.

The locust fungus, *Empusa grylli* (Fresenius), did not make its appearance till late in the wet season of 1933–34, namely, in March. Between that time and early May the disease was responsible for very considerable mortality amongst both the older hoppers and the adults, but it seemed to die down after the advent of dry weather. In late June and July, however, it was found to be very prevalent in the Melsetter district, which had experienced unusually humid rainy weather during June. Large numbers of locusts dead and dying from this disease were inspected by Mr. A. P. M. Michelmore and the writer in July, and prevalence of a similar disease were reported elsewhere in the district. Whole swarms were later stated to have died practically *in toto* where they settled. Natives from the Mozambique Company's Territory reported, up to July at least, that for several months past the locusts had been dying wholesale in Portuguese East Africa, the casual agents being stated as disease and also maggots.

It would seem, therefore, that fungus and parasitic flies have caused great mortality amongst the swarms during the present year. How great this mortality has been it is not possible to estimate, but that it has been sufficient materially to affect the prospects for next season is distinctly probable.

THE OUTLOOK.

It is apparently necessary to look north of the Zambesi in reference to the prospects for Southern Rhodesia during the breeding season, and it may be necessary to look as far afield as Angola and

the Katanga Province of the Belgian Congo. Reports from the two countries mentioned indicate prevalence of swarms of the Red Locust in both, but particularly in Angola. The position in Tanganyika, Northern Rhodesia and Nyasaland does not appear to be very menacing at present.

On the whole it appears probable that the hopper outbreak in Southern Rhodesia during the coming breeding season will be lighter than last year, but the exceedingly heavy infestation reported in Angola makes the position rather uncertain.

The Union of South Africa is concerned with the number of locusts which survive the winter in Southern Rhodesia. It is at present very difficult to sum up the position in the colony. Locust swarms are certainly present in many parts, and as already stated some "enormous" swarms have recently been reported in the Inyanga district flying north-east, so that they must have come from within the colony—recently at least.

On the other hand, comparatively few reports of swarms are being received at present, and the impression gained is that they may on the whole be less prevalent than at this time last year. Possibly the position will become clearer in September when the swarms tend to move about more than they do at present.

APPENDIX 21.

LOCUST RESEARCH IN EGYPT.

By A. M. Mistikawi, *Assistant Director of the Entomological Section and Chief of the Division of Anti-Locust Research, Ministry of Agriculture, Cairo.*

Many of the points here dealt with are fully explained in Bull. No. 110 on "The Desert Locust in Egypt," issued by the Entomological Section, Ministry of Agriculture.

Some of them will be discussed now briefly together with some new observations and remarks on the results of studies carried out since the summer of 1930.

The breeding of the Desert Locust *Schistocerca gregaria* (Forskål) in Egypt.

The recent invasions of *Schistocerca gregaria* (Forskål) started in 1927, and assumed a serious form in 1929 and 1930. Many of the invading swarms bred within our territory mostly in desert regions. They were greatly favoured by suitable weather conditions, humidity in particular. Rain was exceptionally abundant during 1929 and 1930 in the Sinai Peninsula, the soil of which became wet and covered with vegetation, thus forming an excellent breeding ground for the locusts which multiplied in quantities never recorded before.

During the next two years some fliers crossed the eastern frontiers, but did not remain long.

In spite of the great efforts and the extensive campaign some locusts tried to establish themselves and propagate in the more favourable districts, but with no success, due to the timely interference of certain factors which caused them to disperse. The majority of these cases took place in desert regions. The Nile valley being so narrow and densely populated renders the observation and control of locusts more easy and no extensive breeding could possibly take place. Following the great invasion which ended in 1930, the few locusts which escaped destruction in Al Arish and Rafa area, in the Sinai, dispersed among the desert plants and the many vegetables growing near the Mediterranean coast. They gave rise to a generation which did not keep up their paternal characters, although if more suitable conditions had occurred and the remnants of the swarms had not been scattered it would have been possible that they may have behaved as true migratory locusts as actually happened in our breeding cages where some of these hoppers were kept close together.

A similar example was observed on a large scale at El Dirr district of Lower Nubia near the Sudan where, in the autumn of 1930, it was reported that locusts appeared ravaging the crops in the cultivated area, which included the narrow stretch of land between both banks of the Nile and the chains of mountains on the east and west. We found that few of the big swarms which passed over this region in the previous summer stopped to breed. Many of them were destroyed by the natives who were helped in this task by storks. The Assuan Dam lying to the north of this area was opened some time before, and the inundated land to the south emerged from water with the result that the small number of locusts which survived found a favourable breeding ground. Their offspring lived a solitary life, but few, especially those near the khours, *i.e.*, the small paths leading to the vast desert beyond, showed a tendency to congregate and fly in groups. The hoppers assumed different patterns. Control measures and the re-inundation of this region, a few months later, destroyed the eggs laid by the females.

The reverse occurred in December 1932 at the Dakhla oasis in the south-western desert. It was observed that the solitary adults began to gather on trees and showed a tendency to congregate, but the natives gave them no chance and destroyed the greater part. Of the very few that escaped some were collected and put in a breeding cage and their offspring were true *gregaria*.

It is clearly seen that locust swarms visiting Egypt, settle, particularly in desert regions, to multiply if such conditions as abundant humidity and food were available. But on the other hand, if it is a dry year, the deserts being consequently poor in vegetation, the locusts migrate to some other quarter. The few individuals that may settle in the Nile valley and the Delta are not allowed to breed.

Many of the desert regions such as Gebel Elba in the far south-east, some localities in Sinai, and the western oases may form favourable grounds for breeding provided such conditions as abundant humidity, green vegetation and a scarcity of natural enemies, birds, insects and parasites, exist.

Although all these conditions are not well represented in Egypt, they are abundant in regions surrounding this country. If locusts appear there very frequently some of them invade Egypt. It is, therefore, necessary that we should be wide awake and quick in dealing with this long aged pest.

Study of the life history of the Desert Locust.

The 1927–30 invasions gave us a unique opportunity to study many problems connected with the life history of this insect under natural conditions and in captivity. This is fully dealt with in the bulletin already quoted. The following will explain some of the problems taken up for discussion by this Conference.

Life of adults.

This varies much in different seasons. Recent observations confirm former results in breeding that hoppers which reach the adult stage in autumn enjoy a longer period of life than those emerging in other seasons.

The duration of the life of the adults is about the same in both sexes. The average for 63 females was found to be 84 days, while for 30 males it reached 85 days.

Copulation.

The copulation period occupies a long time of the life of the male. The average in 47 cases was 38 days, the maximum reached 80, while the minimum fell to 2 days. In some instances the duration of pairing extends over the whole day, but in general it does not take more than a few hours. Climatic conditions, captivity, &c., greatly influence it; generally speaking in winter and autumn copulation starts late in the afternoon and ends after sunset, while in the other seasons it begins in the morning. A series of copulations follows each egg-laying.

Egg-laying.

The average number of pods laid by 42 females was 3, with 7 as maximum and 1 minimum. In the former case the total number of eggs in the 7 pods was 374. The time taken in ovipositing varies from 15 minutes to 3 hours.

Sexual maturity.

The length of the period between emergence and sexual development is not constant. Climatic conditions, abundance of food, free

movement and crowding play an important rôle in this connection. It also differs in both sexes and is longer in the female.

Generations.

The number of generations per annum was studied by many investigators. It is shown in our work that in Egypt three generations could be raised per year or five in two years. It was also observed that in cages this period is extended; the result being a decrease in the number of generations. This is contrary to what happens in nature or to locusts kept in spaceous cages. The best example is, that some of the locusts which reached the flying stage lately, were put in our large cage, while some were put in the small breeding cages; the first reached maturity and began pairing a long time before the others which were still red in colour.

Migration and conditions influencing it.

Our observations showed that the Desert Locusts may come from the south during the autumn or from the east and north-east in the spring and summer. In some cases, as in 1929, many came from the east beginning from the autumn till the spring of the following year. The history of the different invasions and the routes followed by the locusts during 1927–30 are given in detail in our Bulletin 110. During the spring and the beginning of the summer of 1931 and 1932 few swarms came from the north and north-east, in spite of the fact that many of these were seen hovering on our frontiers before then. These swarms did not settle to multiply, but flew southwards.

Chapter I of the Bulletin 110 gives detailed information regarding the weather conditions, winds and their velocity and the depressions that occur in Egypt all the year round. It is clearly seen from these, that winds especially the spring and summer north-eastern winds, carry with them locusts flying south and south-west. If during these two seasons the *simoom* blew from the west, the locusts would be driven eastwards, thus if the insects are near the sea shore they will settle for a while, but if they were flying across the Red Sea, they are liable to perish as it actually occurred in 1930 and 1931.

