

THE NEWSLETTER OF THE ORTHOPTERISTS' SOCIETY

# Metaleptea

Special Meeting Issue

## **Eighth International Meeting of the Orthopterists' Society**

International Conference on Orthopteroid Insects

Montpellier, France

August 19-22, 2001

**Organised by the Orthopterists' Society and CIRAD  
(Centre de coopération internationale en recherche  
agronomique pour le développement)**

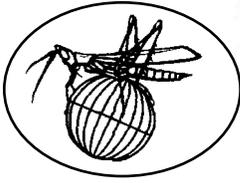


REGION

LANGUEDOC  
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# INTERNATIONAL CONFERENCE ON ORTHOPTEROID INSECTS

18th meeting of the Orthopterists' Society  
Montpellier, France, August 19-22, 2001



## Programme

### Sunday August 19

1200-1900 Registration of participants / Poster installation (coffee, drinks, refreshments available during the entire afternoon)

### Monday August 20

#### OPENING CEREMONY

0900 Opening of the Conference, Prof. Theodore J. Cohn, President of the Orthopterist Society, University of Michigan, USA  
0905 Welcome address, Michel Lecoq, CIRAD-Prifas, France  
0920 Speech from Languedoc-Roussillon Region representative  
0925 Speech from Montpellier District representative  
0930 Speech from CIRAD representative  
0935 Memorial for Prof. Marcello La Greca, Paolo Fontana, Padova University, Italia  
0950 Address of the President of the Orthopterist Society and introduction to the Conference, Prof. Theodore J. Cohn, University of Michigan, USA

1015-1030 Coffee break

#### PLENARY LECTURES

1030 **Graeme Hamilton**, APLC Director, Australia

*Operations-driven research is the key to the APLC's success*

1115 **Douglas W. Whitman**, University of Illinois, USA

*New vintage from old vines : Lubber grasshoppers and natural History for the 21st century*

1200-1330 Lunch

1330-1400 Poster session

## SYMPOSIUM 1. ARE LOCUSTS AND GRASSHOPPERS WORTH CONTROLLING ?

Moderators : **M. Lecoq**, CIRAD-Prifas, France and **J. Lockwood**, University of Wyoming, USA

- 1400 **Michel Lecoq**, CIRAD-Prifas, France  
*Are preventive actions possible ? Recent progress in Desert and Migratory Locust management in Africa.*
- 1430 **Jeffrey Lockwood**, University of Wyoming, USA  
*Can we make locust and grasshopper control sustainable ?*
- 1500-1515 Break
- 1515 **Ralf Peveling**, University of Basel, Switzerland  
*Can the environment support any more locust control campaigns ?*
- 1545 **Chris Lomer**, Royal Veterinary and Agricultural University, Copenhagen, Denmark  
*What is the place of biological control in acridid integrated pest management ?*
- 1615 **Gary Belowskyi**, University of Notre Dame, IN, USA  
*Grasshopper control : no treatment at all... any possible advantages ?*
- 1645-1700 Coffee Break
- 1700-1800 Discussion
- 1800-1830 Poster session
- 1830-2100 Welcome reception (regional buffet - Salon Sully)

## Tuesday August 21

## SYMPOSIUM 2. MOLECULES AND MORPHOLOGY: TOWARDS A SYNTHESIS OF PHYLOGENETIC METHODS

Moderator : **Theodore J. Cohn**, University of Michigan, Ann Arbor, USA

- 0830 **Christiane Amedegnato**, Muséum National d'Histoire Naturelle, France  
*Phallic complex and phylogenetic correlation within Acridomorpha.*
- 0900 **Manda Clara Jost**, Harvard University, USA and **Kerry L. Shaw**, University of Maryland, USA  
*Phylogeny of Ensifera (Orthoptera). Using Sequence Data from Four Molecular Loci, with Implications for the Evolution of Acoustic Communication*
- 0930 Coffee break
- 0940 **Piotr Naskrecki**, Harvard University, USA  
*The surprisingly vocal females - the phylogeny and evolution of female stridulation in katydids.*
- 1010 **Kerry L. Shaw**, University of Maryland, USA  
*Exploring the genomic jungle: testing species boundaries using gene genealogies.*
- 1040 Break
- 1050-1200 Discussion
- 1200-1330 Lunch (Board meeting of OS during lunch at a particular table)
- 1330-1400 Poster session

### **SYMPOSIUM 3. COMPARATIVE ECOLOGY AND FAUNISTICS OF GRASSHOPPERS IN THE GRASSLANDS OF THE WORLD.**

Moderator : **Maria Marta Cigliano**, La Plata National University, Argentina

- 1400 **Charles Bomar**, University of Wisconsin, USA  
*Restoration and the Native Landscape: What are the grasshoppers trying to tell us?*
- 1430 **David M. Hunter, P.W. Walker and R.J. Elder**, Australian Plague Locust Commission, Canberra, Australia  
*Adaptations of locusts and grasshoppers to overcome limiting factors in their environment.*
- 1500-1510 Break
- 1510 **Daniel Otte**, The Academy of Natural Sciences, Philadelphia, USA  
*Morphological Adaptations to living in grasslands.*
- 1540 **Alexandre V. Latchininskii**, University of Wyoming, USA  
*Application of Remote sensing and GIS to grasshopper ecology in temperate Eurasia and North America: how powerful is the tool?*
- 1610-1630 Coffee break
- 1630 **Michael Sergeev**, Novosibirsk State University, Russia  
*Biological diversity of Orthoptera in grasslands of temperate Eurasia: From taxa to communities.*
- 1700 **Maria Marta Cigliano**, La Plata National University, Argentina  
*Grassland grasshopper community composition and temporal variation in the Pampas, Argentina*
- 1730-1800 Discussion
- 1800-1830 Poster session

### **Wenesday August 22**

### **SYMPOSIUM 4. BIOLOGICAL CONTROL AND ITS ENVIRONMENTAL CREDENTIALS**

Moderators : **Chris Lomer**, Royal Veterinary and Agricultural University, Copenhagen, Denmark and **David Hunter**, APLC, Australia  
(in collaboration with the AAAI biocontrol working group)

First half (25 minute talks with 5 minutes questions)

- 0830 **Jürgen Langewald, Ralf Peveling and Ine Stolz**, International Institute of Tropical Agriculture, Benin; University of Basel, Switzerland  
*Large-scale environmental impact of biological control and the future of grasshopper control in the Sahel*
- 0900 **Richard Milner**, CSIRO and **David Hunter**, Australian Plague Locust Commission  
*Recent developments with the use of fungi as biopesticides against locusts and grasshoppers in Australia*
- 0930-0945 Coffee break

Second half : Progress reviews in the implementation of biocontrol  
(12 minute talks with 3 minutes questions)

- 0945 **Ludivina Barrientos**, Technological Institute of Higher Education, Tamaulipas, México  
*Advances in Biological Control of locusts and grasshoppers in México*
- 1000 **Graeme Hamilton**, APLC, Australia  
*Biocontrol place in acridid IPM in Australia*
- 1015 **James Everts, Alpha Diallo, Abdoulaye Danfa and Wim Mullié**, LOCUSTOX, Senegal  
*New ecotoxicity data on Green Muscle*
- 1030-1045 Coffee break
- 1045 **Candido Santiago-Alvarez**, University of Cordoba, Spain  
*A short overview of locust biocontrol in Spain*
- 1100 **Carlos Lange**, CEPAVE, Argentina  
*Twenty years after the introduction of *Nosema locustae* in Argentina: an update*
- 1115 **Bonifacio Magalhaes**, Embrapa, Brazil  
*Development of a mycopesticide for locust control in Brazil*
- 1145-1215 Summary and introduction to panel discussion **C. Lomer**  
Panel discussion (led by **J. Lockwood, J. Everts** and **C. Lomer**)  
Points for action, areas for further research
- 1215-1330 Lunch
- 1330-1400 Poster session
- 1400-1445 Society Affairs (Business Meeting) (Room Citadelle 1)

## ORAL PRESENTATIONS

- Moderator: **Christiane Amedegnato**, Muséum National d'Histoire Naturelle, France
- 1500 **Olivier Bethoux** and **André Nel**, Muséum National d'Histoire Naturelle, France  
*Wing venation pattern, sister group and phylogeny of the Orthoptera.*  
Talk and Poster
- 1515 **Fernando Montealegre-Z.**, University of Toronto, Canada & Colombia  
*The Spiny Devil Katydid, Genus *Panacanthus* : Evolutionary Study of Acoustic Behavior and Morphological Traits.*  
Talk and Poster
- 1530 **David C. Eades**, University of Illinois, USA.  
*Version 2 of the Orthoptera Species File Online.*  
Talk and Poster
- 1545 Coffee break
- 1600 **Holger Braun & Otto von Helversen**, Universität Erlangen, Germany  
*The Bushcrickets (Orthoptera: Tettigoniidae) of a Mountain Rainforest in the Andes of southern Ecuador and Some Aspects of their Ecology in Relation to Elevation.*  
Talk and Poster
- 1615 **Bernard Defaut**, Association pour la Caractérisation et l'Étude des Entomocénoses, France  
*Entomocenotic, a method to study orthopteroid populations*

- 1630 **Gregory Sword**, Northern Plains Agricultural Research Laboratory, USDA, USA  
*The Relationship Between Density-Dependent Aposematism and Density-Dependent Gregariousness in Palatable and Unpalatable Schistocerca emarginata (=lineata) Grasshopper Populations.* Talk and Poster
- 1645 **Paul W. Walker** and **J. Graeme Hamilton**, Australian Plague Locust Commission, Australia  
*Development and management of the 1999/2000 outbreak of the Australian plague locust (Chortoicetes terminifera) in eastern Australia - why locusts are worth controlling.* Talk and Poster
- 1700 **Conference Closure, Michel Lecoq**
- 1710-1745 Disassembly of posters
- 1745 Departure for the gala dinner in bus (meeting point Foyer Pasteur)
- 1830 **Gala dinner in Camargue** (« Manade du Ternen »)

## Thursday August 23

Carcassonne tour : visit of the medieval city

## Friday August 24 - Tuesday August 28

Post conference tour in the Southern part of Massif Central

- 0815 Departure (meeting point near Place de la Comédie, in front New Hôtel du Midi)

**Plenary and symposia..... Einstein Room**

**Poster sessions ..... Foyer Pasteur**

**Coffee breaks..... Foyer Pasteur**

**Lunches and Welcome reception..... Salon Sully**

(lunch tickets for accompanying persons will be available at the reception desk at the price of 100 F).

## SPECIAL EVENTS :

### Orthopterist's Society Board meeting and Business meeting

Tuesday, August 21, 12h00-13h30 Board meeting during lunch (particular table)

Wednesday, August 22, 14h00-14h40 Business Meeting of the OS, room Citadelle 1

### Association for Applied Acridology International meetings

Tuesday, August 21, 18h00-21h00 at Le CORUM, room BE1

Tuesday, August 21, 21h30, Dinner, La Diligence restaurant

Wednesday, August 22, 12h15-13h30 during the lunch (particular table)

### Behaviorists group meetings

Tuesday, August 21, 18h30-21h00 at Le CORUM, room Citadelle 1

Tuesday, August 21, 21h30, Dinner, Le Menestrel restaurant

### Systematists group meeting

Tuesday, August 21, 18h30-21h00 at Le CORUM, room Citadelle 2

Tuesday, August 21, 21h30, Dinner, Le Menestrel restaurant



## Poster List Arranged by Subject (numbers indicate poster panel)

(Grouped within each subject generally by topic)

### Systematics, Biogeography, Bioinformatics

- 1. The phylogeography of rainforest grasshoppers - a comparison of molecular and morphological markers.**  
Hochkirch, Axel
- 2. Phylogenetic Relationships of North American *Schistocerca* (Orthoptera: Acrididae: Cyrtacanthacridinae) and Problems with current taxonomy.**  
Song, Hojun
- 3. Genetic structure of populations of the alpine grasshopper, *Melanoplus alpinus*: Cryptic species or ancient paraphyly?**  
VanDyke, K., D. Kazmer & J. Lockwood
- 4. Pleistocene glaciations as a factor of speciation in the non-flying bush-crickets of the genus *Anonconotus* (Decticinae) in the Central European mountains.**  
Carron, Gilles & Eric Sardet
- 5. The Spiny Devil Katydids, Genus *Panacanthus*: Evolutionary study of acoustic behavior and morphological traits.**  
Montealegre-Z., Fernando
- 6. Song and morphological characteristics of a group of syntopic tree cricket species of the Genus *Oecanthus* from Southern India.**  
Biswas, Sayantan, Sapna Metrani & Rohini Balakrishnan
- 7. A new genus of phalangopsid cricket (Orthoptera, Grylloidea, Phalangopsidae), which lives in the leaf litter of forests in Brazil.**  
Rocha, A., C. Lopes-Andrade, C. F. Sperber & A. Mesa
- 8. Investigation on subspecies of *Locusta migratoria* in Khuzestan Province.**  
Azmayeshfard, P. & Y. Khajehzadeh
- 9. Distribution of Tettigoniinae (Orthoptera: Tettigoniidae) bush-crickets in Turkey: the importance of the Anatolian Taurus Mountains in biodiversity.**  
Çiplak, Battal
- 10. Systematics and phlogeny of the genus *Acanthops* Serville (Mantodea: Acanthopinae).**  
Lombardo, F. & S. Ippolito
- 11. The Surprisingly Vocal Females: The Phylogeny and Evolution of Female Stridulation in Katydids (Orthoptera: Tettigonioidea). Poster and Talk, Symp. 2, Tues. 0940.**  
Naskrecki, Piotr
- 12. Phylogeny of Ensifera (Orthoptera) using sequence data from four molecular loci, with implications for the evolution of acoustic communication. Poster and talk, Symp. 2, Tues. 0900.**  
Jost, Manda Clair & Kerry L. Shaw
- 13. Exploring the Genomic Jungle: Testing Species Boundaries Using Gene Genealogies. d Talk, Symp. 2, Tues. 1010, Powerpoint presentation available here.**  
Shaw, Kerry L.

14. **Evolution of the male genitalia in stick insects (Phasmatodea).**  
Bradler, Sven
15. **Version 2 of the Orthoptera Species File Online. Poster and Talk. Oral Pres., Wed. 1530.**  
Eades, David C.
16. **Fauna Europaea: Orthoptera.**  
Heller, K.-G. & Fauna Europaea Committee
17. **German Orthoptera collections specimen database - current progress with a review of the type specimens.**  
Ingrisch, S., K. Riede & K.-H. Lampe
18. **Integration of Orthoptera collection data within a "Virtual Museum": the "German Orthoptera collections database."**  
Riede, K., S. Ingrisch & C. Dietrich
19. ***Podisma sapporensis* (Orthoptera: Acrididae): is it a new model of chromosome speciation?**  
Bugrov, Alexander G., Elzbieta Warchalowska-Sliwa, Haruki Tatsuta & Shin-ichi Akimoto
20. **The relationship between karyotype diversity and taxonomic differentiation in Landrevinae (Orthoptera, Gryllidae).**  
Warchalowska-Sliwa, Elzbieta & Andrey V. Gorochov
21. **The behaviour of chromosomes of the different acridid species during the first meiotic prophase: Taxonomic diversity and evolutionary diversification.**  
Vysotskaya, L. V., O. S. Kornienko & M.G.Sergeev
22. **Possible phylogenetic relations of some Holarctic acridids as derived from mitochondrial ribosomal RNA sequences.**  
Guljaeva, O. N., A. I. Shevchenko, L. V. Vysotskaya & M. G. Sergeev
23. **Phylogeny of Acrididae (Orthoptera, Acridoidea) as deduced from mitochondrial DNA genes sequences.**  
Chintauan-Marquier, Ioana & François Pompanon
24. **A progress report on the molecular phylogenetic analysis of some species of the genus *Melanoplus* Orthoptera: Acrididae).**  
Chapco, William & Greg Litzenberger
25. **A new tribe of Proscopinae (Orthoptera, Eumastacoidea, Proscoppiidae).**  
Bentos-Pereira, Alba
26. **Wing venation pattern, sister group and phylogeny of Orthoptera. Poster and Talk, Oral Pres., Wed. 1500.**  
Bethoux, Olivier & André Nel
27. **Preliminary essay on the higher classification of orthopteroid insects.**  
Gorochov, A. V.
28. **Some theoretical aspects of taxonomy (remarks by the practical taxonomist).**  
Gorochov, A. V.
29. **The most interesting finds of orthopteroid insects in the end of the twentieth century.**  
Gorochov, A. V.