Weather reports received from Kuntilla helped to prove this. Kuntilla is one of the Sinai stations near the Palestine frontiers; it lies on one of the main paths of the swarms that invade our country from the north-east.

Habits and characters of the swarms.

From the habits and characters of locusts one is apt to treat them as an indivisible unity. When they take to wing, none but the weak and ill stay behind. This is fully described in Bulletin 110. Some factors, however, may cause their dispersal. If one does succeed in exterminating a swarm, the few that are left become

dispersed and lose the habit of migrating. Attacks by natural enemies, birds, &c., lead to the same result.

One can estimate the dimensions of a swarm by the time it takes to fly past a fixed point; the breadth, depth and approximate speed of the swarm should be considered. This can also be calculated by the area of land covered by the settling swarm.

Preliminary investigations showed that 660 locusts weigh one kilogram. A sack with a capacity of 22·5 kgms. holds 17,000 insects, while a petrol tin holds 5 kgms., *i.e.*, 3,300 locusts. This will help in giving an estimate of the locusts that are killed by one method or the other.

Bulletin 110 gives a table of annual and perennial plants which exist in the deserts of Egypt and are favoured by the locusts. Agricultural and horticultural crops are also attacked by locusts which devour even the bark of trees. If food becomes scarce, they resort to eating palm leaves and the leaves of the *dôm*, or the Theban palm (*Hyphaene thebaica*). If food is abundant, they prefer some plants to others, *e.g.*, they like *Beledi Berseem* (*Trifolium Alexandrinum*) and eat it before going to *Alfalfa* (*Medicago sativa*) grown side by side and will never touch it if other food is available.

We mean to carry on with the study of many of these problems for confirmation and more information, giving special attention to factors affecting sexual maturity, embryo development the weight of nymphs, the amount of food they devour in all stages, and the number of generations under different conditions. We shall also continue to inspect desert regions with the object of collecting data that may increase our knowledge with regard to solitary locusts. We also hope that the reports we receive from our meteorological station at Kuntilla, together with the information taken from the Physical Department may help to solve the many problems dealing with the effect of weather conditions on the Desert Locust.

The use of aeroplanes in combatting locusts.

Preliminary experiments were carried out in 1928 with the object of finding out whether aeroplanes are a practical possibility in dusting as a means of controlling locusts. A special dusting apparatus, designed by the Savage Aircraft Company in England was fitted to a D.H. 9 aeroplane kindly loaned to us from the Royal Air Force; sodium fluosilicate was dusted on cotton, and cages holding a known number of locusts were placed in different spots. The aeroplane carried enough powder to dust 40 acres without landing, using 16 pounds per acre. Sixty per cent. of the locusts that fed on the dusted plants perished.

Aeroplanes were not used, however, to combat locusts in Egypt because of the great density of population, and the diversity of crops which are grown in small areas, while hand labour is abundant and cheap. Aeroplanes will be, however, of great value for scouting desert regions and for carrying officials during inspection tours.

Other species of locusts.

Besides *Schistocerca gregaria* (Forskål) there are other species of locusts and grasshoppers in Egypt which are now under investigation. *Anacridium aegyptium* (Linn.) exists all over the country. Sometimes it multiplies and becomes a source of trouble to the cultivation and occasionally migrates from one locality to another.

The migratory locusts *Locusta migratoria* (Linnaeus) exist in the solitary phase and in a very scattered way almost everywhere, but were never recorded to cause any serious damage.

The inspection of desert regions.

Our last locust invasion came to an end in 1930, but since then we have continued to inspect desert regions from time to time, to ascertain whether any locusts were present and to see how far such regions were suitable for breeding should any swarms come. Except for some scattered solitary individuals no locusts of any importance were seen. The examination of the desert area east of Assiut showed that individuals of *Anacridium aegyptium* (Linn.) were to be found there during the winter. In 1932 and 1933 they suddenly appeared in other localities south of Assiut.

Reports on locust movements.

We have never lost touch with other countries interested in locusts and reports are being sent to the Imperial Institute of Entomology as well as to Rome and Algiers. Such exchange of locust reports is most essential. Timely information given to localities subject to an invasion enables them to get ready before the actual arrival of the swarms. We, therefore, suggest that special attention should be given to such reports. Monthly reports should be written in a definite way containing information on definite points.

The Egyptian Ministry of Agriculture distributed all over the country a leaflet describing the methods that should be adopted in reporting the appearance of the locust swarms and how to combat them. Attached to this leaflet is a form to be filled in by government officials and village chiefs, with information dealing with the locality from which the locust came, the point to which it is flying, its density, and condition and the measures taken for its control. These are sent to the Ministry of Agriculture. The Frontier District Administrations, the Ports and Light House and the Coast Guards Departments, have consented to report any locusts seen by their officials.

APPENDIX 22.

RAPPORT PRÉLIMINAIRE SUR L'ACTION DE LA MISSION D'ÉTUDES DE LA BIOLOGIE DES ACRIDIENS EN 1932–1934.

Par B. N. ZOLOTAREVSKY, *Chef de la Mission d'Études de la Biologie des Acridiens.*

But et rayon d'action.

L'ÉTUDE de la Biologie de deux espèces d'acridiens migrateurs : le Criquet Migrateur, *Locusta migratoria migratorioides* (Reiche & Fairmaire), et le Criquet Pèlerin, *Schistocerca gregaria* (Forskål), pour rechercher les lieux de leur habitation permanente en Afrique française, établir les facteurs régissant l'apparition des bandes de la phase grégaire, délimiter les lieux de l'apparition primitive de ces bandes et, enfin, pour établir les voies de leurs migrations, a été désignée par le Comité d'Études de la Biologie des Acridiens comme programme d'action de la Mission.

La région comprise entre Segou, San et Tombouctou, située entre les parallèles 13°20′ et 16°50′ de latitude N., englobant la zone d'inondation du Niger et du Bani, touchant au sud la zone végétale soudanaise et au nord le Sahara méridional, a été désignée pour les premières investigations. Par la suite, les recherches de la mission se sont étendues vers le nord, dans le Sahara méridional, et vers le sud, dans la Guinée Française.

Personnel.

B. Zolotarevsky, Chef du Bureau central de Lutte contre les Sauterelles à Madagascar, appelé par le Comité d'Études de la Biologie des Acridiens pour diriger la mission, a été mis à la disposition du Comité le 11 août 1932, à son arrivée de Madagascar.

J. de Lépiney, Chef de Service à l'Institut scientifique chérifien à Rabat, attaché à la mission par décision du Comité du 9 janvier 1933, a rejoint la mission le 3 juin 1933.

L. Dupont, Météorologiste, a participé aux travaux de la mission à partir du 2 octobre 1932.

Outre ce personnel permanent, deux agents du Service de l'Agriculture du Soudan Français, affectés successivement et pour un temps variable, ont participé aux travaux de la mission dans cette colonie :

P. Coléno, du 6 novembre 1932 au 14 avril 1933;
R. Sagette, du 4 août 1933 au 3 mars 1934.

Organisation des recherches.

Les travaux préparatoires de documentation et d'équipement ont nécessité plusieurs déplacements des membres de la mission à Alger, à Paris et à Londres; ces travaux ont duré du 12 août au 29 octobre 1932.

L'action de la mission en Afrique Occidentale Française a débuté le 6 novembre 1932 et les travaux ont été terminés le 19 avril 1934.

Pour faire face à un programme d'action très complexe et intéressant une très vaste région, les travaux de la mission ont été exécutés souvent simultanément dans plusieurs régions. Dans tous les cas où il a été possible, les recherches ont été faites par deux membres de la mission au moins, ceci tant pour la sécurité que pour éviter l'influence déprimante de l'isolement au cours du travail dans les régions désertiques.

Le matériel recueilli au cours des investigations n'a pas été étudié en détail sur place: près de 4,000 spécimens d'insectes et près de 600 spécimens de plantes ne pouvaient être étudiés sans le concours de spécialistes ou sans documentation scientifique; d'autre part, le travail dans les pays chauds portant un caractère temporaire et entraînant des dépenses d'argent considérables, il a été jugé que tout l'effort devait être concentré sur l'acquisition de la documentation matérielle la plus importante possible, qui serait étudiée ensuite et mise au point dans les conditions normales du travail de laboratoire.