## Ecology and Faunistics

30. **The bushcrickets (Orthoptera: Tettigoniidae) of a mountain rainforest in the Andes of Southern Ecuador and some aspects of their ecology in relation to elevation. Poster and talk, Oral Pres., Wed. 1600**  
Braun, Holger & Otto von Helversen
31. **Etude des peuplements d'orthopteres de la Reserve Naturelle de Montenach (France).**  
Sardet, Eric & Christelle Jager
32. **La faune orthoptérologique de quelques oasis algériennes (Béchar, Adrar, Tamanrasset, Djanet et Ghardaïa).**  
Doumandji-Mitiche B., S..Doumandji, A.Kadi, F.Z. Kara, A.Ayou, Y.Zerghoun & L.Saharaoui
33. **Research on orthopterans in semi-arid climate: case of the region of Sétif (north-east of Algeria).**  
Bounechada, M. & S. E. Doumandji
34. **Contribution à la connaissance de la diversité biologique des Caelifera (Orthoptera) au Maroc: actualisation du catalogue et approche biogéographique.**  
Badih, Abdelmounim, Ursula María Osuna, José Antonio Jurado & Felipe Pascual
35. **Diversite biologique des orthopteres dans les formations vegetales de "Sierras al Sur de Jaen" (Andalousie, Espagne).**  
Badih, Abdelmounim, José Antonio Jurado, Ursula María Osuna, Pedro Fortis & Felipe Pascual
36. **The orthopteroid insects of the Abruzzo National Park (Central Apennine, South Italy): a preliminary checklist. (Blattodea, Mantodea, Orthoptera, Phasmatodea, Dermaptera).**  
Fontana, Filippo Maria Buzzetti, Paola Tollis & Augusto Vigna Taglianti
37. **The orthopteroid insects of the Veneto region (Northern-Eastern Italy). (Blattaria, Mantodea, Isoptera, Orthoptera, Phasmatodea, Dermaptera, Embiidina).**  
Fontana, P., F. M. Buzzetti, S. Celotto & A. Cogo
38. **Towards a synthesis of the Orphtoptera of Italy.**  
Fontana, P. R. Kleukers, B. Massa & B. Odé
39. **Italian endemic Orthoptera.**  
Massa, Bruno, Paolo Fontana & Roy Kleukers
40. **Ecology and ethology of acridids in hill, plateau and plain ecosystems.**  
Haldar, P.
41. **Chemical control of Desert Locust (*Schistocerca gregaria*) in environmentally sensitive areas in eastern Africa.**  
Wiktelius, Staffan, Jonas Ardo & Thord Fransson
42. **Grasshopper (Orthoptera: Acridoidea) and plant community relationships in the argentine pampas.**  
Torrusio, Sandra, María Marta Cigliano & María Laura de Wysiecki
43. **Spatio-temporal analysis of grassland grasshoppers (Orthoptera: Acridoidea) density and environmental Factors in southeastern Buenos Aires, Argentina: application of remote Sensing and GIS.**  
Torrusio, Sandra & María Marta Cigliano
44. **Etude par l'analyse factorielle des correspondances de la répartition des Orthoptères dan trois stations du Parc National de Taza (Jijel, Algérie).**  
Rouibah, M. & S. Doumandji

45. **Ecological succession in herbaceous environments and displacement capacities in Acrididae.**  
Picaud, F. & D. Petit
46. **Long-term changes in the Orthoptera assemblages of an isolated peninsula in Hungary.**  
Nagy, B., F. Szentkirályi & F. Kádár
47. **Why does local cricket (Orthoptera: Grylloidea) species richness not increase with forest remnant size?**  
Pengel, H. O., S. M. Soares, C. F. Sperber & C. Lopes-Andrade
48. **Ecological plasticity of the endemic *Isophya costata* (Orthoptera: Tettigonidae) in the Carpathian Basin exemplified by syntopic Orthoptera assemblages.**  
Nagy, B. & G. Szövényi
49. **How do orthopteran communities indicate the effect of a prolonged disturbance to the wet grasslands?**  
Kisbenedek, T.
50. **Can we use Orthoptera as a probe for global warming in high mountains?**  
Guéguen, Alain
51. **Distribution patterns of Orthoptera in relation to climatic factors in Brittany (France).**  
Dusoulier, François & Alain Guéguen
52. **The short-term effects of fire on grasshopper species abundance and diversity.**  
Divya, B. U., Sapna Metrani & Rohini Balakrishnan
53. **Grasshoppers and the Lesser Kestrel in the Crau steppe (southern France, Bouches-du-Rhône).**  
Braud, Y. & Ph. Pilard
54. **Effects of grasshopper densities and climate conditions on grasshopper survival and reproduction.**  
Branson, David H.
55. **The impact of developing virgin lands and irrigation on quantitative and qualitative changing of Acridofauna.**  
Abashidze, Eleonora
56. **Spatial distribution patterns of African Mole Cricket, *Gryllotalpa gryllotalpa africana* in Qena Governorate (Upper Egypt)**  
Amin, Ahmed A., M. A. Essa & M. F. Gergis

### **Biology, including Behavior, Life History, Morphology, Physiology, etc.**

57. **Leichardt's grasshopper *Petasida ephippigera* - A northern Australian Icon.**  
Lowe, Lynette M.
58. **Does the allelochemicals in *Calotropis procera* plant have the effectiveness on the food utilization of *Poecillocerus bntonius* (Acrididae: Orthoptera)?**  
Al-Otaibi, S. A. & G. Elsayed
59. **Etude de certains aspects biologiques, écologiques et comportementaux d'*Ocneridia volxemi* (Orthoptera: Pamphagidae) dans la région de Sétif (Nord-est d'Algérie).**  
Bounechada, M. & S. E. Doumandji
60. **Riley was right: ectoparasitic mites reduce survivorship, and fecundity in host grasshoppers.**  
Hammond, George Starr

61. **The influence of various host plants on the distribution and development of *Oedaleus nigeriensis*, (Orthoptera: Acrididae) in Nigeria.**  
Nzekwu, A. N. & A. E. Akingbohunbe
62. **The Structure of spermatodotes in Shield-back Bushcrickets (Tettigoniidae, Tettigoniinae: *Platycleis* & *Metrioptera* spp.).**  
Vahed, Karim
63. **On the relationship between vegetation structure and morphology in grasshopper assemblages (Orthoptera: Acrididae).**  
Orci, K. M. & T. Kisbenedek
64. **Labrum sensilla in the Moroccan Locust: relationship with its polyphagous diet.**  
El Ghadraoui, L, D. Petit & F. Picaud
65. **Robust hair sensilla used for sound production in New Zealand giant wetas: a novel mechanism.**  
Field, L. H. & K. Roberts
66. **Behavioural study on *Calliptamus barbarus*. First notice on its sound production. (Orthoptera: Acrididae: Catantopinae).**  
Larrosa, E., M. D. García, E. Clemente & J. J. Presa
67. **Initial data on the acoustic behaviour and sound production of *Rhammatocerus pictus* and *Rhammatocerus brunnea* (Orthoptera, Gomphocerinae).**  
García, M. D., E. Lorier, M. E. Clemente, E. Larrosa & J. J. Presa
68. **Hungarian and Greek males of *Stenobothrus fischeri* use different courtship songs.**  
Orci, K. M. & O. von Helversen
69. **Hybrid zone between closely related grasshopper species of the *Chorthippus albomarginatus*-Group (Orthoptera: Gomphocerinae).**  
Vedenina, V. Yu. & O. von Helversen
70. **Song function in male ambidextral grigs (Orthoptera: Haglidae, *Cyphoderris*).**  
Morris, G. K., P. DeLuca, M. Norton & A. C. Mason
71. **Amplified fragment length polymorphism for the analysis of genetic structure in grasshopper populations.**  
Tatsuta, Haruki & Roger K. Butlin
72. **Locomotory activity measurements in the light phase of transition.**  
Hoste, B., A. De Loof & M. Breuer
73. **Movement patterns of local orthopteran assemblages in a naturally fragmented habitat.**  
Szövényi, G.
74. **A molecular technique for the analysis of grasshopper host plant use.**  
Sword, Gregory A. & Laura B. Senior
75. **The relationship between density-dependent aposematism and density-dependent gregariousness in palatable and unpalatable *Schistocerca emarginata* (=lineata) grasshopper populations. Poster and Talk, Oral Pres. Wed. 1630.**  
Sword, Gregory A.
76. **Why do crickets (Orthoptera: Grylloidea) fall in pitfall traps?**  
Sperber, C. F., C. Lopes-Andrade, A. Rocha, S. M. Soares

77. **Changes in recombination, morphological variation and the central marginal distribution of *Dichroplus pratensis* (Melanoplinae: Acrididae).**  
Martí, Dardo A. & Claudio J. Bidau
78. **Variation of body size in *Dichroplus pratensis* (Melanoplinae: Acrididae): a case of the converse of Bergmann's rule.**  
Martí, Dardo A. & Claudio J. Bidau
79. **Why do males of some Phalagopsidae (Orthoptera, Grylloidea) present metanotal prominences? Testing two hypotheses with scanning electron microscopy.**  
Lopes-Andrade, C. & C. F. Sperber
80. **Ingestive conditioning in the grasshopper *Zonocerus variegatus* (Orthoptera: Pyrgomorphidae).**  
Le Gall Philippe. & Zanitas Djihou
81. **Fluctuating symmetry, developmental instability and reproductive success in crickets.**  
Mallard, Samantha & Chris Barnard
82. **The number of spermatophores transferred correlates with mating duration in *Melanoplus differentialis* (Orthoptera:Acrididae).**  
Hinn, J. & M. Niedzlek-Feaver
83. **Parental size influence on offspring phenotype in *Schistocerca americana* (Orthoptera: Acrididae).**  
Kosal, E. F. & M. Niedzlek-Feaver
84. **Production of acridid biomass and its utilisation for human welfare**  
Das, Amlan, Sarasi Das & P. Haldar
85. **Embryonic development strategy of *Doclostaurus maroccanus* at two different latitudes.**  
Quesada-Moraga, E., P. Valverde-García & C. Santiago-Alvarez
86. **Effects of moisture on egg survivorship and hatching time in two species of lubber grasshopper.**  
Stauffer, Timothy W. & Douglas W. Whitman
87. **Effect of starvation, rearing density and mating on the morphology and development oocyte and follicle resorption bodies in the Lubber Grasshopper, *Romalea microptera*.**  
Luong-Skovmand, My Hanh & Douglas W. Whitman
88. **Postembryonic development of *Stiphra* sp. (Orthoptera: Proscopiidae) feeding on *Psidium guajave* (Myrtaceae) leaves in the laboratory.**  
Lima, Iracilda Maria de Moura & Lígia Helena de Andrade
89. **Extended life cycle of the alpine grasshopper, *Stenobothrus coticus*(Orthoptera, Acrididae): a response to the unpredictable alpine growing season.**  
Guéguen, Alain

## Plague Locust Biology

90. **Effets de l'alimentation en *Peganum harmala* (Zygophyllaceae) sur le tube digestif du criquet pèlerin *Schistocerca gregaria* (Orthoptera: Acrididae).**  
Idrissi Hassani, L. M. & J. Hermas
91. **The search for solitary desert locust (*Schistocerca gregaria*) habitat during winter breeding in the plains of the Sudan Red Sea coast.**  
Woldewahid, G., T. Abate, M. Butrous, O. Abdalla, A. M. Khidir, B. Mustafa, I. Magzoub, O. Abdin, A. Stein, W. van der Werf, A. van Huis

92. **Analysis of the upsurge dynamics of the Desert Locust (*Schistocerca gregaria* in Mauritania (1993-1995).**  
Ould Babah, M. A., M. L. Ould Ahmedou, L. M. Idrissi Hassani, M. F. Courel & J. F. Duranton
93. **Shifts in the outbreak area of the Brown Locust in southern Africa.**  
Kieser, Margaret, Anneke Thackrah & Jane Rosenberg
94. **Characterization of the vegetation of the multiplication and gregarisation biotopes of *Schistocerca gregaria* (Acrididae: Orthoptera) in the Algerian south.**  
Guendouz-Benrima, A., B. Chara & B. Doumandji-Mitiche
95. **Outbreaks of *Schistocerca interrita* in northern Peru.**  
Duranton, Jean-François, A. Monard & Ricardo Solano
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**Phallic complex and phylogenetic correlation within Acridomorpha.** Symp. 2, Tues. 0830**Amedegnato, Christiane**

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**Investigation on Subspeies of *Locusta migratoria* in Khuzestan Province.** Poster 8**Azmayeshfard, P.<sup>1</sup> & Y. Khajehjadeh<sup>2</sup>**<sup>1</sup> Plant Protection Dep. College of Agriculture, Tehran University, Karaj, Iran. pafard@chamran.ut.ac.ir<sup>2</sup> Science and Research Branch, Islamic Azad University, Tehran, Iran.

The migratory locust is a major pest in sugarcane field and develop in rice, corn, and surghum fields in Khuzestan province. Taxonomic differentiation of this subspecies was compared with the nine subspecies in the world. This research was carried out during 1998-2000. Besides biological characteristics, 28 morphometric characters were measured, compared with other subspecies, and then analysed by Duncan and Cluster Analysis methods. Biological studies were done on different population in seven regions of Khuzestan province. 95% correlation was between population of Khuzestan to population of Africa, India and Pakistan. The results showed that all the Khuzestan populations belong to one subspecies, and are highly similar to *L. migratoria migratorioides* Reich et Fairm. The field studies showed that the Khuzestan populations are in solitary status of this subspecies according to E/F and F/C ratios in 1996-1999.

Key Words: morphometric, population, cluster analysis.

**A New Tribe of Proscopinae (Orthoptera: Eumastacoidea: Proscopiidae).** Poster 25**Bentos-Pereira, Alba**

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Liana's (1972) subfamily Proscopiinae comprises a great diversity of genera. Their interrelationships cannot be elucidated without a complete study of the male and female genitalia. The new tribe Tetanorhynchini is erected here; its genera share external morphological features and characters derived from both the male and the female genitalia. The included genera are Cephalocoema, Tetanorhynchus, Pseudoastroma, Scleratoscopia, Orienscopia and a new genus. Distribution maps and tables of characters for the genera and the new tribe are provided.

## Wing Venation Pattern, Sister Group and Phylogeny of Orthoptera. Poster 26, Oral pres., Wed. 1500

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Prior to a phylogenetic analysis of the "orthopteroid" clade based on fossils (mostly known from forewings) we present a reinvestigation of wing venation. Various "orthopteroid" venation patterns have been proposed. That of Sharov (1968: fig. 1) is incongruent with the currently accepted insect venation pattern (Kukalová-Peck, 1991: fig. 6.3), viz. the vein he named MP (normally neutral or concave) is convex. Kukalová-Peck's (1991: figs 6.18 A,B) or Carpenter's (1992: fig. 95.4") patterns suppose the presence of pseudo-veins in the medio-cubital area, but their secondary nature remains undemonstrated. The revision of *Gerarus bruesi* suggests that the "hemipteroid" interpretation of its wing venation (Kukalová-Peck and Brauckmann, 1992) is erroneous: there is no fusion of MA with radial stem. Nevertheless, we agree with their interpretation of the medio-cubital area. It conforms to "orthopteroid" pattern: a convex composite vein (M + CuA) is separated into a neutral vein (M) and a strongly convex vein (CuA), that is fused with a concave anterior branch of CuP. The resulting composite vein (CuA + CuP) is convex. Specimens assigned to Narkeminidae are reviewed. They clearly have the "orthopteroid" medio-cubital structure. Several other fossil taxa assigned to the plesion "Protorthoptera" (sensu Carpenter, 1992) share this pattern. It conforms to the venation of recent taxa. We propose including Orthoptera and a part of the former 'Protorthoptera' in a common clade. The sister-group of Orthoptera is defined. The new "orthopteroid" lineage appears as old as first recorded Pterygota (Namurian, Carboniferous). A cladistic analysis of Orthoptera is performed, using the new wing venation pattern. The results partly resolve relationships between Caelifera and Ensifera and relationships between the major clades of modern Ensifera. The use of the fossil taxa in phylogenetic analyses of the "orthopteroid" insects is discussed.