Cette organisation a permis de prospecter et d'étudier l'ensemble de la partie septentrionale du Soudan Français et une partie de la Guinée Française. Le Soudan Français a été exploré entre les parallèles 13° et 18°40′ de latitude N. dans l'ouest et entre les parallèles 15° et 19°40′ dans l'est de la colonie. Les régions comprises entre les parallèles 14° et 17° de latitude N., à cause de la diversité de leur nature due à la succession dans ces limites des zones climatiques et végétales soudanaise, sahélienne et saharienne et à la présence de la zone d'inondation du Niger, ont été étudiées en détail; deux pointes, poussées vers le nord dans les parties occidentale et orientale du Soudan Français, ont encadré la vaste région du Sahara méridional située dans les limites de cette colonie.

Déplacements et séjours de la Mission en Afrique Occidentale Française.

Les premières investigations, concernant *Locusta migratoria migratorioides* (Reiche & Fairmaire), ont été faites par MM. Zolotarevsky, Coléno et Dupont dans le Cercle du Macina, aux abords et dans l'intérieur de la zone d'inondation de la rive gauche du Niger. Du 26 novembre au 8 décembre 1932, les recherches ont porté le caractère de prospection; ensuite, Dia, village dans la zone d'inondation, a été choisi comme centre d'action de la mission pour les observations méthodiques.

MM. Coléno et Dupont, chargés de recherches à Dia, y ont travaillé du 8 décembre 1932 au 8 avril 1933; M. Coléno est parti à cette date pour se rendre en France; M. Dupont seul a continué les observations à Dia jusqu'au 5 juin 1933, date à laquelle il a été rejoint par M. Zolotarevsky.

Le 15 juin 1933, l'arrivée dans le Soudan Français de M. de Lépiney, qui s'est joint à la Mission, a permis d'étendre le rayon d'action. M. Zolotarevsky, sur la proposition de M. le Gouverneur Général de l'Afrique Occidentale Française, s'est rendu en Guinée Française, où il a étudié, du 28 juin au 31 juillet 1933, les voies de migrations de *Locusta migratoria migratorioides*. Le centre d'étude de *Locusta migratoria migratorioides* dans le Soudan Français a été transporté de Dia à Sokolo, village situé en dehors de la zone d'inondation, dans le Sahel. MM. de Lépiney et Dupont s'y sont rendus et, après les recherches préliminaires dans cette région, M. Dupont y est resté pour poursuivre les observations sur *Locusta migratoria migratorioides*, alors que M. de Lépiney, affecté pour les recherches sur *Schistocerca gregaria* (Forskål), s'est rendu, le 19 juillet 1933, à Néma.

Le 4 août, au retour de M. Zolotarevsky de la Guinée Française, M. Sagette a été adjoint à la Mission et affecté pour l'étude de *Locusta migratoria migratorioides* à Sokolo, où il a rejoint M. Dupont.

M. Zolotarevsky, après avoir visité Sokolo, s'est rendu à Néma, où il a poursuivi, avec M. de Lépiney, les recherches sur *Schistocerca gregaria* jusqu'au 1er novembre, dans les régions Néma–Oualata–Djouf.

Le 2 décembre 1933 (après un séjour de MM. de Lépiney et Zolotarevsky à Bamako de 8 novembre au 1er décembre), tous les membres de la mission se sont réunis à Sokolo.

Le 13 décembre, la mission a quitté le nord-ouest du Soudan Français et les investigations se sont portées vers l'est de la colonie. MM. de Lépiney et Dupont se sont rendus, par Tombouctou et Gao, à Kidal et ont exploré, du 30 décembre 1933 au 13 mars 1934, l'Adrar des Iforas et la région entre Kidal et Menaka. MM. Sagette et Zolotarevsky, après avoir visité, du 24 décembre 1933 au 2 janvier 1934, la partie septentrionale du Macina, se sont transportés dans l'intérieur de la Boucle du Niger, où ils ont exploré, du 3 janvier au 23 février, le sommet de la Boucle, sa partie orientale entre la mare de Gossi et Gao et la région des lacs Kourarou, Haougoundou et Niangay.

Après un court séjour à Bamako, où M. Sagette est resté pour reprendre ses fonctions au Gouvernement du Soudan Français, M. Zolotarevsky a rejoint, le 14 mars 1934, MM. de Lépiney et Dupont à Kidal. Le 18 mars la Mission a quitté Kidal et s'est rendue à Gao. Du 29 mars au 14 avril, la mission a visité les rives du Niger entre Bourem et Bentia.

Le 19 avril 1934, la mission a quitté Gao pour se rendre, par Tabankort, Bidon 5, Reggan, Adrar, Timimoun, Fort Mac-Mahon, El-Goléa et Djelfa, à Alger, où elle est arrivée le 27 avril 1934.

Moyens de déplacement.

Les déplacements sur toute la vaste étendue explorée ont été effectués soit par les moyens de transport trouvés sur place et appropriés à chaque région (par chemin de fer, par fleuve, à cheval ou à chameau), soit par les moyens de transport appartenant à la mission : deux chevaux ont été mis à la disposition des membres de la mission au cours des travaux à Dia et à Sokolo; une automobile, appartenant également à la mission, a facilité les déplacements rapides tant pour les besoins des recherches que pour les communications avec les centres administratifs. Le voyage de retour de la mission, de Gao à Alger, a été effectué dans la voiture appartenant à la mission.

Rapports avec l'Administration des colonies visitées.

Un concours sans réserve a été prêté par les autorités des colonies visitées pour faciliter le travail de la mission. Les locaux pour abriter le matériel et pour héberger le personnel de la mission ont été offerts dans tous les Cercles. A Sokolo, les locaux d'une ferme agricole expérimentale ont été mis à la disposition de la mission par l'Office du Niger pendant toute la période des recherches dans cette localité. Toutes les facilités ont été données par les autorités pour le recrutement des moyens de transport et du personnel auxiliaire indigène.

M. le Général commandant les troupes du Soudan Français a bien voulu subordonner les déplacements du Groupe nomade du Hodh aux besoins des recherches de la mission, afin d'assurer sa sécurité dans les régions désertiques du nord-ouest du Soudan Français. Le meilleur accueil a été réservé à la mission par les officiers du Groupe nomade du Hodh et en particulier par son commandant, Capitaine Dessert, qui a tenu à se mettre personnellement en tête du détachement des méharistes avec lequel la mission a exploré une région du Djouf.

Une étroite collaboration a été établie entre la mission et les services de l'agriculture et météorologique des colonies visitées. Des renseignements très précieux ont été fournis par ces services à la mission; de leur côté, les membres de la mission ont prêté leur concours pour l'établissement des bases d'organisation des institutions antiacridiennes locales.

Résultats des recherches.

Le matériel important recueilli par la mission au cours de ses recherches est actuellement à l'étude. Les notes suivantes ont été soumises au Comité d'Études de la Biologie des Acridiens :

(1) Note préliminaire sur *Schistocerca gregaria* (Forskål) dans le Nord-Ouest du Soudan Français, par B. N. Zolotarevsky et J. de Lépiney.

(2) Note préliminaire sur *Schistocerca gregaria* (Forskål) dans le Soudan Français oriental, par B. N. Zolotarevsky, J. de Lépiney et L. Dupont.
(3) Invasions des acridiens en Guinée Française, par B. N. Zolotarevsky.
(4) Note préliminaire sur le Criquet Migrateur, *Locusta migratoria migratorioides* (Reiche & Fairmaire), dans le Soudan Français, par B. Zolotarevsky.

Le résumé suivant des notes concernant les investigations dans le Soudan Français tracera, dans ses grandes lignes, les résultats obtenus par les recherches de la mission.

Locusta migratoria migratorioides (Reiche & Fairmaire).

La partie méridionale du Sahel et la zone d'inondation du Niger constituent dans le Soudan Français les régions auxquelles est limitée vers le nord l'aire d'habitation permanente de *Locusta migratoria migratorioides*. La limite nord des lieux d'habitation permanente de l'espèce peut être fixée dans cette colonie au parallèle 15°30′ de latitude N.; elle passe au delà de cette latitude dans la zone d'inondation du Niger et dans la région des mares de Nara.

A partir de cette limite, vers le sud, l'espèce se trouve dans des conditions d'existence très différentes, suivant les zones climatiques ou végétales habitées; les possibilités de transformation de la phase solitaire de l'espèce dans la phase grégaire dans ces zones sont également différentes.