Key words: fossil, Protorthoptera, Caelifera, Ensifera, informativity.

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## Song and Morphological Characteristics of a Group of Syntopic Tree Cricket Species of the Genus *Oecanthus* from Southern India. Poster 6

Biswas, Sayantan, Sapna Metrani & Rohini Balakrishnan

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Tree crickets of the genus *Oecanthus* (Gryllidae: Oecanthinae) are represented by 64 extant species, mostly distributed in the New World. Only four species, namely *O. bilineatus*, *O. henryi*, *O. indicus* and *O. rufescens* occur in South Asia, of which *O. bilineatus* and *O. henryi* are restricted to India and Sri Lanka respectively. We present data on the morphology and calling songs of the four species from a semi-urban habitat in Southern India. *O. henryi*, which was earlier recorded only from Sri Lanka, is also reported here from Southern India. In an attempt to apply quantitative methods using a relatively large set of characters to classify the above species, we examined 48 external morphological characters (both qualitative and quantitative) and analyzed the same using clustering and ordination methods based on overall similarity. This approach was successful in unambiguously delineating the four *Oecanthus* species. We subsequently examined the structure of the calling songs of each of these species. *O. bilineatus* and *O. rufescens* had relatively long trills (more than one second in length) whereas *O. henryi* produced short chirps (less than 300 milliseconds in length). *O. indicus* showed more variation, ranging from short chirps (400-750 milliseconds in length) to trill-like calls (one to two seconds long), sometimes within the same individual. The songs of *O. bilineatus* and *O. rufescens* had higher carrier frequencies (3.6-4.4 kHz and 3.0-3.5 kHz respectively) whereas those of *O. henryi* (2.6-3.0 kHz) and *O. indicus* (2.3-2.7 kHz) were somewhat lower. The song of *O. bilineatus* had the highest syllable rate (59-79 syllables per second), followed by *O. henryi* (50-58 syllables per second). Both *O. rufescens* and *O. indicus* produced songs with lower syllable rates (45-50 and 37-47 syllables per second respectively).

Key words: acoustic, taxonomy, Oecanthinae, South Asia.

**Evolution of the Male Genitalia in Stick Insects (Insecta: Phasmatodea).** Poster 14**Bradler, Sven**

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Until now the relationships within the Phasmatodea have not been investigated using the theory and methods of phylogenetic systematics. Based mainly on male genital structures it has now been possible to find monophyletic groups previously unknown while many of the traditional “subfamilies” proved to be para- or polyphyletic.

The Phasmatodea consist of the two basal sister groups Timematodea with only few species described and the Euphasmatodea, which include the remaining species. In the ground pattern of all Phasmatodea a derivative of the 10th abdominal sternum of the male forms a rigid, hook-shaped clasper, the so-called vomer, which grasps the posterior margin of sternum 7 of the female during copulation. Apparently the vomer has been reduced several times within the Phasmatodea, and its function has been taken over by various other structures. In one group of the Euphasmatodea the vomer is replaced by the modified tergum 10, which forms a pair of forceps.

The assumption that this new taxon is monophyletic is strongly supported by the basiventral articulation of the tergal margins of abdominal segment 10, the narrow base of the vomer and its transverse tergal adductors. In a subordinated group the tergum 10 is medially divided into movable hemitergites. The new taxon comprises the Eurycanthinae and members of the “Lonchodinae”, “Necrosiinae”, “Pachymorphinae” and “Phasmatinae”. As there are no features supporting the monophyly of the four latter taxa it is likely that they are artificial groupings.

Key words: phasmids, phylogenetic systematics, morphology.

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***Podisma sapporensis* Shir. (Orthoptera: Acrididae): is it a new model of chromosome speciation?** Poster 19
**Bugrov, Alexander G. <sup>1</sup>, Elzbieta Warchalowska-Sliwa <sup>2</sup>, Haruki Tatsuta <sup>3</sup> & Shin-ichi Akimoto <sup>4</sup>**

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The grasshopper *Podisma sapporensis* consists of two main chromosome races in Hokkaido, Sakhalin and Kunashiri Islands. Sakhalin population and the western group of populations in Hokkaido have diploid number of chromosomes  $2n$  (male)=23 and  $2n$  (female) = 24 (sex determination: XO male/XX female). A population in Kunashiri Island and the eastern group of populations of this species in Hokkaido belonging to the XY race resulting of Robertsonian translocation between originally acrocentric the X-chromosome and M5 autosome in homozygous state consist of different sex determination ( $2n$  male= 20 + neo-X+neoY/ $2n$  female=20 + neo-XX). In Hokkaido these races are geographically isolated by the mountainous system consisting of the Mts. Daisetsu and Hidaka range, occupying the central part of the Island.

Various levels of polymorphism for the pericentric inversions and C-banding variation exist in different chromosomes throughout populations in both chromosome races. In some solitary populations in Hokkaido (population in the summit of Mt. Yotei, populations in the vicinity of Naganuma, Oketo and Tanno) pericentric inversions are fixed in some pairs of chromosomes, which enables marking the discrete karyomorphes. In Mt. Daisengen population all chromosomes are two-armed, presumably resulting from the pericentric inversions. The level of diversity of *P. sapporensis* karyotypes would provide a new perspective on the evolutionary process of different karyotype in Orthoptera.

A large amount of polymorphism in chromosomes suggests that karyotypic diversification is undergoing in *P. sapporensis*. We also proposed that *P. sapporensis* would be divided into four chromosome subraces in the XO chromosome race and two chromosome subraces in the XY chromosome race, based on karyotypic features. These races may have been established by substantial climatic changes during glacial epoch.

## Pleistocene Glaciations as a Factor of Speciation in the Non-flying Bush-crickets of the Genus *Anonconotus* (Decticinae) in the Central European Mountains. Poster 4

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During the Pleistocene period, certain populations of alpine plants and invertebrates spent the glacial period(s) in glacial refugia (“Massifs de refuge”) located in the Southern Alps. Some of these isolated populations differentiated in endemic subspecies or species. The medium sized, micropterous bush-crickets of the genus *Anonconotus* Camerano, 1878 (Decticinae) includes, according to current description, 3 species: *A. alpinus* (Yersin, 1858), *A. baracunensis* (Nadig, 1987) and *A. apenninigenus* (Targioni-Tozzetti, 1881). In 1999 - 2000 we compiled available data and visited the Western Alps to make a morphological study of all *Anonconotus*. We drew up a distribution map of each species. *A. alpinus* is widespread in the dorso-external margin of the whole Alpine Arc, except for an isolated Southern site and a large gap in the central Swiss Alps which was very strongly covered with ice during glacial maxima. *A. baracunensis* is endemic of a very limited area in the Western Alps, a region which holds many micro-endemic taxa which are thought to have differentiated in glacial refugia. *A. apenninigenus* is present in the inner margin of the Western Alpine Arc and in the Italian Apennine mountains. It reached this last area probably during a glacial period. We found that a clearly distinct species, formerly mistaken as *A. apenninigenus*, was present in a limited area of the North-Western Italian Alps, in the Gran paradiso massif. The main character separating this new species is the distinctive shape of titillators, a particularly important structure used in systematics of Decticinae. The area where this new *Anonconotus* was found, formed glacial refugia in its Southern margin and was surrounded by two large glaciers which were impassable barriers to the terrestrial fauna. This same area is presently inhabited by several endemic species and subspecies of plants and insects.

Key words: Systematics, alpine fauna, biogeography, glacial refugia.

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## A Progress Report on the Molecular Phylogenetic Analysis of some Species Belonging to the Genus *Melanoplus* (Orthoptera: Acrididae). Poster 24

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This research expands upon a previous molecular analysis of phylogenetic relationships within the genus *Melanoplus* by incorporating additional mitochondrial genes and taxa. Included in the latter are the now-extinct Rocky Mountain grasshopper *M. spretus*, two “relict” species: *M. gaspensiensis* and *M. madeleineae* as well as members of 2 genera with uncertain affiliations to *Melanoplus*: *Phoetaliotes* and *Bohemanella*.

Portions of 4 mitochondrial genes (cytochrome b, cytochrome oxidase subunits I and II, and NAD dehydrogenase subunit II) were sequenced and phylogenetically analyzed using (weighted and unweighted) parsimony and neighbour-joining methods. Maximum resolution of relationships was achieved using weighted parsimony and by treating all sequences, totaling 1716 base pairs, as a unit.

The following clades emerged, supported by (mostly) moderate to high bootstrap values: A -(*sanguinipes*, *femurrubrum*, *spretus*, *devastator*, *gaspensiensis*, *fasciatus*, *borealis*, *madeleineae*, *dawsoni*); B -(*bivittatus*, *differentialis*); C -(*packardi*, *foedus*, *angustipennis*, *gladstoni*, *aspmus*); D -(*infantilis*, *alpinus*, *aridus*, *Phoetaliotes*, *scudderi*); and E - (*confusus*, *Bohemanella*, *marginatus*, *microtatus*). *M. lakinus* occupied a basal position to all species. Relationships within and among these clades are described and discussed against pronouncements made in the traditional literature.

Key words: mitochondrial DNA, phylogeny, Melanoplinae.

## Phylogeny of Acrididae (Insecta: Orthoptera: Acridoidea) as Deduced from Mitochondrial DNA Genes Sequences. Poster 23

Chintauan-Marquier, Ioana <sup>1,2,3</sup> & François Pompanon <sup>1</sup>

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The extensive use of certain morphological characters (especially of male and female genitalia) has generated a plethora of subfamilies, tribes and “groups” in the classification of the Acrididae. On the assumption that such splitting of a family is excessive and tends to hide the real evolutionary history of the group, the phylogenetic relationships among 28 subfamilies of Acrididae (over the 35 notified by V. R. Vickery in “The Bionomics of Grasshoppers, Katydid and Their Kin”, 1997) were estimated based on DNA sequencing. We used two mitochondrial genes: large-subunit rDNA (16S) and cytochrome oxidase II (COII). A variety of different computer programs was employed in the data analysis using parsimony, likelihood and distance as the optimality criteria.

Key words: combined analysis, evolution, phylogeography, systematics.

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## Distribution of Tettigoniinae (Orthoptera: Tettigoniidae) Bush-crickets in Turkey: the Importance of the Anatolian Taurus Mountains in Biodiversity. Poster 9

Çiplak, Battal

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The distribution of Tettigoniinae (Orthoptera: Tettigoniidae) species within four phytogeographical provinces in Turkey is reviewed and presented on the basis of field and collection studies during 1987-2001 and miscellaneous data from previous literature. One hundred and fifty-nine species belonging to 28 genera have been recorded. The Anatolian species constitute approximately 30% of the world-wide species of the subfamily, with a very high proportion (>=83%) of those being endemic, of which nearly all are brachypterous. Regarding the numbers of total and endemic species, the provinces can be ordered as follows: Mediterranean > Irano-Anatolian > Euxin > Mesopotamia. Also, Anatolian Tettigoniinae have a very high rate of endemism in each province; 84.3% in the Mediterranean, 78.1% in Irano-Anatolia, 56.3% in Mesopotamia and 50% in Euxin. The two provinces in Anatolia having the greatest species diversity are also the two most mountainous provinces, so it is suggested that a primary factor in Tettigoniinae diversity is the Anatolian Taurus mountains.

Key words: Biodiversity, Tettigoniinae, Anatolia, Taurus Mountains.

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## Version 2 of the Orthoptera Species File Online. Poster 15 and Demonstration. Oral pres., Wed.1530

Eades, David C.

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An improved version of the Orthoptera Species File Online is now available for Tettigoniioidea and Gryllacridoidea. Many cross checks have been incorporated to test the internal consistency of the data. Many errors have been located and corrected. There is improved adherence to the International Rules of Zoological Nomenclature. Updating the database is made easier, and others are invited to participate. Plans for future work are described.

## **Preliminary Essay on the Higher Classification of Orthopteroid Insects. Poster 27**

**Gorochov, A. V.**

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The origin of the infraclass Polyneoptera was possibly connected with the transition of some early Pterygota from the open mode of life on plants to the usage of plant rubbish on soil for the protection from predators. The subsequent evolution of the early Polyneoptera was presented by the different variants of specializations within this adaptive zone.

The first variant was the further adaptation to the life among very loose soil covering. This variant allowed the first representatives of the dictyopteran stock to preserve their more or less primitive appearance. This stock originally was represented by 1 suborder (or order) Mylacridina, but in Mesozoic, this taxon gives 3 branches (suborders or orders): Blattina (with reduced ovipositor) and their possible descendants - Mantina and Termitina (=Isoptera).

The second variant was the partial return to more or less open mode of life. This way was probably passed by the early representatives of the orthopteran stock. The most primitive true Orthopteroidea are the specialized triassic predators from the order Titanoptera. Some Carboniferous Polyneoptera with indistinct systematic position (Geraridae, Protophasmatidae) are very similar to Titanoptera, but they were probably adapted to other kinds of open mode of life on plants. The orders Phasmatoptera and Orthoptera are possible descendants of some unknown Carboniferous, more or less cockroach-like Titanoptera.

The third variant of specialization led to the development of the dermapteran stock. It was connected to the adaptation of life among dense soil covering. This stock originally was presented by 1 suborder (Protocoleina or Protelytrina) which was ancestral for second one (Forficulina).

The positions of the orders Grylloblattida, Plecoptera, Embioptera, Zoraptera, and several Palaeozoic groups are less clear or quite unclear. Some of them are true or probable Polyneoptera, but others (for example Zoraptera) are possibly related to some other primitive Palaeozoic Pterygota.

Key words: Polyneoptera, taxonomy, paleontology, evolution.



## **Some Theoretical Aspects of Taxonomy (Remarks by the Practical Taxonomist). Poster 28**

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The taxonomists who try to build a particular Natural classification usually look for the ways of construction of classification with the maximal prognostic power. One of these ways proposes the use of the phylogenetic scheme as the true Natural classification (phylogenetic taxonomy), the second way consists of the calculations of numbers of similarities and differences (numerical taxonomy), and third way is the more or less intuitive measuring of value of the qualitative distinctions (evolutionary taxonomy).

The first way does not lead to the classification with the maximal prognostic power. The second way is little perspective also as for the approach to the Natural classification it is necessary to analyze an enormous number of characters. The problem of the third way is its undisguised subjective nature. But it is possible this problem at present is minimal for the construction of Natural classification in comparison with the defects of other ways, as the third way allows to use the phylogenetic and numerical studies, and both previous ways in reality also grounded on subjective appreciations.

The representatives of some cladistic schools consider that usage of some “logical” principles (principles of parsimony and outgroup comparison) allows an objective basis for the phylogenetic reconstruction. They postulate that these principles follow from the philosophical principle of economy. But the favourite principle of parsimony is not in conformity with the logic of the economy principle as the latter principle is possible for usage only in case of the absence of any contradictory facts. We cannot reject these facts only because of their minority in comparison with the number of non-contradictory facts, but we can remove these contradictions with help of the method of analogy. The use of the analogy method inevitably leads to a certain subjective component in the phylogenetic study.

The presence of subjective (intuitive) elements in taxonomy is not a defect in taxonomical work, but it is the evidence of insufficiency of our knowledge and methodology when investigating the complex systems.

Key words: classification, phylogeny, methodology, problems.

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## The Most Interesting Finds of Orthopteroid Insects in the End of Twentieth Century.

Poster 29

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During the 20 final years of the twentieth century, numerous very interesting finds of Polyneoptera have been made. They include the discoveries of representatives of a new high taxon (subfamily or family) of recent Ensifera, new genera of most relict recent Ensiferan groups, new genera and species of recent Orthoptera and Dictyoptera with remarkable morphological characteristics, and a series of paleontological finds including the new highest taxa, most ancient representatives of some other highest taxa, several interesting problematic and enigmatic fossils. Some of these finds clarify the difficult problems of classification and evolution of Polyneoptera (the origin of Hagloidea and Tettigoniodea, the fossil history of Grylloblattida, the peculiarities of phylogeny of main branches of Dictyoptera, and so on).

Key words: Polyneoptera, discoveries, significance.

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## Possible Phylogenetic Relations of Some Holarctic Acridids as Derived from Mitochondrial Ribosomal RNA Sequences. Poster 22

**Guljaeva, O. N., A. I. Shevchenko, L. V. Vysotskaya & M. G. Sergeev**

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The fragments of 16S mitochondrial ribosomal RNA gene of 30 species (representing 3 subfamilies of the Acrididae family) were sequenced. Standard insect mtDNA primers were used for the amplification: 5'-CCGGTCTGAACTCAGATCACGT-3' and 5'-CGCCTGTTTATCAAAAACAT-3'. The PCR amplification products were sequenced by Sanger dideoxy method (Sanger et al., 1977). The sequences of 7 species of the Acrididae family and cricket (*Gryllus fultoni*) were taken from NCBI. Phylogenetic analysis was performed using a variety of different computer programs (PAUP v3.11, PHYLIP v3.57). Bootstrap replicates were generated for the maximum likelihood program using the SEQBOOT program.

The species belongs to Catantopinae s.l. (Cyrthacanthacridini, Melanoplinae), Acridinae s.l. (Aulacothrini, Hypernephini, Arcypterini, Gomphocerini, Chrysochraontini, Dociostaurini), and Locustinae s.str. (=Oedipodinae) (Locustini, Oedipodini, Bryodemini, Sphingonotini, Arphiini).

Different methods of analysis indicated several general trends. All trees have usually two main branches. One of them includes the locustine grasshoppers. Another one unites catantopines and acridines. This result is surprising because now taxonomists prefer to decrease a taxonomic level of Locustinae in comparison with Catantopinae s.l. and Acridinae s.l.

In some cases the studied species of one genus are very similar (*Arphia*, *Eremippus*, *Stenobothrus*). However, the members of several genera are extremely different (*Celes*, *Bryodema*, *Chorthippus*). Thus, they can be divided into some separate groups. It is interesting that *Dociostaurus* and *Eremippus* belong to extremely different branches of the Acridinae-Catantopinae stem. This supports an idea about excluding *Eremippus* from the tribe Dociostaurini. Another intriguing branch unites *Euchorthippus* (Gomphocerini) and two typical members of Chrysochraontini.

These studies were partly supported by the Russian Federal Programs "Integration" and "Universities of Russia".

Key words: grasshopper, taxonomy, biogeography.

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## The Phylogeography of Rainforest Grasshoppers, a Comparison of Molecular and Morphological Markers. Poster 1

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The Eastern Arc Mountains in Tanzania are a hot spot of biodiversity in Africa. The number of endemic taxa is particularly high for flightless species, such as forest grasshoppers. The grasshopper genus *Afrophaeoba* contains four species, each of which is endemic to one single mountain block. *A. usambarica* occurs in the East Usambara Mts., *A. nguru* in the Nguru Mts., *A. euthynota* in the Uluguru Mts. and *A. longicornis* in the Rubeho Mts. Those species are believed to have evolved due to separation of the forested areas in Eastern Africa during periods of drought, since they are not able to cross larger forest gaps. A phylogenetic analysis was performed to reconstruct the former connections for gene flow between them. Three mitochondrial gene fragments (ND1, ND5, 12S rRNA) have been sequenced for a phylogenetic inference of a gene tree. The most parsimonious tree proved to be very stable, as the branches are supported by high bootstrap values. The phylogenetic inference with distance methods or different weighting schemes did not influence the tree as well. A low skewness and a high proportion of transitions suggests a low homoplastic content. Within the genus the genetic distances are extremely low, especially between *A. nguru* and *A. longicornis*. This assumes a young phylogenetic origin of the species or at least a recent gene flow of the mitochondria studied. For both events a connection between the populations has to be assumed. The close relationships are also supported by a discriminant analysis of 27 morphometric characters and an examination of 52 nonmetric characters. A former or even still existing connection between the species is proposed along the river Wami and along the coastal forests, since the species seem to survive in riverine forests.

**Fauna Europaea: Orthoptera. Poster 16****Fauna Europaea Committee <sup>1</sup> & K.-G. Heller <sup>2</sup>**

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Fauna Europaea is a challenging project with the objective to produce a Web based information infrastructure of all European land and freshwater animals. The project serves as a scientific baseline, and will also provide information for issues such as human health, agriculture, or freshwater quality. The infrastructure will manage a very large number of high quality data from widely distributed data sources in Europe. The system has a dynamic structure to allow for changes through time. The European Commission will support this project for a period of four years from 1 March 2000. The University of Amsterdam, in collaboration with the University of Copenhagen and the National Natural History Museum in Paris coordinate the efforts of more than 100 specialists in 33 other institutes from all countries in Europe. A review process on the inclusiveness and quality of the data files supports the development of a digital infrastructure that reflects the latest scientific results. The project will result in a unique overview of the state of art with respect to our knowledge of the taxonomy of the European species, and will help to identify gaps in taxonomic knowledge and expertise.

Specialist for Blattodea is Dr. Horst Bohn, Munich (bohn@zi.biologie.uni-muenchen.de), for Dermaptera, Dr. Fabian Haas, Ulm (fabian.haas@biologie.uni-ulm.de), and for Orthoptera s.s., Dr. Fer Willemse (fer.willemse@worldonline.nl), together with the author who also works as group coordinator for all orders of orthopteroid insects.

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**German Orthoptera Collections Specimen Database - Current Progress with a Review of the Type Specimens. Poster 17 and demonstration**
**Ingrisch, S., K. Riede & K.-H. Lampe**

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The DORSA project (abbreviation for “Deutsche Orthopteren-Sammlungen” = German Orthoptera Collections) is supported by the German Federal Ministry of Education and Research to establish a specimen based database with internet access of the Orthoptera held in German museum collections. The database will include illustrations of type specimens, sound recordings, and geographic information on a world-wide basis. As a first step, the type specimens in the nine largest collections are considered. From a compilation of published data we expected that there are more than 7600 type specimens belonging to over 3000 species in German collections. First examinations in the museums Berlin, Dresden and Hamburg showed that the real numbers are obviously higher. A review of the current progress of the project is given, together with estimations of numbers of specimens held in the collections, and with examples of the multimedia presentations. Databasing is also a good opportunity to verify the published type information. The Orthoptera Species File (OSF, Otte & Naskrecki 1997: <http://viceroy.eeb.uconn.edu/Orthoptera>) is used as a taxonomic backbone for DORSA. On the countermove, DORSA delivers numerous complements to the information regarding type specimens and original publications in OSF. Examples from the Tetrigidae are given.

Key words: German museums, specimen numbers, type information, multimedia.

## Phylogeny of Ensifera (Orthoptera) Using Sequence Data from Four Molecular Loci, with Implications for the Evolution of Acoustic Communication. Poster 12., Symp. 2, Tues. 0900

Jost, Manda Clair <sup>1</sup> & Kerry L. Shaw <sup>2</sup>

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Phylogenetic relationships within the Ensifera are poorly understood, despite several attempts to reconstruct these relationships using morphological data. The two most recent studies reviewed prior analyses, described potentially informative morphological characters, and estimated phylogeny using modern algorithms and parsimony. However, in both studies characters were scored at the family level only, without sampling within families. Such an approach cannot test for family monophyly, and conceals the variation that exists within clades, introducing a data bias that can affect phylogenetic analysis. We present a phylogeny of the Ensifera for approximately 40 taxa, under both parsimony and maximum likelihood criteria, using sequence data from 16s rRNA, 28s rRNA, and Cytochrome Oxidase I. We sampled within families as widely as possible given the availability of specimens. Our estimates support a monophyletic Grylloidea, and illuminate relationships between Tettigoniidae, Rhaphidophoridae, Stenopelmatidae, Anastostomatidae, and Haglidae. We then use phylogeny to examine the evolution of acoustic structures in the Ensifera. We compare our results with two other studies that each concluded multiple origins of acoustic communication. Prior conclusions of multiple origins were dependent on the assumption of equal probabilities of gains and losses of acoustic structures. We argue that gains and losses of acoustic characters should not be weighted equally in Ensifera, since the loss of acoustic characters is common in this suborder, having occurred at least 100 times in the Gryllidae alone. We recommend a future analysis of this problem which more closely examines structural homology, combining phylogeny with detailed studies of ensiferan ontogeny and morphology.

Key words: molecular data, Grylloidea, parsimony, homology.

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## Systematic and Phylogeny of the Genus *Acanthops* (Mantodea: Acanthopinae). Poster 10

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The genus *Acanthops* includes 14 species that occur in Central-south America; this is a monophyletic group defined traditionally by the excavation of the anterior wings. The genus is revised, providing redescriptions and illustrations of its species based on external morphology and male genitalia. Phylogenetic relationships among *Acanthops* were investigated using PAUP version 3.1.1. Four groups were recovered in the analysis. The first one includes four species (*A. falcataria*, *A. mortuifolia*, *A. contorta*, *A. erosa*) all living in rain forests and characterised by a slender pronotum, absence of basal lobe on the anterior femurs, mesothoracic wings of the females with a well developed apical lobe and arcuated upward. *A. falcataria* and *A. mortuifolia* are very similar and in consideration of their geographic distribution they can be defined as vicariant species. The second group includes four species present in rain forests (*A. falcata*, *A. parafalcata*, *A. royi*, *A. centralis*), and are characterised by a short pronotum, a large basal lobe on the anterior femurs, mesothoracic wings of the females with a well developed apical lobe and moderately arcuate. *A. falcata* is the more widely distributed species, and is vicariant with *A. parafalcata* in Trinidad. The third group includes two species (*A. tuberculata*, *A. erosula*) both living in rain forests and characterised by a long and slender pronotum, and mesothoracic wings of the females with a sigmoide apical lobe. The fourth group includes four species (*A. bidens*, *A. godmani*, *A. elegans*, *A. onorei*) characterised by a small basal lobe on the anterior femora. *A. bidens* and *A. godmani* are sympatric in Mexico.

Key words: Review, Cladistic analysis, Neotropical fauna.

## The Spiny Devil Katydids, Genus *Panacanthus*: Evolutionary Study of Acoustic Behavior and Morphological Traits. Poster 5, Oral pres., Wed. 1515

Montealegre-Z, Fernando

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A cladistic analysis of the genus *Panacanthus* using the genera *Lirometopum*, *Copiphora* and *Lesina* as outgroups is presented. The analysis was based on the total evidence philosophy and involved 35 morphological and 5 behavioral (acoustic and natural history) traits. The phylogeny of *Panacanthus* is resolved by just one most parsimonious explanation, and shows that it is more closely related to Neotropical katydids (*Lirometopum* and *Copiphora*) than to Old World species (*Lesina*). *Panacanthus cuspidatus* and *P. pallicornis* do not reside in separate clades as proposed previously. The group formed by *P. spinosus* and *P. varius* (and the new species reported here) is actually a paraphyletic group derived from *P. pallicornis*. Early workers, basing their studies on pronotal morphology, attempted to group *Panacanthus* together with other spiny genera. This analysis shows, however, that a variable number of pronotal processes and modifications evolved independently in other genera of Conocephalinae. The pronotal structure of *Panacanthus* is unique and may be taken as synapomorphic for the genus.

This study supports the hypothesis that the broad band songs of *Panacanthus* may have evolved from a pure song prototype. Thus the production of a pure tone song is not always an evolved characteristic. It has probably been lost several times across Tettigoniidae. The cladogram shows the gradual reduction of the resonant generation capability. From *Panacanthus cuspidatus*, the production of pure tone song gave rise to a less elaborated but still sustained song in *P. pallicornis*. This song, in turn, evolved into a song with a more complex infrastructure, that may be shared by the remaining species of the genus for which the song is still unknown. A separate study of character evolution shows that this gradual loss of pure tone song capability seems to be correlated with the appearance of body spination, especially on the pronotum.

Key words: Tettigoniidae, Conocephalinae, *Panacanthus*, spiny katydids, bioacoustics, defensive mechanisms.

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## The Surprisingly Vocal Females: The Phylogeny and Evolution of Female Stridulation in Katydids (Orthoptera: Tettigoniodea). Poster 11, Symp. 2, Tues. 0940

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A hypothesis is presented of the phylogenetic relationships among 195 genera of katydids (Insects: Orthoptera: Tettigoniodea), representing nearly all suprageneric taxa of the family. A phylogenetic analysis based on over 330 morphological characters yielded multiple, most parsimonious trees of length 1994.

The characters used included not only those traditionally used in katydid systematics, but also characters never before evaluated, such as the structure of the tarsi, the thoracic endoskeleton, the internal structure of the ovipositor, and a number of egg characters. Three genera of the Prothalangopsidae (*Cyphoderris*) and Anostomatidae (*Cratomelus* and *Anabropsis*) were used as outgroups. The results support the most basal position for the tribe Bradyporini. The subfamily Bradyporinae *sensu* Gorochoff 1995 appears to be paraphyletic, as there is strong support for the monophyly of the more derived Ephippigerinae. The subfamily Listroscelidinae is polyphyletic, and the tribes Phlugidini and Phisidini form a monophyletic lineage closely related to the Meconematinae. Several genera of the Listroscelidinae (e.g., *Lioesthomimus*, *Terpandrus*, *Chlorobalius*) are more closely related to the Saginae. The Copiphorinae appear to be polyphyletic, with some genera (e.g., *Caulopsis*, *Euconocephalus*, *Ruspolia*) forming a monophyletic clade with the Conocephalinae. The subfamilies Austrosaginae, Saginae, and Phaneropterinae are paraphyletic.

Based on this analysis, the evolution of female stridulation has been reconstructed. At least seven different tegminal mechanisms of sound production are known in females of the Tettigoniidae, suggesting several independent evolutionary events. It appears that female stridulation, in which females employ an apparatus homologous to that of the males, is the ancestral condition within the Tettigoniodea, and is found only in the Bradyporinae *s. str.* Females of the Ehippigerinae have evolved a unique mechanism, in which the stridulatory file is located dorsally on the surface of the right tegmen, non-homologous to that of the males. A similar mechanism, but employing different veins, appeared independently in the Polyancistrinae (Pseudophyllinae). The Pterophyllinae mechanism consists of a tuberculate scraper on the inner margin of the right tegmen, and a field of teeth on the underside of the left tegmen. Less complex mechanisms appeared in the Phaneropterinae, Meconematinae, Tettigoniinae, and Pseudophyllinae.

Early hypotheses, suggesting that female sexual stridulation have evolved secondarily from defensive stridulation find no support in the current phylogeny. On the contrary, courtship or advertisement stridulation of females, which requires a sophisticated stridulatory apparatus capable of producing pure or near-pure tone calls, appears to be the ancestral condition within the Tettigoniodea. The subsequent losses may be explained by the increased parental investment of females, which shifts the risk of calling to the males. In taxa where the male's parental investment is high, females frequently stridulate.

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## Integration of Orthoptera Collection Data within a “Virtual Museum”: the “German Orthoptera Collections Database.” Poster 18 and Demonstration

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The wealth of information contained within museum collections can only be tapped by digitizing collection data, and making them available on-line. The “Global Biodiversity Information Facility (GBIF: [www.gbif.org](http://www.gbif.org)) has been established to provide an interoperable network of biodiversity databases and the necessary information technology tools. The German Ministry of Science and Education is funding the EDIS-project (Entomological Data and Information System) to digitise and harmonise the rich, but scattered entomological collections housed at various German institutions. The core of the Orthoptera subproject is a specimen-based database of important Orthopteran collections in Germany, accessible by an internet-based user interface “Virtual Museum” (“German Orthoptera collections database”: DORSA; see <http://www.dorsa.de> and separate Poster). It is a network project, connecting expertise in data-basing, collection management, systematics, geographical information systems, bio-acoustics and neuroinformatics. The species-specific songs are used as a knowledge base for song recognition algorithms based on neural networks. First results indicate that reliable automatized classification is possible for songs of Grylloidea from South East Asia and Amazonia. For all specimens with reliable locality information, collection sites will be geo-referenced by latitude/longitude coordinates, which can be mapped by any geographical information system (GIS) and intersected with environmental data. A first prototype for a java-based graphical user interface is demonstrated, which allows geographic queries, retrieval and mapping of taxonomic data.