Les travaux antérieurs de plusieurs auteurs sur la biologie de *Locusta migratoria migratorioides* ont démontré que l'accumulation des individus de la phase solitaire est un facteur primordial déterminant la transformation de l'espèce dans sa phase grégaire. Cette accumulation ne se produit en présence des éléments climatiques, normaux actuellement, dans aucune des zones habitées par l'espèce dans le Soudan Français.

Dans le Sahel, entre les parallèles 15°30′ et 14° de latitude N., les stations de l'espèce se trouvent morcelées et confinées aux mares temporaires dont les abords déboisés et herbeux offrent à l'espèce des stations habitables. L'existence de l'espèce dans le Sahel est précaire; la période de sa reproduction est confinée à une seule époque de l'année: celle des pluies; la saison des pluies y est de courte durée et est suivie d'une longue saison de sécheresse, pendant laquelle les stations habitables pour l'espèce sont presque entièrement anéanties par les troupeaux de bétail.

Dans la zone d'inondation, entre son commencement et le lac Debo, l'espèce vit dans des conditions particulières. Son activité génitale se manifeste deux fois par an; le début de la première période a lieu après les premières pluies, à la mi-mai ou en juin, et l'espèce se reproduit jusqu'au moment de l'arrivée des eaux de crue, en juillet ou en août. L'activité génitale des individus, se trouvant

à cette époque sur les herbes au-dessus d'une nappe d'eau, s'arrête jusqu'en novembre ou décembre. La deuxième période de reproduction débute en novembre ou en décembre, après le retrait des eaux de crue et dure jusqu'en février ou mars; à partir de ces mois et jusqu'à la nouvelle reprise de l'activité génitale, en mai ou en juin, après les chutes de pluies, la reproduction paraît être suspendue.

L'espèce peut prospérer dans la zone d'inondation, mais la destruction d'un grand nombre d'individus par les feux d'herbes en février–mars et l'échelonnement des pontes et des éclosions pendant la période de reproduction après le retrait des eaux de crue, entravent la pullulation et la formation des bandes migrantes.

Dans la zone d'inondation au nord du lac Debo, les conditions d'existence de l'espèce doivent être similaires à celles de la partie méridionale de cette zone, mais elles peuvent présenter des modifications de détail à cause du climat plus sec et de l'arrivée des eaux de crues plus tardive dans le nord.

Dans les régions situées au sud du parallèle 14° de latitude N., se trouvant dans la zone climatiquement apparentée à la zone soudanaise, la pluviosité annuelle relativement abondante et le climat régulier maintiennent une végétation herbacée riche pendant une période relativement longue de pluies; mais dans ces régions bien drainées la végétation herbacée se dessèche simultanément sur de grandes superficies; de plus, elle est incendiée par les indigènes après sa dessication. Ces conditions ne permettent pas une concentration considérable des individus.

Pour se représenter les facteurs qui ont pu déterminer l'apparition des premières bandes de *Locusta migratoria migratorioides* enregistrées en 1928, il a fallu se reporter aux conditions de vie de l'espèce pendant et avant l'apparition de ces bandes et les confronter avec les conditions de vie observées au cours des recherches de la mission faites en 1932–34.

Cette étude a fait constater que dans la zone d'inondation du Niger et dans les régions limitrophes de cette zone, l'année 1927 a été plus pluvieuse que l'année 1928 et que cette dernière a été particulièrement pauvre en précipitations atmosphériques dans la partie septentrionale des régions considérées. Cependant, les écarts de pluviosité sur différents points de ces régions n'ont pas paru suffisants pour justifier à eux seuls l'apparition de la phase grégaire. Il a été relevé également que le régime d'inondations du Niger a subi en 1924–26 des perturbations considérables. Après une longue période de crues déficientes, les crues importantes de 1924 et de 1925 ont envahi des superficies étendues du Sahel et ont dû déterminer l'apparition de nombreuses stations favorables à une reproduction intense de *Locusta migratoria migratorioides;* la crue de 1926, déficiente, n'a pas atteint les régions du Sahel inondées en 1924 et 1925. Sur les stations nouvellement créées par les crues de 1924 et 1925, mais non atteintes par la crue de 1926, les insectes ont dû se reproduire sur des superficies restreintes, ce qui a pu provoquer la

concentration des pontes et maintenir les larves groupées. Ces conditions ont pu se réaliser surtout dans les régions soumises au climat nettement sahélien, mais ne sortant pas des limites de l'aire d'habitation de l'espèce dans le Sahel.

Toutes ces déductions, jointes aux observations faites par la mission, font considérer les abords de la zone d'inondation du Niger, dans sa partie entre Ké-Macina et le lac Debo, comme foyers grégarigènes probables de *Locusta migratoria migratorioides*. Les régions limitrophes de la zone d'inondation situées au nord du lac Debo doivent se trouver dans des conditions rappelant celles de la partie méridionale de cette zone, mais les faits que dans cette partie le Sahel ne paraît plus présenter d'éléments qui permettraient à l'espèce de se perpétuer, que la végétation de la partie septentrionale de la zone d'inondation a un caractère particulier, enfin, que le climat et les époques des crues y diffèrent de ceux de la partie méridionale de la zone d'inondation, incitent à réserver l'opinion sur cette région jusqu'au moment où son étude sera plus détaillée.

L'étude des régions sahéliennes se trouvant en dehors de la zone d'inondation du Niger a démontré que dans sa partie méridionale et dans les régions des mares de Nara l'existence de l'espèce, précaire dans les conditions climatiques normales pour l'époque actuelle, pourrait se trouver facilement améliorée par une période exceptionnellement pluvieuse. Le retour, après une période particulièrement favorable à la pullulation, au régime normal constituerait dans ce cas les conditions caractérisant les foyers grégarigènes de l'espèce. Aucun renseignement n'est venu confirmer l'existence de telles perturbations dans les régions sahéliennes mentionnées, mais la documentation recueillie n'est pas ample et, jusqu'à preuve du contraire, ces régions doivent être considérées comme foyers grégarigènes possibles.

Schistocerca gregaria (Forskål).

La documentation assez restreinte existant sur la biologie de *Schistocerca gregaria* n'a pas permis une localisation précise des recherches sur les lieux d'habitation permanente de cette espèce. Les investigations ont porté par conséquent un caractère de prospection. Dès le début, la présence de la phase solitaire de *Schistocerca gregaria* dans la zone de contact du Sahel et du Sahara méridional située entre les parallèles 17° et 19° de latitude N., a incité à concentrer les recherches dans cette zone.

Les observations, fragmentaires à cause de la méthode des recherches que la mission a dû adopter, ont amené à conclure que les stations d'habitation permanente de l'espèce entrent dans le domaine saharien et s'y présentent sous forme d'îlots dans des régions arides pendant toute l'année ou tout au moins pendant une grande partie.

Dans le Sahel proprement dit, caractérisé par une végétation diffuse et par une pluviosité annuelle, la présence de *Schistocerca*

gregaria ph. *solitaria* n'a pas été enregistrée. Dans certaines régions où la transition entre le Sahel et le Sahara est très progressive, les individus de *Schistocerca gregaria* ph. *solitaria* ont été rencontrés sur des stations se trouvant dans un pays rappelant dans son ensemble le Sahel typique, mais il a pu être constaté que ces régions appartenaient climatiquement au Sahara. Par conséquent, le parallèle 17° de latitude N. a été proposé comme limite sud de l'aire d'habitation permanente de *Schistocerca gregaria* dans le Soudan Français.

Les investigations de la mission n'ayant pas été effectuées au-dessus du parallèle 19°, il n'a pas été possible de conclure sur les limites de répartition de l'espèce vers le nord.

Dans les conditions climatiques présentes pendant la période des recherches, il doit exister dans les régions explorées une seule génération de l'espèce par an, confinée à la saison des pluies. L'existence de l'espèce pendant la saison sèche paraît être assurée par des individus ailés, dont l'activité génitale est suspendue, mais dont les autres fonctions vitales ne sont pas en repos : à tout moment de la saison sèche, d'octobre en mars, les individus observés étaient très agiles, leur tube digestif a toujours été trouvé gonflé d'un contenu vert et aqueux, témoin d'une alimentation active. La présence d'une végétation vivante paraît donc nécessaire pour la vie de l'espèce pendant la saison sèche.

La documentation qui a pu être rassemblée sur *Schistocerca gregaria* par les recherches de la mission n'est pas suffisante pour juger de la valeur des stations observées de l'espèce en tant que lieux de transformation de la phase solitaire dans la phase grégaire. Il est toutefois certain que sous le climat du Sahara, à chutes de pluies très irrégulières, l'espèce est soumise à des conditions d'existence très variables. Ces conditions d'existence de l'espèce et leur influence sur son comportement restent encore à étudier.