Key words: biodiversity databases, geographical information systems, bio-acoustics, automatized song classification.

## A New Genus of Phalangopsid Cricket (Orthoptera: Grylloidea: Phalangopsidae), which Lives in the Leaf Litter of Forests, in Brazil. Poster 7

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The crickets of the new genus were collected upon leaf litter in Atlantic Forest remnants, in the region of Viçosa, Minas Gerais State, Brazil. We provide photographs of male and female, of the metanotal glands, chromosomes, electron microscope scanning of the male genitalia, and drawing of the genitalia dissected and separated in the component sclerites. There is a group of five genera of phalangopsid crickets, which have similarities with the new genus here proposed. The new genus differs from *Vanzoliniella* Mello & Reis, 1994, because it has no auditory tympana in the basis of the front tibia, and the morphology of the metanotal glands and of the male genitalia is different. The new genus differs from *Izecksohniella* Mello, 1992, *Cacruzia* Mello, 1992, *Aracamby* Mello, 1992 and *Guabamima* Mello, 1992, because all these described genera do not have metanotal glands. Support: NAP/MEPA - ESALQ/USP & UEEC/UFV.

Key words: Scanning electron microscopy, systematics, chromosome, metanotal gland, male genitalia.



## Exploring the Genomic Jungle: Testing Species Boundaries Using Gene Genealogies.

Symp. 2, Tues. 1010, Powerpoint presentation available at Poster 13

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There are several ways in which gene trees will not completely represent species trees. These discrepancies may be due to, for example, gene lineage sorting, gene duplication (paralogy versus orthology), or hybridization leading to “interspecific” gene flow. In this talk, I will discuss the kinds of evolution, including morphological, behavioral and gene-genealogical changes, that are likely at the level of recently diverging species. In particular I will examine the rates of change between phenotypes and genealogies and the conditions under which gene trees are unlikely to completely reflect the phyletic and branching evolution of species trees (as identified through traditional taxonomy). Although these phenomena may lead to conflict in the estimate of phylogenies, they embody the diversity of processes that occur during lineage splitting events. One manifestation of this diversity of process is the recent production of numerous species concepts. To many, this has rocked the foundations of systematics and evolutionary biology. However, to the speciation biologist, this is a productive time and species concepts can be seen as models invoked to “explain” and/or organize the diversity of processes and natural evolutionary groups. Isolated biotas such as are found on island archipelagos and lake systems, frequently harbor groups of closely related species living to different degrees in allopatry and sympatry. Features of such species radiations offer excellent natural systems in which to examine the complexities of “species”. I will illustrate some of these complexities in part

## Phylogenetic Relationships of North American *Schistocerca* (Orthoptera: Acrididae: Cyrtacanthacridinae) and Problems with Current Taxonomy. Poster 2

Hojun Song

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The genus *Schistocerca*, famously known for the desert locust, *S. gregaria*, includes 22 species and numerous subspecies and deserves a major revision. A preliminary morphological study was conducted to resolve the current subspecific status of North American Alutacea species group. A detailed study of male genitalia determined that the subspecies of *Schistocerca alutacea* in Dirsh's (1974) revision are valid species. This study also revealed that it is important to recognize the genitalic form of sexually mature males for taxonomic studies. Freshly molted adults are not sexually mature because their internal genitalia are not fully developed. These undeveloped genitalia are morphologically very different from the fully developed genitalia, and can be incorrectly considered as ones from different species. In addition, the immature genitalia of closely related species have different affinities. For example, the immature internal genitalia of *S. albolineata* and *S. obscura* look much the same, whereas the immature genitalia of *S. americana* look significantly different from both. To test phylogenetic relationships of the genus, a cladistic analysis of North American *Schistocerca* including 5 species in Alutacea group was performed. Ten *Schistocerca* species were included in the analysis, and *Austracris guttulosa*, *Acanthacris ruficornis*, and *Cyrtacanthacris aeruginosa* were used as outgroups. Thirty-one characters from male genitalia and external morphology were used in the analysis. The resulting cladogram indicated the monophyly of all the North American *Schistocerca*. Although Dirsh (1974) treated *S. obscura* separately from the Alutacea group due to the subgenital plate morphology, it is more closely related to *S. albolineata*. Hubbell (1960) treated *S. lineata*, *S. alutacea*, and *S. rubiginosa* as sibling species, but the present analysis showed that only the latter two are sisters, and *S. lineata* is more related to *S. shoshone*. This preliminary study highlights problems with current taxonomy and calls for more studies of North American *Schistocerca*.

Key words: systematics, male genitalia, ontogeny

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## Genetic Structure of Populations of the Alpine Grasshopper, *Melanoplus alpinus*: Cryptic Species or Ancient Paraphyly? Poster 3

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Relatively little is known about the ecology and population dynamics of the alpine and montane grasshoppers that currently inhabit "sky islands" in the Rocky Mountains of western North America. We are studying one such species, *Melanoplus alpinus*, that is restricted to disjunct meadows at elevations of 2,400-3,350 m in our study area. A total of 215 individuals were collected from 43 meadows (5 individuals per meadow) in 1-3 drainages of 4 ranges (Medicine Bow, Big Horns, Wyoming Range, and Flatheads) of the Rocky Mountains. This sample structure allows genetic analysis at 4 spatial scales: within meadows, among meadows within drainages, among drainages within ranges, and among ranges. RFLP analysis of the CO1 and CO2 regions of *M. alpinus* mitochondrial DNA revealed 9 haplotypes among the 215 individuals. Analysis of molecular variance (AMOVA) shows that significant variation in the frequencies of these haplotypes occurs within meadows (21% of total variation), among meadows (22%) and among drainages (41%) but, paradoxically, not among ranges (16%). Sequencing of 470bp of the mtDNA CO1 region for 23 individuals representing the various RFLP haplotypes and ranges revealed 3 major lineages with divergence rates that have been typically observed between species of *Melanoplus*. Thus, the 3 lineages may represent 3 cryptic species with one species found in all 4 ranges, one found in two ranges, and the remaining species found in just one range. Alternatively, the 3 lineages may represent a relatively ancient paraphyly in a single species that was widely distributed at some point during the Pleistocene but has retreated to the sky islands of the Rocky Mountains since the end of the last Pleistocene glaciation. Under the latter hypothesis, limited gene flow appears to occur in *M. alpinus* among meadows and especially among drainages.

Key words: Mitochondrial DNA, Sky Islands, AMOVA.

## The Behaviour of Chromosomes of the Different Acridid Species During the First Meiotic Prophase: Taxonomic Diversity and Evolutionary Diversification. Poster 21

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We studied 22 Palaearctic acridid species with an XO/XX sex determining mechanism. These species represent three widely distributed subfamilies (Catantopinae s.l. - 4, Acridinae s.l. - 10, and Oedipodinae - 8).

Five types of the synapsis and synaptonemal complex (SC) formation in the autosomal bivalents have been discovered. The chromosome pairing can start from the proximal or (and) distal chromosome regions. The SC can spread to entire or partial length of a chromosome. Locations of chiasmata usually coincide with the positions of synapctic initiation.

In the Acridinae subfamily, each studied tribe shows the specific pattern of the synapsis. All studied catantopine grasshoppers have the uniform pattern of the synapsis. In the Oedipodinae subfamily, this pattern varies on the species level.

The axial element of the male sex chromosome is always found in the Acridinae and Catantopinae subfamilies. It looks like the lateral elements of the synaptonemal complex.

In the Oedipodinae subfamily, the chromosome behaviour is evidently different. The axis of the male sex univalent is revealed only in the species with the complete synapsis of autosomes. The species with the partial synapsis does not show the axial element of the X chromosome. The sex bivalent of females of these species does not distinguish from the autosomal bivalents that form the SC over the entire length of bivalents.

Thus, the behaviour of chromosomes during the first meiotic prophase can be used as an evolutionary trait that allows us to evaluate difference between some taxa. Another interesting result is specificity of Oedipodinae supporting an old idea about its independent status.

Key words: X-univalent, bivalent, synaptonemal complex.

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## The Relationship between Karyotype Diversity and Taxonomic Differentiation in Landrevinae (Orthoptera: Gryllidae). Poster 20

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Ten species belonging to three genera of Landrevinae from Java, Sumatra, Vietnam, Cambodia, and Thailand were subjected to cytogenetic analysis.

Analysis of chromosome complement, location of C-heterochromatin, and NORs of seven species of two subgenera *Duolandrevus* (*Duolandrevus* s. str. and *Eulandrevus* Gor.) showed the same karyotype,  $2n=19(XO)\%$  with acro- or subacrocentric autosomes and metacentric X chromosome, similar C-bands, and NORs location. These seven species are also similar in morphology and model of life. However, the eighth species, *Duolandrevus* sp. 4, from eastern Thailand, has a different karyotype,  $2n=21(XO)\%$  with all chromosomes being metacentric. This species, resembling the genus *Duolandrevus*, also shows a slight similarity to the genus *Repapa* in some details of male genitalia.

The next two species of two other genera, *Ectodrelanva* (from Cambodia), and *Vasilina* (from central Vietnam), are characterized, respectively, by a chromosome number  $2n=21(XO)$  with one metacentric and nine acrocentric pairs of autosomes and subacrocentric X, with  $2n=17(XO)$  acro/subacrocentric autosomes and subacrocentric X chromosome.

Thus, the majority of the analysed species can be divided into four groups according to their karyotype pattern. Comparative cytogenetics gave especially good results in three groups with karyotypes greatly differing from one another, and they are also well separated morphologically. These groups are considered here as distinct genera. Cytogenetic methods did not resolve the systematic position of one species (*Duolandrevus* sp.4), which should be subjected to further morphological study.

Key words: cytogenetics, heterochromatin, gryllids.

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## The Impact of Developing Virgin Lands and Irrigation on Quantitative and Qualitative Changing of Acridofauna. Poster 55

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The study of impact of developing virgin lands and irrigation on changing of Acridofauna was carried out in Georgia. Acridofauna of Georgia includes 96 species and subspecies. It differs as zoogeographically so in ecological valence. Of 96 species distributed in Georgia 50 species inhabit East Georgia where there are favorable conditions for their development and spreading. The purpose of our study was to determine quantitative and qualitative changing of Acridofauna in Georgia (Samgori Steppe) in the result of its developing and creating spatio-temporal interactive map in GIS. This map can be the most comprehensive source of spatio-temporal dynamics of population of locust and grasshoppers and very helpful for forecasting. Carried out studies and comparative analysis of Samgori Steppe Acridofauna before and after irrigation revealed definite regularities of Acridofauna changing. 9 species of 30 registered species before developing the virgin lands have not been found. Basically they belong to typical xerophilous ones. Meanwhile for the first time 16 species belonging to mesophilous ones have been registered by us in Samgori Steppe after irrigation. Considerable changing is recorded in *Doclostaurus marroccanus* population dynamics. After developing the invasion area significantly is decreased. As to ecological plastic species *Calliptamus italicus* developing and irrigation did not affect on its population numbers. *Calliptamus italicus major* plague in East Georgia has been observed in 1994-1998. The permanent population of these species require constant surveillance and regular control. At present Samgori Steppe entomofauna forming process is completed and the further intensification may affect only on the quality correlation of Acrididae species. Our work is supplied with maps in GIS, tables, diagrams and photos.

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## Spatial distribution Patterns of Africana Mole Cricket, *Gryllotalpa gryllotalpa africana* in Qena Governorate (Upper Egypt). Poster 56

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Dispersion indices, including (k) the negative binomial distribution, Green's coefficient of dispersion ( $C_x$ ), mean crowding ( $m^*$ ), Lloyd's (Patchiness index) ( $m/m^*$ ) and variance mean ratio ( $v/m$ ), were calculated for the populations of Africana Mole Cricket, *Gryllotalpa gryllotalpa africana* in Qena Governorate (Upper Egypt) using light traps all over 2 years (April 1999 to March 2000) at Naga Hamady and Qena Districts, Qena Governorate. Comparison showed that: k,  $C_x$  and  $m/m^*$  as well as slopes from regression, all indicated that under the conditions of this test (at densities tested), the population of the *Gryllotalpa gryllotalpa africana* was random. The variance / mean ratio fluctuated considerably more than other indices examined, which, by comparison, appears less reliable than previously thought.

Key words: *Gryllotalpa*, Dispersion, Upper Egypt.

## Diversité biologique des Orthoptères dans les formations végétales de “Sierras al sur de Jaen” (Andalousie, Espagne). Poster 35

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On réalise une étude sur la diversité biologique de la faune orthoptérique de “Sierras Al Sur de Jaen”, lors d’un cycle annuelle. La région présente une richesse spécifique de 48 espèces et un indice de diversité  $H' = 2,58$ . Les paramètres de diversité alpha des 9 formations végétales montrent que les espaces cultivés sont les plus divers ( $H' = 2,53$ ); cette importante diversité est due principalement à une haute équitabilité ( $E = 0,80$ ), une faible dominance ( $d = 0,21$ ). Contrairement, le milieu le moins divers correspond aux Gras Pâturage de haute portée, caractérisé par une faible richesse spécifique ( $S=12$ ) avec une espèce dominante avec un 37 % d’individus. Diversité et richesse spécifique des 9 biotopes, présentent une corrélation positive ( $r = 0,816$ ;  $p = 0,007$ ), alors que l’abondance et l’équitabilité sont négativement corrélatives ( $r = - 0,771$ ;  $p = 0,015$ ). L’analyse de l’affinité faunistique nous permet d’établir 3 groupes: le premier correspond aux matorrals et Genêtiers, le second réuni les gras pâturages, herbages et prairies humides, et finalement les terrains cultivés s’individualisent comme biotopes différents du reste des formations considérées.

Mots clés: Biodiversité, Affinité faunistique, Orthoptera, Andalousie, Péninsule Ibérique.



## Contribution à la connaissance de la diversité biologique des Caelifera (Insecta: Orthoptera) au Maroc: Actualisation du catalogue et approche biogéographique. Poster 34

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Parmi les handicaps les plus important au moment où on décide de préserver et/ou de gérer les ressources naturelles, est le problème de la méconnaissance de la diversité biologique tant au niveau d’organismes qu’au niveau écologique. Ainsi l’établissement des inventaires résultent d’une extrême importance pour initier tout action qui cible la conservation et/ou l’aménagement de la biodiversité. Dans la présente communication on prétend établir une base de connaissance sur la faune des Caelifera du Maroc, en actualisant le catalogue des espèces. Le travail se base sur une exhaustive révision bibliographique, une étude de la collection de notre département et des spécimens issue de quelques musées. Il en résulte donc qu’au Maroc les Caelifera sont représentés par un total de 232 taxons (216 espèces et 16 sous-espèces) appartenant à 4 superfamilles: Tridactyloidea (1 famille, 1 genre et 2 espèces); Tetrigoidea (1 famille, 3 genres et 4 espèces); Pamphagoidea (3 familles, 20 genres, 78 espèces et 12 sous-espèces); Acridoidea (2 familles, 52 genres, 132 espèces et 4 sous-espèces). Parmi ces espèces, il est remarquable le haut pourcentage des endémiques (44 % soit 101 espèces). Une étude comparative entre les différentes zones géographiques marocaines, nous permet de réaliser une esquisse biogéographique sur ce groupement orthoptérique.

Mots clés: Biodiversité, Inventaire, Caelifera, Afrique du Nord.