Recherches futures.

Les recherches faites par la mission de novembre 1932 en avril 1934 dans le Soudan Français sont loin de résoudre le vaste problème acridien.

La documentation recueillie sur *Locusta migratoria migratorioides* permet d'attribuer l'apparition des premières bandes de l'invasion enregistrée en juin 1928 dans la région de la Boucle du Niger à une transformation dans la phase grégaire des individus de la phase solitaire appartenant à la faune locale. Les recherches de la mission ont permis d'entrevoir les facteurs qui peuvent entraîner la pullulation de l'espèce et sa transformation dans la phase grégaire et de localiser par conséquent les foyers grégarigènes probables de l'espèce. Ces constatations préliminaires doivent être étayées par des recherches méthodiques sur le climat, sur les modalités du régime des crues du Niger et sur l'influence de ces facteurs en ce qui concerne le comportement de l'espèce dans les régions désignées

comme foyers grégarigènes. Au cas où se produirait une nouvelle période de perturbations climatiques ou hydrographiques pouvant entraîner l'apparition de la phase grégaire, cette documentation permettra à une organisation antiacridienne locale de prévoir l'éventualité d'une pullulation et de porter sur des produits précis ses efforts pour combattre l'invasion.

L'avancement de nos connaissances sur *Locusta migratoria migratorioides* permet de localiser les recherches et de prévoir leur portée pratique immédiate. Il n'en est pas de même pour *Schistocerca gregaria,* dont la biologie laisse encore beaucoup de points inconnus. Les observations de H. B. Johnston(1) et R. C. Maxwell-Darling(2) dans le Soudan Anglo-Égyptien, ainsi que les investigations de la mission dans le Soudan Français, localisent l'aire d'habitation permanente de *Schistocerca gregaria* dans les régions à facies saharien situées entre les parallèles 17° et 20° de latitude N. Les stations d'habitation permanente de l'espèce dans toute cette vaste zone sont très localisées à cause du caractère contracté de la végétation du Sahara. La délimitation de ces stations ne pourra être faite qu'après une période de recherches s'étendant sur plusieurs années. En effet, les recherches de la mission permettent d'affirmer que la présence ininterrompue d'une végétation vivante est nécessaire pour la perpétuation de l'espèce. Or, les chutes de pluies ne se produisent pas régulièrement tous les ans sur la totalité des régions désertiques et il est impossible de juger de la valeur d'une station d'après son aspect au cours d'une seule année.

Les facteurs qui déterminent l'apparition des bandes primitives de *Schistocerca gregaria* ne sont pas élucidés non plus. Les observations de H. B. Johnston en 1926 près de Port-Sudan permettent de supposer que l'apparition des bandes peut être attribuée à la transformation de la phase solitaire dans la phase grégaire, due à une pullulation de l'espèce sous l'influence des facteurs favorables à la reproduction. La nécessité des facteurs similaires à ceux qui entraînent l'apparition de la phase grégaire de *Locusta migratoria* pourrait être par conséquent admise, mais la nature exacte de ces facteurs pour *Schistocerca gregaria* n'est pas encore connue.

Les recherches sur *Schistocerca gregaria* doivent être concentrées sur la délimitation des stations de son habitation permanente et sur l'étude de son comportement dans ces stations.

Il est difficile de préciser actuellement les régions où ces stations doivent être recherchées de préférence. La documentation publiée en 1933 par B. P. Uvarov(3) établit indiscutablement l'inter-

(1) A Further Contribution to our Knowledge of the Bionomics and Control of the Migratory Locust *Schistocerca gregaria* Forsk. (*peregrina* Oliv) in the Sudan. 1926, Khartoum.

(2) The Solitary phase of *Schistocerca gregaria* Forsk. in North-Eastern Kordofan (Anglo-Egyptian Sudan). *Bull. ent. Res.*, 25, 1934, London.

(3) The locust outbreak in Africa and western Asia in 1932. Economic Advisory Council, Committee on Locust Control. October 1933, London.

dépendance des invasions de *Schistocerca gregaria* en Afrique tropicale et le nord africain et amène cet auteur à considérer, dans les limites de l'Afrique française, deux zones de migration de l'espèce : 1°) la zone maroco-sénégambienne et 2°) la zone algéro-nigérienne.

La distinction de ces deux zones pourrait servir, à première vue, pour la localisation des recherches dans la Mauritanie et le Sénégal, d'une part, et dans les régions situées au nord du lac Tchad, d'autre part; mais les passages des bandes de l'espèce, du Sénégal ou de la Mauritanie au Soudan Français ou dans la Colonie du Niger et dans le sens inverse, ainsi que les directions des vols vers le nord existant dans les régions de Néma et d'Oualata et la présence des bandes de *Schistocerca gregaria* à Taoudeni, enregistrée en octobre 1933 par les officiers méharistes, montrent que les bandes, partant par ex. de la Mauritanie vers le Maroc, peuvent provenir des parents grégaires qui seraient venus de loin et qu'il existe en dehors du Rio de Oro et du Hoggar d'autres voies de pénétration des acridiens vers le nord.

Les passages de grandes masses d'Acridiens en migration par le Rio de Oro et le Hoggar pourraient être déterminés par les climats particuliers de ces régions, où les endroits possédant une végétation ne sont jamais séparés par de trop grandes superficies stériles.

Il ne peut pas être par conséquent affirmé que les lieux d'apparition des bandes primitives se trouvent en Mauritanie et dans les régions avoisinant le lac Tchad. D'autre part, l'insuffisance des renseignements sur les premiers vols de *Schistocerca gregaria* ne permet pas d'attribuer l'existence des foyers grégarigènes à une de ces régions à l'exclusion de l'autre. Les recherches devront être effectuées dans les deux régions.

Action future de la Mission.

Les problèmes de la biologie des acridiens qui se posent dans l'Afrique tropicale française sont trop vastes pour que l'on puisse songer à essayer de les résoudre simultanément en présence des effectifs actuels de la mission. Le travail de la mission devra par conséquent être sérié, afin d'éviter la dispersion de l'effort et de le porter sur les problèmes essentiels.

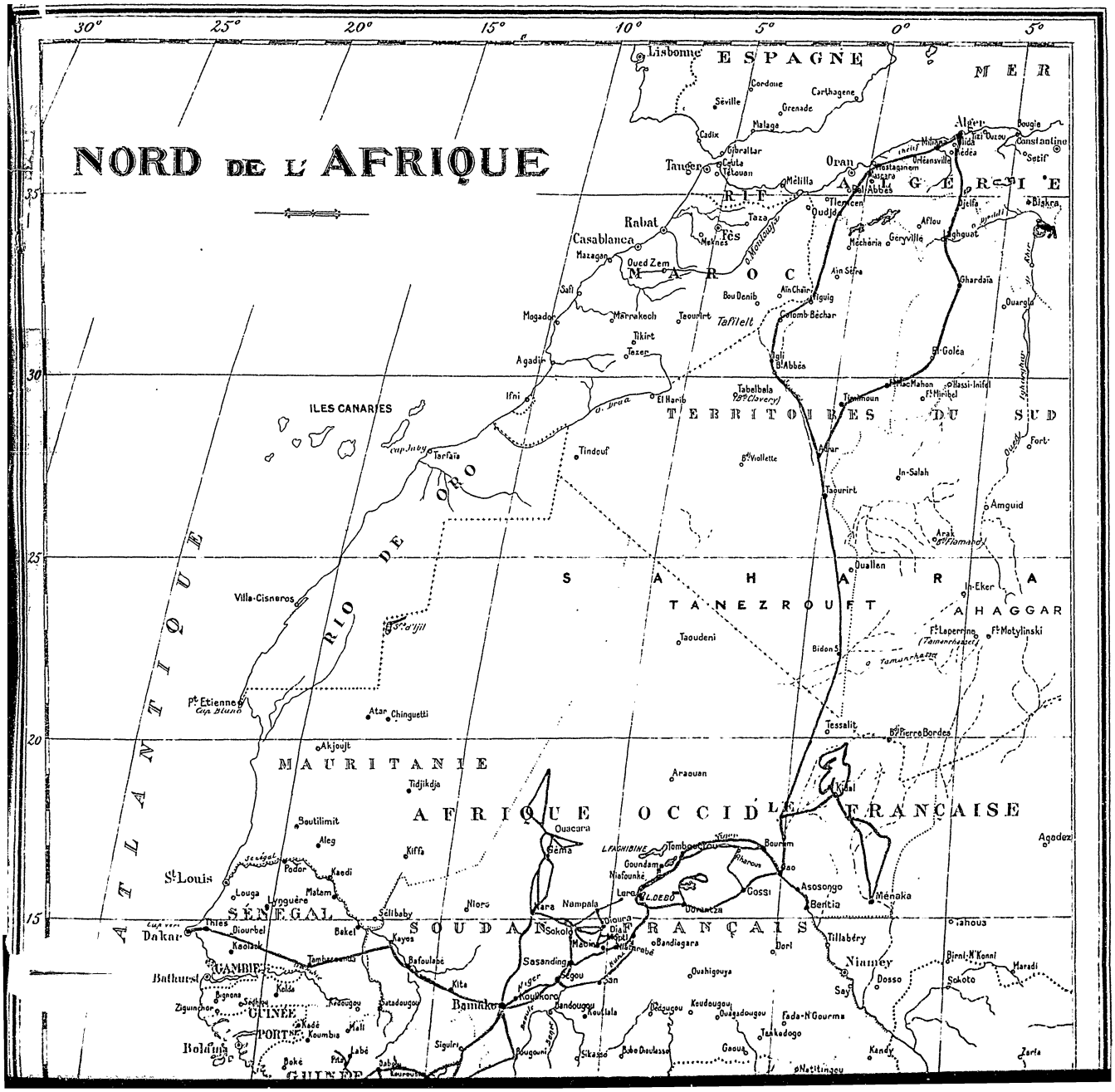
La question des foyers grégarigènes de *Locusta migratoria migratorioides* dans le Soudan Français passe dans la phase des recherches méthodiques sur place, en des points définis; ce travail très important devrait être fait par un personnel spécialisé sédentaire.