**Restoration and the Native Landscape: What Are the Grasshoppers Trying to Tell Us?**

Symp. 3, Tues. 1400

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Restoration of remnant prairies and reconstruction of prairies that model native ecosystems is a common activity in the Midwestern US. Little understanding exists of what insect populations inhabit these systems. This research focused monitoring grasshopper (Orthoptera: Acrididae) populations in various remnant and reconstructed prairies in western Wisconsin. Remnant sites were in an assortment of stages of restoration; reconstructed sites represented various ages ranging from 5 to 65 years. Grasshoppers from remnant sites represented a wide array of species diversity, including over 30 species from four subfamilies. Reconstructed sites generally had lower diversity, with two species being present almost immediately after construction. *Melanoplus femurrubrum* and *Chorthippus curtipennis* appear to play a deterministic role in the establishment of grasshopper populations at constructed sites. The long-term establishment of a diverse population is directly influenced by the presence of meta-populations in nearby remnants. Lack of habitat management or absence of proximal remnant communities will hinder the establishment of native coevolved insects in constructed communities.

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**Research on Orthopterans in Semi-arid Climate: Case of the Region of Sétif (Northeast of Algeria). Poster 33**
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The biology and ecology of the grasshoppers was carried out in the Sétif region during six years from 1994 to 1999. Research was conducted at 12 ecologically homogeneous sites, which seemed typical of three acridian biotopes of the region. A total of 36 species of orthoptera are recorded, 6 Tettigonidae, and 30 Acrididae pertaining to 11 sub-families and 22 kinds. The most abundant species and most frequent especially are *Tmethis laevisculus*, *Tmethis cisti*, *Dociostaurus maroccanus*, *Calliptamus wattenwyllianus*, *Platycleis laticauda*, *Ocneridia volxemi*, and *Praeophyppigera pachygaster*. Some years these species causes heavy damage to the vegetation and certain crops in the area of study. The acridids living in the region are more or less adapted to these environmental fluctuations. Each species has its own levels of susceptibility and resistance: crash to larval, embryonic and imaginal hibernation. The number of generations varies from 1 to 2 in a year. The majority of the species recorded (26%) have a winter diapause in the embryonic state and 1 generation in a year. The biological cycles are narrowly dependent on the duration of the dry season and in particular species with embryonic hibernation. A shift was noted in the larval stage of one zone to another. Collecting sites, dates, available biological or ecological dates are provided for each species. The corresponding analysis (A.C.P.) was employed to obtain an overall interpretation of the results.

Key words: Locusts, grasshoppers, biology, ecology.

## Effects of Grasshopper Densities and Climate Conditions on Grasshopper Survival and Reproduction. Poster 54

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Although considerable research has been conducted on the population dynamics of grasshoppers, there are many unresolved questions regarding the mechanisms responsible for observed grasshopper population fluctuations. I experimentally examined the effect of grasshopper densities, climate, and vegetation on survival and reproduction of grasshoppers. The experiment was conducted in eastern Montana in a mixed grass prairie highly dominated by western wheatgrass (>90%). The dominant grasshopper species at the site were *Melanoplus sanguinipes* and *Phoetaliotes nebrascensis*. Grasshoppers were stocked in 4 density treatments and 2 climate treatments using 10 m<sup>2</sup> cages, with 4 replicate cages per treatment. Grasshopper densities at the site averaged between 25 to 30 nymphal and adult grasshoppers per m<sup>2</sup>. Grass biomass declined over the summer, although high quality regrowth occurred late in the season after an 8 cm rainfall. Treatments affected both vegetation quantity and vegetation quality at the end of the experiment. The decline in grasshopper densities in the outside controls matched the decline in grass biomass. Shade and water treatments did not affect grasshopper survival at the end of the experiment. Although high density cages had higher numbers of grasshoppers remaining at the end of the experiment compared to low density cages, proportional survival was higher in low density cages. There was no effect of avian predation on grasshoppers, as grasshopper numbers did not differ between enclosures and controls.

Key words: Acrididae, Orthoptera, Competition, herbivory.

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## Grasshoppers and Lesser Kestrel in Crau Steppe (South of France, Bouches-du-Rhône). Poster 53

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The only French population of Lesser Kestrel (*Falco naumanni*) is the subject of a conservation programme in Crau. This project, financed by the European Union and the French state, and led by the Ligue de Protection des Oiseaux with the Conservatoire-Etude des Ecosystèmes de Provence, aims to get a better knowledge of this falcon and to increase its population.

68% of the prey brought to the young falcons are Orthoptera insects of dry and hot biotopes. In 1999, three enclosures where grazing is excluded were built in order to increase the density of big Decticinae (most of prey brought to the young falcons), and subsequently, to favour the reproduction success of the Lesser Kestrel. A monitoring study of the Orthoptera populations in enclosures and control pastures began the next year (weekly counting of larvae and imagoes on 40 m<sup>2</sup> per station). Others biotopes are also examined: the grass-belt between the two separated lanes of a road (preferential hunting zone) and three old fallow lands (to obtain a prospective information about the development of the populations in enclosures).

After one year without grazing:

- > the specific compositions don't change;
- > the density of some species involve already significantly;
- > the proportion of Ensifera species increase;
- > the alimentary availability doesn't evolve.

The study of the other biotopes reveals the abundance of *Decticus albifrons* and *Platycleis falx* in the preferential hunting zone. Moreover, the very low density of these grasshoppers in the fallow lands shows that the absence of grazing doesn't guarantee their abundance.

In 2001, the enclosures monitoring will go on, and the ecological needs of *Decticus albifrons* will be studied.

Key words: grazing, conservation, Lesser Kestrel, Orthoptera.

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**The Bushcrickets (Orthoptera: Tettigoniidae) of a Mountain Rainforest in the Andes of Southern Ecuador and Some Aspects of their Ecology in Relation to Elevation.** Poster 30, Oral pres. Wed. 1600

**Braun, Holger & Otto von Helversen**

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The region of the Andes and adjacent Amazon lowlands around the equator is supposed to host the highest biodiversity worldwide. In the area of the Podocarpus National Park in the very south of Ecuador, which comprises almost 150.000 ha of comparatively undisturbed mountain rainforest, 100 species of bushcrickets were found. The actual number of species is expected to be much higher, and at least half of them seem to be new to science. Recordings of the males' specific calling songs were made for 63 species. The knowledge of these (mostly ultrasonic) songs was proof of the acoustical presence of many species in the very steep and almost inaccessible area, thus enabling assessment of their distribution along the altitudinal gradient from 1000 to 3400 m (the highest-occurring bushcricket, maybe belonging to an unknown subfamily, lives up to 3200 m). Although the data are somewhat fragmentary due to the rarity of most species, it is possible to analyse different ecological, morphological and acoustical characteristics in relation to elevation. Many species are restricted to relatively narrow altitudinal ranges. Species diversity is highest between 1500 and 2000 m, and between 2000 and 2500 m it is still approximately as high as below 1500 m. With increasing elevation increases the fraction of brachypterous and small-bodied species. [data analysis is still in progress]

Key words: acoustic monitoring, altitudinal gradient, tropical diversity.

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**Grassland Grasshopper (Orthoptera: Acridoidea) Communities Composition and Temporal Variation in the Pampas, Argentina.** Symp. 3, Tues. 1700

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Long-term studies were conducted to describe the major features of geographical variation in the diversity of grassland grasshopper communities in the Pampas region. Species richness and relative abundance were assessed at sites in the occidental Pampas district and were then compared to patterns observed from a study in the austral Pampas district. In order to evaluate temporal changes in grasshopper communities, species density was estimated at each site established in the austral Pampas during a 5-year period. Results showed that the western Pampas had a greater species diversity with a mean species richness of 10, and a total of 34 grasshopper species collected throughout the district, compared to

a mean species richness of 4 and a total of 22 species collected in the austral Pampas. Differences in grasshopper assemblages among the two districts were also detected. In the western Pampas the three top-ranked species in the communities were *Dichroplus elongatus*, *D. pratensis* and *Staurorhectus longicornis*, while in the austral Pampas, the three-top ranked species were *Covasacris albitarsis*, *D. elongatus* and *Scotussa lemniscata*. From a taxonomic perspective, within the Acrididae, the Melanoplinae was the most abundant and diverse subfamily followed by the Gomphocerinae, Acridinae, Copiocerinae, and Leptysminae, only 5 species of Romaleidae were collected throughout the studied districts. Results from the analyses of temporal changes in grasshopper communities showed that it was possible to categorize years into non-outbreak, transitional and outbreak based on adult grasshopper density. Average densities were about 3-5 grasshoppers per m<sup>2</sup> during non-outbreak years, while the maximum grasshopper densities estimated reached 60 grasshoppers per m<sup>2</sup> during the outbreak year. Species richness changed significantly in outbreak versus non-outbreak years. Although *D. elongatus*, *C. albitarsis*, and *S. lemniscata* were the three top-ranked species in both outbreak and non-outbreak years, *D. elongatus* contributed most to overall shifts in grasshopper density.

The Pampas have a number of ecological similarities in grasshopper fauna with the Great Plains of North America, however there are some differences in their diversity. Although the Great Plains grasslands have greater species diversity, the Pampas grasslands have a greater diversity of higher acridid taxa. In both regions, the Melanoplinae is one of the most common subfamilies, being the grasshopper fauna of the Great Plains taxonomically dominated by the genus *Melanoplus* while the Pampas is dominated by *Dichroplus*. The Gomphocerinae play an important role in both faunas too. There is one essential difference between both ecosystems in terms of taxonomic richness, the Great Plains grasslands also have many Oedipodinae species while the Argentine fauna has only one species of Oedipodinae (*Trimerotropis pallidipennis*), and it is not common in the Pampas region. On the other hand the Acridinae subfamily, highly diversified in Argentina, it is only represented by one species (*Metaleptea brevicornis*) in the Great Plains. The remaining subfamilies of Acrididae collected in our study are endemic taxa from South America. Finally, the Romaleidae, present in both ecosystems, is more diversified in the Pampas.

Key words: species diversity, population dynamics, grasshopper outbreaks.

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## Entomocenotic, a Method to Study Orthopteroid Populations. Oral pres., Wed. 1615

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The entomocenotic is a method of studying orthopteroid populations, borrowed directly from the zuricho-montpelliéraine phytosociology. THE METHOD. In a practical way, a hierarchical syntaxonomical system (or “synsystem”) is built as follows: all orthopteroid samples which resemble each other, according to their faunistic composition, constitute a synusy (# association), all the synusies which resemble each other constitute an alliance. And so on with the orders, classes and divisions. This method was described in detail in Defaut, 1994. SYNTAXONOMIC RESULTS. The application of this method since 1976 in France and in Morocco led to a syntaxonomical system currently including 5 divisions, 10 classes, 11 orders, 13 alliances, 42 synusies and 12 groups. The most recent state of the synsystem is expressed in details in Defaut, 1999a. The various levels of this synsystem are closely related to bioclimatic parameters (for the units of higher rank: divisions and classes), to chorologic parameters (generally for the orders) and with biotope characteristics (for the units of lower rank, especially alliance). APPLICATIONS FOR LAND MANAGEMENT AND ENVIRONMENTAL PROTECTION. The comparison of the parameters purely entomocenotic (i.e. those which result from the simple presence/absence of the species) that are the number of species (N), the index of similarity (S') and the index of originality (O'), in the samples of a same synusy, makes it possible to appreciate the health of the corresponding biotopes (by simple reference to the average and maximum values in the synusy). And the evolution of these parameters in a same biotope, year after year, makes it possible to evaluate the effect of the land management measures implemented. Several studies led in this spirit in protected areas were regularly published in the review “Matériaux Entomocenotiques”, in particular Defaut, 1999b.

Key words: environmental preservation, synsystem, syntaxonomy, synusy.

**The Short-term Effects of Fire on Grasshopper Species Abundance and Diversity.** Poster 52

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Grasshopper species abundance and diversity were examined in a semi-urban landscape in Southern India over a seven-month period of recovery from surface fire. In this context, the effects of two additional factors, dispersal and vegetation, were also studied. Twelve plots were sampled, six burned and six unburned. Three of the burned and three of the unburned plots were covered with nylon mesh cages to prevent dispersal; free dispersal was allowed to occur between the other six plots. Burned areas had a higher abundance but lower species richness of grasshoppers than unburned areas, irrespective of whether or not free dispersal of grasshoppers into and out of these areas was allowed to occur. Of a total of twelve grasshopper species, six were found to occur exclusively in unburned areas. Relative abundance data showed that all of the plots sampled were dominated by one gomphocerine grasshopper species, *Aulacobothrus luteipes*. Analysis of the vegetation revealed that fire had no effect on the total grass or forb biomass per unit area. The effect of fire on the proportion of forb to grass biomass was, however, contingent on whether the area was subsequently caged. The percent biomass of forbs decreased in burned, uncaged plots and increased in burned, caged ones, when compared with unburned areas. Plant species richness was not significantly affected by either burning or caging alone. There was, however, a strong interaction between the two factors, such that burned, caged and unburned, uncaged plots had a higher plant species richness than burned, uncaged or unburned, caged plots. The effects of fire on vegetation, in terms of both biomass and species richness, were thus complex, being influenced by additional factors. Grasshopper species richness and composition were not significantly correlated with plant species richness and composition.

Key words: Orthoptera, acridid, ecology, India.

**La faune orthoptérologique de quelques oasis algériennes (Béchar, Adrar, Tamanrasset, Djanet et Ghardaïa).** Poster 32

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Au cours de nos prospections pour l'étude bioécologique de *Schistocerca gregaria* dans le Sahara algérien et vue la place qu'occupent les orthoptères parmi les insectes et leur intérêt économique, nous avons jugé utile d'inventorier les autres orthoptères vivant dans le même biotope que la sauterelle pèlerine dans 5 régions différentes: Béchar, Adrar, Tamanrasset, Djanet et Ghardaïa. A Béchar, dans les 7 stations d'étude nous avons inventorié 25 espèces orthoptérologiques en plus du criquet pèlerin. Il s'agit de 5 Ensifères *Grylotalpa grylotalpa*, *Gryllus bimaculatus*, *Conocephalus fuscus* et 2 espèces non déterminées et de 20 Caelifères: *Aiolopus. sp.*, *A. thalassinus*, *A. stepens*, *Tropidopola cylindrica*, *Spingonotus rubescens*, *Pyrgomorpha cognata*, *Acridella nasuta*, *Eyprepocnemis plorans*, *Acrotylus patruelis*, *Wernella pachecoi*, *Morphacris sulcata*, *Ochridia gracilis*, *O. harterti*, *Thysiocetrus littoralis*, *T. annulosus*, *Thysiocetrus sp.*, *Acanthacris ruficornis*, *Anacridium aegyptium*, *Calliptamus sp* et *Paratettix meridionalis*. A Adrar, 13 espèces d'orthoptères sont notées dans le même biotope que *Schistocerca gregaria* dont deux Ensifères *Gryllus bimaculatus* et *Grylotalpa vulgaris* et 11 Caelifères sont notées il s'agit de *Aiolopus thalassinus*, *A. strepens*, *Acrotylus patruelis*, *Pyrgomorpha cognata*, *Locusta migratoria*, *Platypterna kraussi*, *Thysiocetrus harterti*, *T. annulosus*, *T. littoralis*, *Spingonotus rubescens* et *S. savignyi*. A Tamanrasset en plus de la sauterelle pèlerine *Schistocerca gregaria* et de 2 espèces spécifiques *Sphodromerus cruentatus* (Calliptaminae) et *Poecilocerus hyeroglyphicus* (Acrididae), nous avons noté 7 caelifères. Il s'agit de *Aiolopus thalassinus*, *Acrotylus patruelis*, *Ochridia harterti*, *Ochridia sp.*, *Pyrgomorpha cognata*, *Spingonotus canariensis* et *S. rubescens*. A Djanet, 12 espèces d'orthoptères sont notées; il s'agit de 2 gryllons, *Gryllus sp1* et *Gryllus sp2*, de *Pyrgomorpha cognata*, *Pyrgomorpha sp.*, *Thysiocetrus annulosus*, *Anacridium aegyptium*, *Schistocerca gregaria*, *Aiolopus thalassinus*, *Acrotylus patruelis*, *Spingonotus*

*rubescens*, *Ochrilidia kraussii* et *Ochrilidia sp* A Ghardaïa, 38 espèces d'Orthoptères sont notées dont 2 Ensifères, *Phaneroptera quadripunctata* et *Brachytrypes megacephalus* ainsi que 36 Caelifères appartenant à 4 familles. Les plus caractéristiques sont: *Nadijia sp*, *Eremocharis insignis* et *Tmetis cisti* (*Pamphagidae*) *Tenuitarsus angustus* (*Pyrgomorphidae*), *Thisiocetrus harterti*, *Hyalorrhapis calcarata*, *Sphingonotus carinatus*, *S. rubescens*, *Pseudosphingonotus savigni*, *Platyterna kraussi*, *P. gracilis*, *P. harterti* et *Dericorys millierei* (*Acrididae*) ainsi qu'une espèce *Acrydiidae*, *Paratettix meridionalis*. Nous constatons donc que la faune orthoptérologique varie qualitativement et quantitativement en fonction des stations et du tapis végétal.