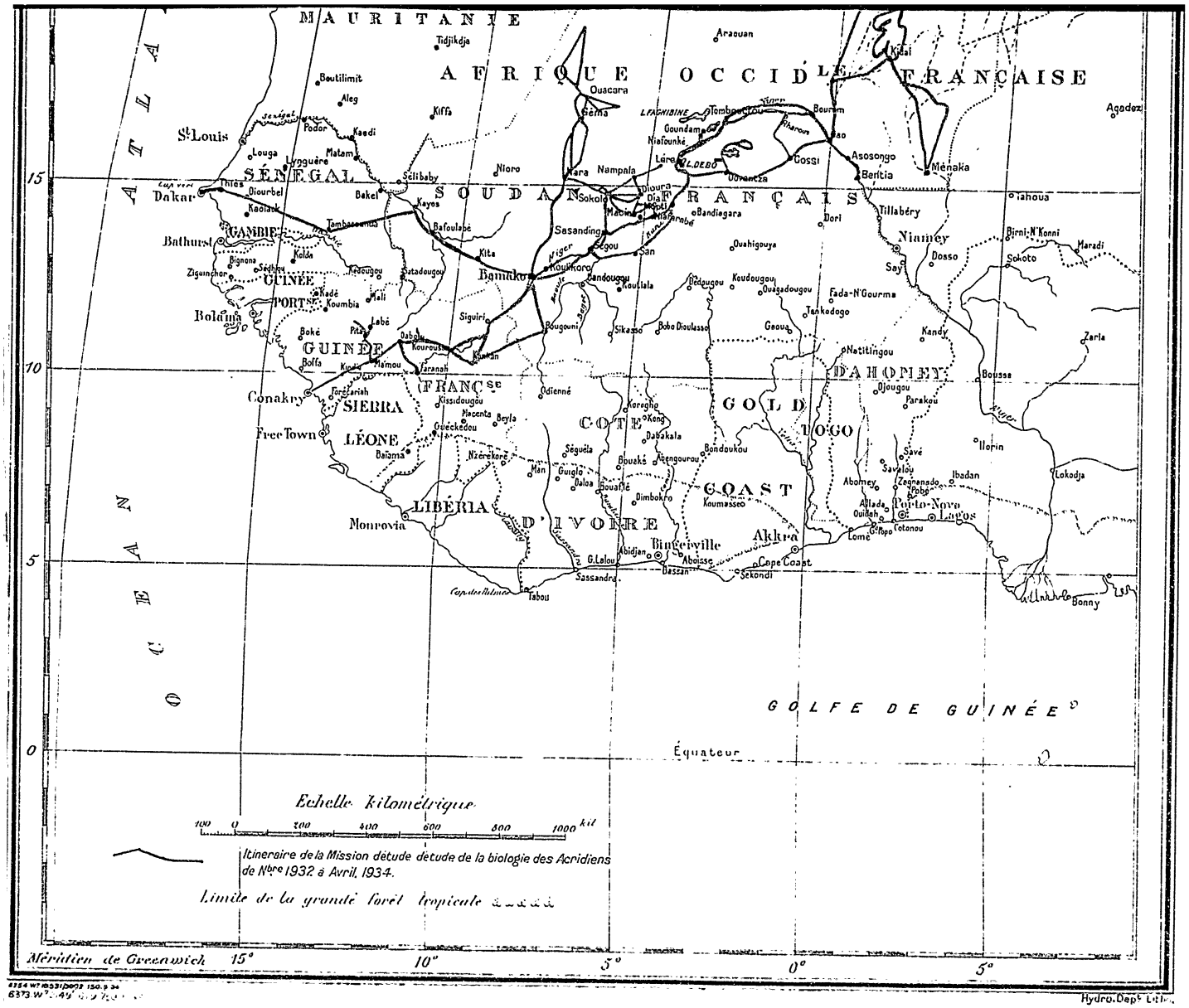
Par contre, les recherches sur *Schistocerca gregaria* restent encore à la période de prospection et l'action de la mission doit être concentrée sur cette espèce. La complexité du problème exigera le travail conjugué de tous les spécialistes accrédités de la mission.

Le nord du Soudan Français ayant été exploré en 1933–34, les recherches doivent être portées vers l'est, dans les régions situées au nord et au nord-est du lac Tchad. Le choix de ces régions est dicté

par les considérations suivantes: 1°) la présence d'une grande nappe d'eau du lac s'avançant loin vers les régions sahéliennes ou semi-désertiques et d'un réseau hydrographique particulier existant vers le nord-est du lac pourra apporter des éléments nouveaux à nos connaissances de la biologie de *Schistocerca gregaria*; 2°) les investigations dans ces régions pacifiées pourront se poursuivre plus régulièrement que dans le nord de la Mauritanie, voisine du Rio de Oro; 3°) la prospection de la Mauritanie, qui devra être faite dans sa partie septentrionale rapidement à cause de la proximité du Rio de Oro, sera effectuée avec plus de profit si elle est exécutée en possession des connaissances sur la biologie de l'espèce approfondies par l'étude dans les régions accessibles à une exploration méthodique.

Les recherches dans le Soudan Français ont démontré que l'étude de *Schistocerca gregaria* doit être faite principalement pendant la période de son activité génitale; les investigations doivent coïncider par conséquent avec la saison des pluies et la mission doit être sur place à partir de la fin d'avril.





APPENDIX 23.

DÉCLARATIONS ET VŒUX SOUMIS PAR LA DÉLÉGATION FRANÇAISE.

(i) Action du Comité d'Études, de 1932 à 1934.

Le Comité français d'Études de la Biologie des Acridiens s'est conformé, depuis la Conférence de Paris, aux "déclarations et propositions" présentées en 1932 par la délégation française ainsi qu'aux "résolutions" adoptées par la Conférence elle-même.

C'est ainsi que :

a) Il a donné toute sa coopération à l'Imperial Institute of Entomology, centre international des recherches antiacridiennes (résolution A–V). L'intégralité des documents tant élémentaires que généraux qu'il a reçus, ou élaborés, ont été transmis à Londres. Le Président du Comité se tient en relations permanentes avec l'Imperial Institute of Entomology, en vue de hâter ou de compléter ces communications. Les renseignements fournis sont d'ailleurs incorporés au "survey" annuellement rédigé par M. Uvarov et publié par le Committee on Locust Control.

b) Les procès-verbaux de ses réunions annuelles sont adressés *in extenso* à l'Imperial Institute of Entomology. Lors de la réunion de janvier 1934, M. Uvarov, prié par le Comité, a bien voulu assister à Alger à ses séances.

c) Il a complété sa représentation par celle des deux territoires africains du Togo et du Cameroun, placés sous mandat français.

d) Il a désigné, pour chacune des trois régions françaises indiquées par la Conférence de Paris (résolution C–III) un entomologiste spécialisé.

e) La mission d'études que le Comité envisageait en 1932 dans la région nigérienne Ségou–San–Tombouctou, et dont le programme (Déclaration V de la délégation française) avait été soumis à la Conférence de Paris, a poursuivi ses recherches depuis le 6 novembre 1932 jusqu'au 19 avril 1934, sous la direction de M. B. Zolotarevsky. Elle comprenait, au début, deux explorateurs. Depuis le 3 juin 1934, elle en comporte trois, MM. Zolotarevsky, Dupont et de Lépiney. Elle s'est adjoint temporairement deux agents appartenant au service de l'agriculture du Soudan Français, MM. Coléno et Sagette. La région nigérienne a été explorée entre les parallèles 13° 20′ et 16° 50′ L.N., en ce qui concerne le Migrateur et le Pèlerin. La mission s'est avancée au sud jusqu'en Guinée Française d'une part, et, d'autre part, au nord du Niger, en deux points du Sahara méridional. Elle a parcouru au total 25,000 kilomètres environ.

Ainsi qu'il avait été recommandé (résolution c–IV), la mission s'est tenue en contact avec le centre régional d'Alger et le centre international de Londres.

Le "rapport préliminaire sur l'action de la mission d'études de la biologie des Acridiens en 1932–1934" est soumis à la présente Conférence.

f) Enfin, le Comité a réalisé l'intention exposée (VII) par la Délégation française à la Conférence de Paris, en organisant en Algérie l'étude biologique du Criquet Marocain. Cette étude est confiée à M. R. Pasquier, qui en a fait connaître les premiers résultats.

Depuis 1934, le Comité fait paraître sur la question de biologie acridienne, les mémoires rédigés soit par ses membres, soit par les membres de la mission d'études, soit par toute autre personne qualifiée. Ces publications, réunies sous le titre commun de "Travaux du Comité d'Études de la Biologie des Acridiens" sont actuellement au nombre de cinq :

1°) "Note préliminaire sur *Schistocerca gregaria* (Forskål) dans le Nord-Ouest du Soudan Français," par B. N. Zolotarevsky et J. de Lépiney.

2°) "Quelques données sur la biologie de *Schistocerca peregrina* d'après les élevages expérimentaux. Influence de l'anhydrobiose dans le cycle annuel de l'espèce et de déterminisme ou comportement grégaire," par E. Roubaud.

3°) "Contribution à l'étude du Criquet Marocain, *Dociostaurus maroccanus* (Thunberg), en Afrique Mineure, 1ère note," par R. Pasquier.

4°) "Note préliminaire sur *Schistocerca gregaria* (Forskål) dans le Soudan Français Oriental," par B. N. Zolotarevsky, J. de Lépiney et L. Dupont.

5°) "Invasion des acridiens en Guinée Française," par B. N. Zolotarevsky.

Cette énumération ne serait pas complète sans le rappel du mémoire fondamental publié en 1933 par M. Zolotarevsky : Contribution à l'étude biologique du Criquet Migrateur (*Locusta migratoria capito*) dans ses foyers permanents. Thèse de la Faculté des Sciences de l'Université de Paris.

En dehors de ces publications, la délégation rappelle que d'autres travaux concernant la biologie des acridiens ont été publiés en France et dans le Nord de l'Afrique, en dehors de l'action du Comité.

(ii) Projet du Comité d'Études.

Le Comité, comme il l'a fait jusqu'ici, s'efforcera d'améliorer la qualité et la rapidité des renseignements élémentaires qu'il réunit dans les différents pays africains français, et qu'il adresse ensuite à l'Imperial Institute of Entomology.

Il insistera auprès des Gouvernements français coopérants constamment par l'intermédiaire de ceux de ses membres qui les représentent, pour assurer la réalisation des vœux adoptés à cet égard par la présente Conférence.

Dès 1932, le Comité avait envisagé, à la suite de la mission opérant dans la région Ségou–San–Tombouctou, l'envoi de deux autres missions, l'une en Mauritanie, l'autre dans la région Oubanghi–Chari–Tchad.

L'ampleur de la prospection réalisée par la première dans la zone du Moyen Niger, les terrains favorables qu'elle a rencontrés, la valeur des renseignements qu'elle a été à même de recueillir tant sur le Migrateur que sur le Pèlerin, ont conduit le chef de cette mission, entièrement approuvé d'ailleurs par le Comité, à poursuivre ses recherches jusqu'en 1934 dans la même région.

A partir de 1935 inclusivement, la mission se portera vers l'est, dans la zone située au nord et au nord-est du Tchad. Elle aura pour principal objectif l'étude du Pèlerin. Les motifs de ce choix sont exposés dans le rapport de réunion de M. Zolotarevsky, dont le texte est soumis à la présente Conférence.

Sans méconnaître aucunement le grand intérêt que présente le nord de la Mauritanie pour l'étude biologique du Pèlerin, le Comité estime qu'il ne dispose pas d'un personnel suffisant pour mener à bien simultanément une exploration en Mauritanie et une exploration sur les confins du Tchad. Au surplus, le voisinage du Rio de Oro soulève un problème de sécurité qui doit être résolu avant d'envisager de rechercher dans ces régions encore incertaines. Un vœu à cet égard est rédigé plus loin. L'orientation des recherches se réglera sur l'opportunité, et pourra se modifier si les deux points de vue dont il s'agit se modifient eux-mêmes dans le sens favorable.

Les études entreprises en Algérie sur le Criquet Marocain seront poursuivies et prolongées autant qu'il sera nécessaire.

(iii) Vœux.

La délégation française :

1°) Considérant le grand intérêt qui s'attache à la prospection acridienne dans le Rio de Oro et les régions avoisinantes,

souhaite que la Conférence fasse remarquer au Gouvernement espagnol combien il serait désirable qu'il facilitât, le cas échéant, aux missions de prospection, l'accès de cette région ;

2°) Considérant l'ampleur et la complexité du problème des foyers permanents (zones grégarigènes), clé du problème des migrations,

souhaite que les prospections soient continuées comme elles ont été entreprises, c'est-à-dire par des spécialistes de la biologie acridienne, déchargés de toute autre mission administrative ou agricole ;

3°) Pour le même motif, et considérant en outre la nécessité d'acquérir la connaissance approfondie du comportement des acridiens lors de leurs transformations phasées,

souhaite que des laboratoires centraux d'étude et d'expérimentation, ayant pour mission de rechercher la solution des questions biologiques accessibles par les méthodes expérimentales, soient

organisés auprès des centres scientifiques ainsi que dans les régions typiques;

4°) Considérant que les missions d'études, dont le rôle principal est de délimiter les foyers permanents (zones grégarigènes), doivent être, après leur départ, prolongées par des équipes de surveillance qui appliqueront et développeront leurs méthodes d'investigation et continueront plus tard les noyaux des organismes chargés de s'opposer à la formation des phases émigrantes,

souhaite que les Gouvernements coopérants désignent parmi leur personnel agricole, et dans chaque région où la nécessité s'en manifestera, des observateurs qui recevront les directives des chefs de mission;

5°) Considérant l'importance des données météorologiques dans les recherches présentes et futures de biologie acridienne,

souhaite que les Gouvernements coopérants installent des stations météorologiques appropriées, soit permanentes, soit temporaires, partout où les indications fournies par les chefs de mission en feront apparaître la nécessité.