Mots clés: orthoptères, ensifères, caelifères, oasis, Sahara.

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## Distribution Patterns of Orthoptera in Relation to Climatic Factors in Brittany (France).

Poster 51

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Orthopteran communities are spatially and temporally variable in response to a variety of biotic and abiotic factors. Also, they have long been considered as bioindicators in various topics. The objective of this study is to determine environmental factors that are the most closely linked with changes in Orthoptera distribution at a regional scale in Brittany (Northwest France). 663 sites were sampled during the summer of 1998 and inventories have been carried out with the help of Orthoptera specific song recognition. This intensive study of Orthoptera fauna in Brittany led us to assess and map 59 species. First of all, the occurrence of each Orthoptera species was correlated with thirty-year regional climatic data to show how significant the relation is. Our results show that both mean annual temperatures and precipitations are important in governing aspects which explain northern edge and species range. In a second time, the overlay of each taxa distribution range led us to deduce three distributional range patterns or corotypes. The latest also were closely correlated with weather regional features. The significant results would suggest that some Orthoptera could be considered as "climatic bioindicators" as they are very sensitive to regional climate. However, the interpretation of the results should be tempered as the whole relationship is not well understood and probably involves very complex interactions at different scales. As well, a few species don't spread in relation to these regional data. It seems that scaling and landscape perception of these Orthoptera species is more local. Therefore, they might be bioindicators of other environmental factors such as human land-use or microclimatic features.

Key words: biogeography, bioindicator, corotype, scaling perception.

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## Towards a Synthesis of the Orthoptera of Italy. Poster 38

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The Orthoptera fauna of Italy is as varied as the Italian landscape, in total covering more than 340 species. Throughout the past 150 years many national and international researchers have contributed to the knowledge of Italian Orthoptera, but until recently the information was scattered over many publications. In 1997 a checklist was published and many distribution data from literature and collections were summarized in preliminary distribution maps, within the framework of the 'Progetto checklist e distribuzione invertebrati' (1999-2000, organized by the Italian Ministero dell'Ambiente). Recently it was decided to bring together all available data for a volume in the series Fauna d'Italia, to be published in the next years. In the book will be presented: keys to all the species, distribution maps, species treatments, general chapters (including a bibliography) and a cd with the sounds.

## The Orthopteroid Insects of the Veneto Region (Northern-Eastern Italy); (Blattaria, Mantodea, Isoptera, Orthoptera, Phasmatodea, Dermaptera, Embiidina). Poster 37

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The Veneto region, in north-eastern Italy, is characterized by many different habitats. It extends from the high peaks of the Dolomiti Mountains in the Alps, through the Padana plain to the Adriatic Sea, where the Venice Lagoon and the Po river delta are the most interesting coastal habitats. Xerothermic areas and natural caves are very frequent and interesting too. In the area several nature reserves and parks were also established: e. g. Dolomiti Bellunesi, Delta del Po National Parks, and Colli Euganei, Monti Lessini, Dolomi d'Ampezzo e Fiume Sile Regional Parks. In the last few years, the authors studied the orthopteroid insect fauna of many areas of the Veneto region, publishing some articles on this topic. On the basis of this work, the Museo Naturalistico Archeologico di Vicenza charged the authors to write a field guide on the orthopteroid insects of the region. The book will include a general part, comprehensive of keys in Italian and English for all the species, a colour photo atlas, a discussion about each species, a proposal for a Red List, and a CD with the songs of all singing species.

In Veneto are present 170 species of orthopteroid insects consisting of about 38% of the whole Italian orthopteroid fauna, while the surface of the region covers only the 6% of Italy. The species are representative of 7 orders: 14 Blattodea, 4 Mantodea, 2 Isoptera, 134 Orthoptera, 2 Phasmatodea, 14 Dermaptera and 1 Embiidina. Several species, mostly in the wet habitats, are endangered and need protection. The most interesting species are: *Loboptera decipiens*, *Capraiellus tamaninii* (Blattodea), *Empusa fasciata* (Mantodea), *Calotermes flavicollis* (Isoptera), *Acrometopa macropoda*, *Poecilimon elegans*, *Barbitistes vicetinus*, *Roeseliana brunneri*, *Zeuneriana marmorata*, *Saga pedo*, *Ephippiger vicheti*, *Dolichopoda latitie*, *Stenonemobius gracilis*, *Chorthopodisma cobelli*, *Pseudoprumna baldensis*, *Pseudopodisma fieberi*, *Epacromius c. coerulipes*, *E. t. tergestinum*, *Chrysochraon dispar giganteus*, *Aeropadellus v. variegatus* (Orthoptera), *Bacillus rossius redetenbacheri*, *Clonopsis gallica* (Phasmatodea), *Chelidurella mutica*, *C. vignai*, *C. thaleri* (Dermaptera), and *Embia tyrrhenica* (Embiidina).

Key Words: Orthopteroid insects, Veneto region, faunistic, protection.

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## The Orthopteroid Insects of the Abruzzo National Park (Central Apennine, South Italy): A Preliminary Checklist (Blattodea, Mantodea, Orthoptera, Phasmatodea, Dermaptera). Poster 36

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The Abruzzo National Park, established in 1923, is one of the oldest Italian protected areas and extends over 50,000 hectares in the Abruzzo, Lazio and Molise regions. The territory is mountainous, the main peaks being Mt. Greco (2,285 m), Mt. Petroso (2,249 m), Mt. Marsicano (2,245 m) and Mt. La Meta (2,242 m). During the glacial ages, glaciers covered much of this area and the flora and fauna remained isolated, differentiating from other Italian areas. Consequently, many Apennine species are endemic to a single mountain. Another interesting aspect of the Central Apennine is the presence of xerothermic areas on high altitude, where xerophilous species live not far from orophilous

ones. This aspect makes the fauna and flora of Central Apennine very rich and peculiar. In the past, the Abruzzo National Park has been studied by several orthopterologists (Capra, Baccetti and La Greca). Recently new field researches have been carried out by the Centro Studi Fauna Appenninica of the Abruzzo National Park in cooperation with the Dipartimento di Agronomia Ambientale e Produzioni Vegetali (Entomologia) of the University of Padua, Italy and the Dipartimento Biologia Animale e dell'Uomo, Univ. di Roma "La Sapienza", Italy. On the basis of the available literature and on the new field data, it was possible to update the checklist. The number of species now recorded is 75: 4 Blattodea, 1 Mantodea, 64 Orthoptera, 2 Phasmatodea and 4 Dermaptera. The most interesting species are *Capraiellus tamaninii*, *Ectobius caprai* (Blattodea), *Barbitistes yersini*, *Tettigonia cantans*, *Decticus aprutianus*, *Bicolorana bicolor*, *Saga pedo*, *Ephippiger cavannai*, *Ephippiger ruffoi*, *Italopodisma a. acuminata*, *I. a. marsicana*, *I. t. trapezoidalis*, *I. t. aprutiana*, *Aeropus s. sibiricus*, *Chorthippus affinis bruttius*, *Italohippus monticola* (Orthoptera), *Bacillus rossius*, *Clonopsis gallica* (Phasmatodea), *Pseudochelidura orsinii* (Dermaptera).

Key words: faunistic, protected area.

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## Can We Use Orthoptera as a Probe For Global Warming in High Mountains? Poster 50

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In mountain system, given the existence of altitude-specific adaptations and environmental constraints, Orthoptera distribution shows a zonation of species from lowland to upland. We present here results of a survey in the Haut-Var valley in the National Park of Mercantour in French South Alps. Along an elevational gradient ranging from about 1800 to 2600 m and including the two facing slopes of the Var valley, we describe the quantitative distribution of 21 Orthoptera species. We show a species continuum with a sequence of overlapping distributions. Inside, using a quantitative method of sampling, we can distinguish areas where density of individual species is higher in respect to elevation gradient. Altitude through its effect on temperature may explain this zonation because temperature preferendum is important to determining Orthoptera habitat requirements and also their developmental rates and threshold temperatures vary among species. Whether the observed temperature changes are signs of natural fluctuations of the climate system or a sign of man-made alterations of the greenhouse effect, in any case the observed warming will push Orthoptera species upwards in altitude and may cause disastrous extinctions in mountains' summit communities. For example the biennial life cycle of *Stenobothrus coticus* raises the question whether, even if capable of living at warmer temperatures, the upland species will be able to adapt their life-cycles in the presence of lowland species. Zonation described here was obtained in 1983-1986, other transects were sampled in different sites in the National Park of Mercantour in the same period. About 20 years ago, we propose to study if some changes have occurred since then.

Key words: Altitudinal distribution, transect, zonations, climate change, Alps.

**Ecology and Ethology of Acridids in Hill, Plateau and Plain Ecosystem.** Poster 40**Halдар, P.**

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Biodiversity, seasonal occurrence and population dynamics on short horned grasshopper in three distinct vegetation sites such as woodland, grassland and agricultural land from three different ecosystem namely hill ecosystem at Solan, altitude approx. 1500 metre, plateau ecosystem at Santiniketan altitude approx. 58.9 metre and plain ecosystem at Howrah, approx. 8 metre, India were investigated. Study on habitat preference reveals that *Spathosternum prasiniferum prasiniferum*, *Oxya fuscovittata*, *Acrida exaltata*, *Aiolopus thalasinus tamulus* and *Trilophidia annulata* are widely distributed in all these three ecosystems. Comparative study on the biology focused that *Acrida exaltata* is univoltine in hill ecosystem and bivoltine in plateau and plain ecosystem. The total Acridid population was at a higher level during late monsoon and autumn at hill ecosystem. Population estimation for sex ratio revealed dominance of males over female in plain ecosystem. Finding of this study also reflected that in the grassland *Trilophidia annulata* and in Woodland *Phlaeoba panteli*, *Gesonula puntiformis* and *T. annulata* and in agricultural land only *A. t. tamulus* are the opportunistic species where as *S. p. prasiniferum*, *O.fuscovittata* and *A. exaltata* are the characteristic species in all these different environment of the plateau ecosystem.

Key words: Ecology, Acridids.

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**Adaptations of Locusts and Grasshoppers to Overcome Limiting Factors in their Environment.** Symp. 3, Tues. 1430
**Hunter, D. M.<sup>1</sup>, P. W. Walker<sup>1</sup> and R. J. Elder<sup>2</sup>**<sup>1</sup> Australian Plague Locust Commission, Department of Primary Industries and Energy, GPO Box 858, Canberra, ACT. 2601, Australia.<sup>2</sup> Department of Primary Industries, P.O. Box 6014, Rockhampton, Qld. 4702, Australia.

In Australia, where approximately 80% of the land area is arid or semi-arid, rainfall is the major factor limiting acridid populations. Rainfall is not only limiting in terms of quantity but also in being highly variable both temporally and spatially. In this paper, the main adaptations seen in Australian Acrididae to overcome limiting rainfall are discussed with special reference to economically important species.

In the arid interior, many species of grasshopper withstand substantial dry periods by having a drought resistant egg stage that can survive a year or more without rain. In the semi-arid sub-tropics (23-33°S) rainfall is slightly summer dominant but extended dry periods can occur in any season. *Chortoicetes terminifera*, the main pest species, survives dry periods in the egg stage by entering diapause during winter or quiescence when it is warmer. Migration is critical for survival as it allows locusts to locate areas of localised rainfall. Outbreaks are frequent and develop when enough rain falls to allow continuous breeding over 3-4 generations. In the tropical north (13-23°S) rainfall is strongly summer dominant and winters are dry. *Austracris guttulosa*, a univoltine species, survives the dry winter as immature adults that do not mature until onset of the wet season. Migration is also important, allowing adults to locate localised areas of rain that fall early in the wet season.

*Locusta migratoria* does not have a stage that can survive extended dry periods. Consequently, it is mainly restricted to areas of subcoastal Queensland where moderate rainfall occurs. Populations often decline during the slightly drier winter but outbreaks develop when good rain falls in all seasons.

In temperate areas of sub-coastal southern Australia, summers are dry and most rain falls in winter or early spring. *Austroicetes cruciata*, another univoltine pest species, avoids the dry summers by having an embryonic diapause throughout summer and winter.

## How do Orthopteran Communities Indicate the Effect of a Prolonged Disturbance to the Wet Grasslands? Poster 49

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The riverine wet grasslands are special habitats for the inhabiting insects because they are exposed to regular perturbations such as annual floods, mowing and cattle grazing, but they still show a stable constancy in their species composition and species rank order. However a non-recurrent permanent large-scale disturbance might easily change the essential ecological processes which are responsible for the developing of the insect communities and so it might change the insect community structures. In the present study the changes of the diversity and the stability of the orthopteran communities were compared in disturbed and undisturbed riparian wet grasslands during a six-year monitoring period. Our study sites were located in the Szigetköz region in north-western part of Hungary, where the river Old-Danube was diverted in 1992 so the water output decreased by 90 percent of the original output. After the diverting of the river the underground water level, which is an essential environmental factor for the inhabiting insects in this ecosystem, decreased in the region by 3 metres. Adding to this long lasting disturbance the annual flooding period also changed. However in the species composition and diversity of the orthopteran communities of the disturbed and undisturbed sites slight differences were found during our monitoring period. While the stability of the orthopteran communities, beside the fluctuation of the total density both in the disturbed and undisturbed sites, changed in the long-lasting decreased underground water levelled sites. That is the order of the species in the communities, based on their relative abundance, showed temporally inconstancy.

Key words: stability, diversity, species rank order, constancy.

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## Application of Remote Sensing and GIS to Grasshopper Ecology in Temperate Eurasia and North America: How Powerful is the Tool? Symp. 3, Tues. 1540

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Grasshoppers (Orthoptera: Acrididae) are pests of rangeland and crops in temperate Eurasia (Siberia) where landscapes are dominated by short-grass vegetation and have many common features with the prairies of the Great Plains of North America. Specific composition and density of grasshopper communities were studied over a variety of habitats in East Siberia (Russia) and Wyoming (USA).

Spatial distribution of historic grasshopper infestations was studied using GIS (ERDAS IMAGINE®) and remote sensing (Landsat TM satellite imagery) and was found to be significantly clumped. In East Siberia, the highest grasshopper densities were associated with dry grasslands in transitional zones between foothills and valleys characterized by particular elevations (600-650 m), soil type (sod-forest, or pararendzina), amount of April-October precipitation (250 mm) and degree of grazing (moderate). In Wyoming, the most frequent grasshopper outbreaks were found to be associated with open woodlands with an understory of grasslands and herbs characterized by elevations ranging from 1,200 to 1,500 m, particular soil associations (Torriorthents) and a certain amount of mean annual precipitation (200-300 mm) (Schell & Lockwood, 1997). Identification of such zones allows for the efficient concentration of management resources and optimization of spatial structuring of grasshopper survey. Development of GIS and remote sensing techniques in applied acridology will contribute to progress towards more rational, economically sound and environmentally viable methods of grasshopper pest management. Advantages and shortcomings of the application of these techniques to grasshopper ecology are discussed.