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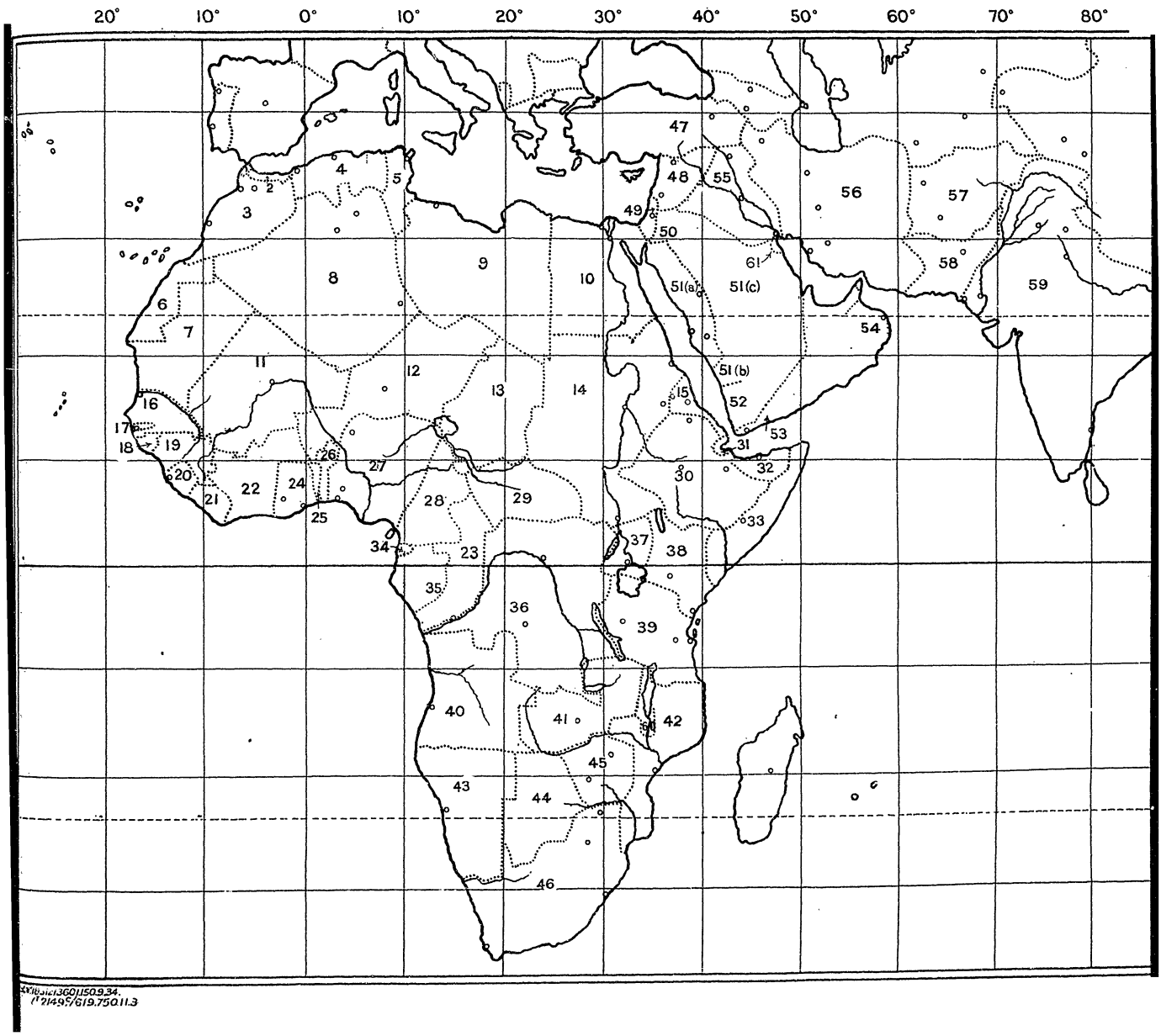
APPENDIX 24

MAP OF AFRICA AND WESTERN ASIA

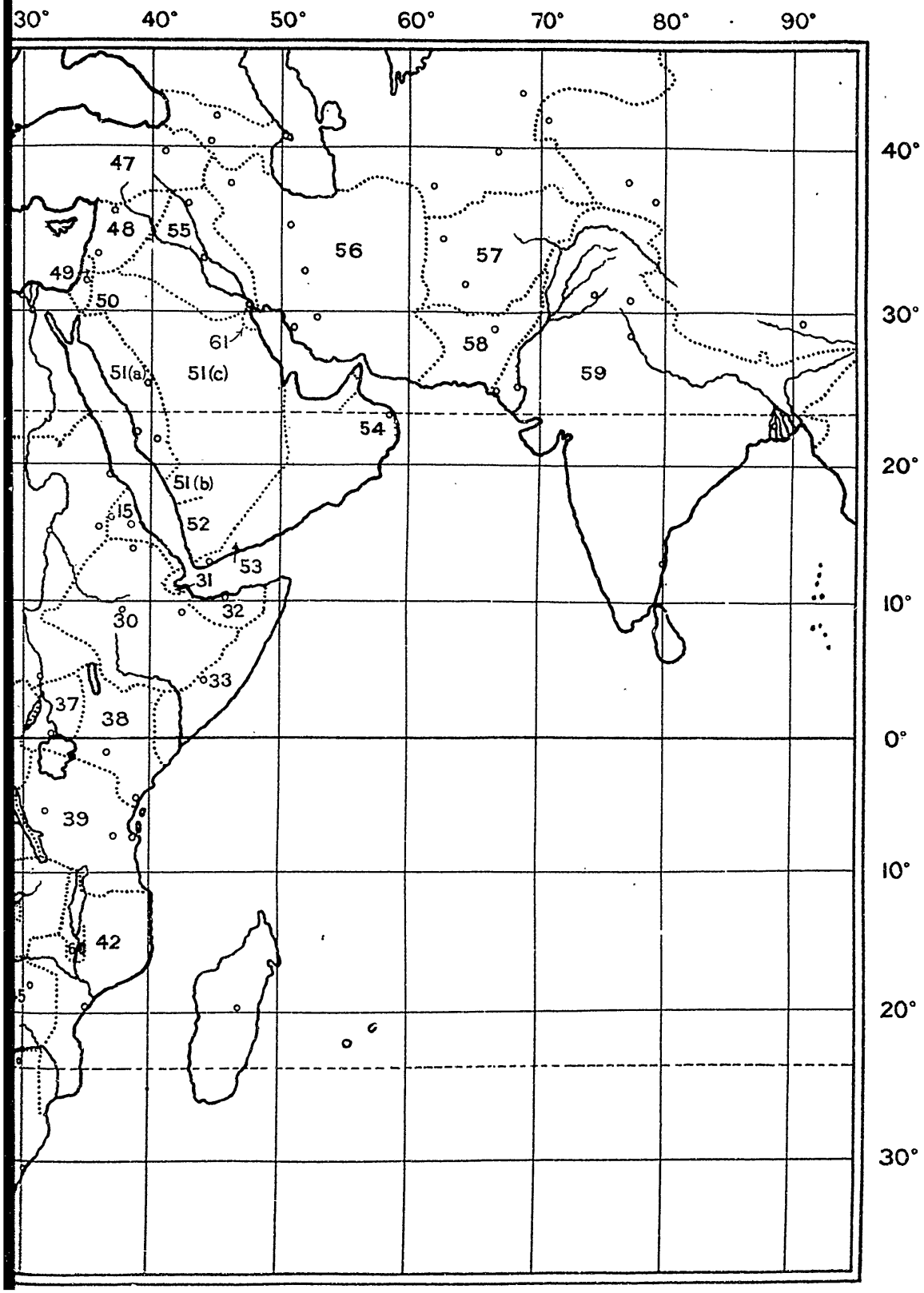
SHOWING POLITICAL AND ADMINISTRATIVE DIVISIONS.



NDIX 24

CA AND WESTERN ASIA

ND ADMINISTRATIVE DIVISIONS.



EXPLANATORY KEY.

1. Tangiers
2. Spanish Morocco
3. French Morocco
4. Algeria
5. Tunisia
6. Rio de Oro
7. French Mauretania
8. Territoires du Sud d'Algérie
9. Tripolitania and Cyrenaica
10. Egypt
11. French Sudan
12. French Niger Colony
13. French Chad Territory
14. The Anglo-Egyptian Sudan
15. Eritrea
16. Senegal
17. Gambia
18. Portuguese Guinea
19. French Guinea
20. Sierra Leone
21. Liberia
22. Ivory Coast
23. Middle Congo
24. Gold Coast
25. Togoland (British & French Mandates)
26. Dahomey
27. Nigeria & Cameroons (British Mandate)
28. Cameroons (French Mandate)
29. Ubangi-Chari
30. Abyssinia
31. French Somaliland
32. British Somaliland
33. Italian Somaliland
34. Rio Muni
35. Gabon
36. Belgian Congo
37. Uganda
38. Kenya
39. Tanganyika Territory
40. Angola
41. Northern Rhodesia
42. Portuguese East Africa
43. South West Africa
44. Bechuanaland
45. Southern Rhodesia
46. Union of South Africa
47. Turkey
48. Syria
49. Palestine
50. Transjordan
51. Saudi Arabia
    (a) Hedjaz
    (b) Asir
    (c) Nejd
52. Yemen
53. Aden & Aden Protectorate
54. Muscat and Oman
55. Iraq
56. Persia
57. Afghanistan
58. Baluchistan
59. India
60. Nyasaland
61. Koweit