**Italian Endemic Orthoptera. Poster 39****Massa, Bruno <sup>1</sup>, Paolo Fontana <sup>2</sup> & Roy Kleukers <sup>3</sup>**<sup>1</sup> Dip. Scienze Entomologiche, Fitopatologiche, Microbiologiche e Zootecniche (SENFIMIZO), Settore Entomologia applicata (University of Palermo), Viale delle Scienze, 13 90128 Palermo, Italy.<sup>2</sup> Dip. Agronomia Ambientale e Produzioni Vegetali - Entomologia (University of Padua), AGRIPOLIS - Via Romea, 16 35020 Legnaro (Padova) Italy. paolo.fontana@unipd.it<sup>3</sup> European Invertebrate Survey - The3 Netherlands, Matioanal Museum of Natural History, Postbus 9517, 2300 RA Leiden, The Netherlands.

Endemic taxa contribute remarkably to the biodiversity of Italian Orthopterofauna. Endemic Italian Orthoptera are spread from Alps to the southern tip of Italian peninsula and on small and large islands. Their origin always derived from geographic isolation which, by different processes and during different geological ages, favoured their differentiation. The quaternary vicissitudes, characterized by alternate increasing and dissolution of glaciers, originated some peculiar mountain fauna, derived from northern species (e. g.: gen. *Metrioptera*, *Decticus*, *Podisma*, *Italopodisma*, *Chorthopodisma*, *Pseudoprumna*, *Epipodisma*, *Kisella*, *Nadigella*, *Pararcyptera*, *Stenobothrus*, *Italohippus*, *Chorthippus*). Some endemic species of the Po River delta and of the Venice lagoon, are particularly interesting; in fact the fast formation of the Padana plain, subsequent to the periodical glacier dissolutions, produced a coastal fauna isolation, with many taxa clearly differentiated from central-European species, now present in Italy only on the Alps (e. g.: gen. *Roeseliana*, *Zeuneriana*, *Epacromius*, *Chrysochraon*). Alternate lowering and rising of the sea level, often related to the glacial ages too, favoured the migration and/or the isolation of coastal or lowland fauna. Micro- and macro-insular endemic taxa, as transadriatic ones, show clearly such origin (e. g.: gen. *Acrometopa*, *Poecilimon*, *Barbitistes*, *Tettigonia*, *Eupholidoptera*, *Rhacocleis*, *Ephippiger*, *Dolichopoda*, *Prionotropis*, *Dirshius*, *Dreuxius*, *Glyptobothrus*, *Euchorthippus*). The influence of the tectonic on the origin of some Sardinian and Sicilian taxa (e. g.: gen. *Odontura*, *Steropleurus*, *Bolivarius*, *Uromenus*, *Praehippigerida*, *Pamphagus*, *Ocneridia*, *Acinipe*), is still discussed; the influence of tectonic events seems to be confirmed by biogeographical knowledge, even if further paleogeographical studied are needed.

Key words: Italy, endemic taxa.

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**Ecological Plasticity of the Endemic *Isophya costata* (Orthoptera: Tettigonidae - Carpathian Basin) Exemplified by Syntopic Orthoptera Assemblages. Poster 48**
**Nagy, B. & G. Szövényi**

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*Isophya costata* should be considered as a “flagship”-insect species in the Hungarian nature protection. It is a rare, endemic and vulnerable grasshopper species in the Carpathian Basin, placed under nature protection in Hungary and, it became - being an endangered species - a member of the list of the Hungarian Red Data Book. Although it occurs at several sites, its distribution is very disjunctive. These isolated populations inhabit very limited areas and generally show low densities. In spite of these, the habitats occupied by the populations can be characterised by varied features of the geographical position (exposition, elevation), and vegetation (species composition, patchiness, grass-structure). Our aim in this study is to show how the wide variety of habitat characteristics reflects the composition and structure of the syntopic Orthoptera assemblages. The overwhelming majority of the Orthoptera assemblages including also *I. costata*, consist of mesophilous species (e.g. *Poecilimon intermedius*, *Polysarcus denticauda*, *Metrioptera bicolor*, *Odontopodisma decipiens*, *Stenobothrus lineatus*, *Omocestus rufipes*). Extreme, suboptimal cases, where *I. costata* also occurs, are represented by such species as the xerophilous *Saga pedo*, *Calliptamus italicus*, *Oedipoda caerulescens*, *Pezottetix giornaie*, *Stenobothrus nigromaculatus*, *St. eurasius*, or the hygrophilous *Mecostethus parapleurus*, *Chrysochraon dispar* and *Conocephalus discolor*. The results of multivariate statistical analyses also confirm the above. The ecological plasticity of *I. costata* is also indicated by the wide range of its food plants and by the conspicuously variable egg diapause (1-4 years), ensuring the survival of subpopulations in case of local extinctions.

Key words: associated grasshoppers, disjunct, survive strategy.

## Long-term Changes in the Orthoptera Assemblages of an Isolated Peninsula in Hungary. Poster 46

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Long-term changes in species composition and diversity of the Orthoptera assemblages were studied based on 86 samples collected by sweep netting mainly in 1947 and in 1998-2000, and supplemented by limited qualitative samplings in 1973, 1979 and 1983. Samples were taken from six habitat types on the relatively isolated Tihany Peninsula. The transformation of the assemblages was evaluated considering both vegetation structure and habitat quality (condition, disturbance/degradation). Data sets were analysed by various multivariate statistical methods (e.g. hierarchical clustering, PCA, PCoA) and diversity ordering. The attractive, hilly region, 12 km<sup>2</sup> in size, has been under nature protection for a long time and it later became even a part of the Balaton-felvidéki National Park. In spite of these facts, this fashionable resort place is suffering more and more under heavy civilisation pressure, (agriculture/viniculture, buildings, tourism, hiking, grazing, etc.), that affect even the fragmented natural/seminatural habitats. During the half century after our first survey, 37,5% of the formerly found 48 Orthoptera species have “disappeared”, but recently 6 species were newly detected. Among the species which disappeared there are both hygrophilous- (e.g. *Conocephalus dorsalis*, *Chortippus montanus*) and xerophilous (e.g. *Acrida ungarica*, *Oedaleus decorus*, *Platycleis affinis*) ones, mainly species that showed low dominance and frequency in the earlier assemblages. The newly detected spp. are represented also by very low dominance and frequency and their appearance is possibly due to the new, but small sampling sites that were avoided earlier. Artificial flooding of a former wet meadow strongly diminished the area of suitable habitat for the *Chortippus* - *Mecosthetus* - *Stetophyma* species complex.

Key words: assemblages impoverishment in half century.

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## Morphological Adaptations to Living in Grasslands. Symp. 3, Tues. 1510

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In grasshoppers the accidental coming together of individuals belonging to different species occurs frequently in the field, even between distantly related species belonging to different genera and subfamilies. Such interactions must have evolutionary consequences on the behavior and ecology of interacting species. The level of interaction between species belonging to the same genus is significantly higher than it is for species belonging to different genera. It follows that a species is most likely to undergo evolutionary changes in its sexual behavior and ecological interactions in relation to more closely related species. If grasshopper species are more prone to accidents in pair formation than other groups of acoustical Orthoptera, then there might be fundamental differences in the ease with which reproductive isolation can be achieved and in the manner in which it is achieved. It is probably easier for newly formed species of nocturnal ensiferans to achieve sympatry with one another than it is for grasshoppers to do the same. In ensiferans the call seems to be the prevalent means of pair formation, and a difference in the calls alone can prevent most interspecific interactions. In grasshoppers, where pair formation is achieved by visual as well as by acoustical means, more than just a call difference is needed. The issue is complicated where no premating signals are evident. Extensive differences in courtship among closely related species, as contrasted to the lack of such pronounced differences among closely related species of crickets, might also be a consequence of the relative difficulty that grasshoppers may have in perfecting their system of pair formation. Many biologists maintain that behavioral or premating differences function as isolating mechanisms, and that genitalic differences are incidental byproducts of selection for increased efficiency in coupling (within species selection pressures) and have not been selected in the context of reproductive isolation (between species selection pressures). The situation found in certain grasshoppers suggests that the question is not yet resolved. Genitalic differences are very distinct among the species of Melanoplinae and others, whereas among Oedipodinae and Gomphocerinae the differences are much less pronounced. In Melanoplinae no signalling is apparent before the male has mounted the female. Interspecific recognition probably occurs partly as a result of chemical and mechanical-tactual signalling between male and female after the male has mounted the female. It seems likely that genitalic differences have been favored because they prevent interspecific matings. A very similar pattern exists in Hawaiian Drosophilidae. The lock-and-key theory of reproductive coupling is not dead. But the mechanism may involve more than mechanical fitting; it probably involves the operation of sensory fields.

## Why Does Local Cricket (Orthoptera: Grylloidea) Species Richness Not Increase with Forest Remnant Size? Poster 47

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The regional cricket species richness increased with the logarithm of forest remnant area. However the local species richness was not affected by remnant area (Sperber 2001). Why did this occur? We tested the hypothesis that local species richness resulted from a local sampling effect. If this was true, local species richness should increase linearly with the number of individuals collected in each sample unit. To test this hypothesis, we used observed species richness per sample unit as our response variable. The explanatory variable was the number of individuals collected per sample unit. We used a general linear model, with binomial errors, total species number as binomial denominator, and complementary log-log link function (Crawley 1993). The adjusted model was not statistically significant ( $n=45$ ;  $c2=0.50$ ;  $P=0.48$ ). This result means that there was no local sampling effect. There was a limit for local species richness, which was not affected by the number of cricket individuals. The limit for local species richness could result from: i) stronger interspecific than intraspecific competition; ii) exhaustion of the regional species pool; iii) stochastic equilibrium between local immigration and extinction (Soares et al. 2001). Support: CAPES; UEEC/UFV.

Key words: local diversity; regional diversity; stochastic equilibrium; pool exhaustion; competition.

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## Ecological Succession in Herbaceous Environments and Displacement Capacities in Acrididae. Poster 45

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Ten species of *Acrididae* belonging to a primary ecological succession in herbaceous environments were studied. The following order respects the succession observed near Limoges (France), from the first to the last species: *Oedipoda caerulescens*, *Aiolopus strepens*, *Chorthippus brunneus*, *Omocestus rufipes*, *Chorthippus biguttulus*, *Chorthippus albomarginatus*, *Chorthippus dorsatus*, *Euchorthippus declivus*, *Chorthippus parallelus* and *Chrysochraon dispar*. We measured morphometrical variables dealing with displacement organs and distance performed during jumping flights.

Organ morphometry: a discriminant analysis reveals a correlation between the succession order and the projection of species on the first factorial plan.

Jumping flights: we recorded (i) the reactivity of individuals (10 males and 10 females by species) with different stimuli (presence of experimentalist, body approach, hand approach and touch), (ii) the covered distance and (iii) the number of jumping flights until weariness.

A Canonical Analysis of Correspondence between the two data sets showed that:

- The early species are characterized by long hind wings and a great size of posterior pronotum width. The females are more reactive than males.
- The late species are characterized by short hind wings and parallel lateral carinae. Females are less reactive than males, that can be related to an important reproductive investment.
- The variations of the tegmina and hind femur lengths are not significantly related to any parameter of displacement capacity.
- There is an inverse correlation between the covered distance and the number of jumping flights.

## Etude par l'analyse factorielle des correspondances de la répartition des Orthoptères dans trois stations du Parc National de Taza (Jijel, Algérie). Poster 44

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Cette méthode d'exploitation des résultats permet de décrire les relations qui existent entre les stations et les Orthoptères. Elle est obtenue grâce à un tableau de présence-absence des acridiens représenté selon un code à p colonnes dans chacune des stations représentées par n lignes. A partir de ce tableau, nous pouvons obtenir par voie informatique, un graphe à plusieurs axes dans lequel les n points sont décrits dans un nuage à p dimensions. Grâce à la dispersion de ce nuage, nous pouvons interpréter les relations insecte-station et insecte-insecte.

Afin d'étudier l'impacte de certains paramètres comme la végétation, l'altitude ou la température sur la répartition des Orthoptères, nous avons choisi les stations de telle sorte que celles-ci soient différentes les unes des autres; il s'agit en l'occurrence de la friche de Taza localisée au bord de la mer et la garrigue de Tifraouene ainsi que le maquis de Guerrouch situées toutes les deux en montagnes mais à des altitudes différentes. Pour réaliser ce travail, nous avons effectué des sorties mensuelles au niveau de chacune des trois stations et ce en utilisant entre autre un filet fauchoir et des sachets en papier pour la capture des insectes. Une fois au laboratoire, ces derniers sont identifiés grâce à la clé de détermination de Chopard (1943).

A la faveur des résultats obtenus, il s'est avéré que quatre groupes d'Orthoptères se sont dégagés. Il s'agit en l'occurrence du premier groupe composé d'*Omocestus lucasii*, *Eyprepocnemis plorans*, *Truxalus nasuta*, *Acrida turrata* et *Anacridium aegyptium*. Le deuxième groupe renferme entre autre *Acrotylus insubricus*, *Aiolopus strepens*, *Pezotettix giornai* et *Calliptamus barbarus*. Les espèces *Ochrilidia* sp, *Talpomena algeriana*, *Oedaleus decorus* et *Sphingonotus lucasii* constituent le troisième groupe. Enfin le quatrième et dernier groupe est composé des espèces *Omocestus ventralis*, *Ochrilidia tibialis* et *Heterocris annulosus*.

En se référant au tableau de présence-absence d'une part et aux caractères de chacune des trois stations d'autre part, il convient de dire que l'axe horizontal du graphe représente différents gradients croissant ou décroissant de végétation, d'altitude, de pluviométrie et de température.

Mots clés: Friche, Garrigue, maquis, Groupe, présence-absence, Gradient.

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## Etude des peuplements d'Orthopteres de la Réserve Naturelle de Montenach (France). Poster 31

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La Réserve Naturelle de Montenach (Moselle) comprend une quarantaine d'hectares de pelouses calcicoles sèches, réparties sur six collines qui représentent une surface totale de 107 hectares. Ces pelouses, actuellement gérées par la fauche (fréquence annuelle à quinquennale), présentent une diversité végétale importante qui leur confère un intérêt patrimonial fort. Le fauchage actuel, très contraignant, permet difficilement d'atteindre l'objectif principal de la Réserve Naturelle, soit la conservation des pelouses sèches typiques appartenant à l'alliance phytosociologique du Mesobromion. Le gestionnaire du site (l'association du Conservatoire des Sites Lorrains) envisage de mettre en place une gestion par pâturage ovin et /ou équin, à partir de l'année 2001, afin d'enrayer la dynamique naturelle de fermeture de la végétation

et le maintien des pelouses dans un stade dynamique ouvert. Cette étude présente d'une part, un bilan de l'impact de 11 années de gestion par la fauche sur les cortèges d'Orthoptères et d'autre part constitue un état initial qui servira de référence avant la mise en place d'un pâturage ovin et /ou équin. Ainsi la démarche scientifique utilisée pour appréhender les peuplements d'Orthoptères permet un suivi dans le temps des populations afin d'évaluer l'impact du pâturage sur ce groupe d'insectes. La méthodologie retenue, basée sur la description des peuplements orthoptériques (indices horaire d'abondance), confirme une nette évolution des pelouses. Cette tendance évolutive de la végétation au boisement progressif se caractérise dans la composition des relevés orthoptériques, par la dominance d'une espèce, *Gomphocerippus rufus*. De plus, les résultats obtenus démontrent que la fauche hivernale des pelouses a un impact largement positif sur les peuplements d'Orthoptères.

Mots clés: Orthoptères, peuplements, pelouses sèches, gestion, impact, fauche, pâturage.

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## Biological Diversity of Orthoptera in Grasslands of Temperate Eurasia: From Taxa to Communities. Symp. 3, Tues. 1630

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Grasslands of temperate Eurasia are inhabited by several hundreds of orthopteran species. There are several areas of high diversity and endemism. One of them is associated with the Daurian and Mongolian steppes. It includes a specific set of tribes (Drymadusini, Platycleidini, Deracanthini, Hypernephini, Bryodemini), genera and species. Uvarov (1929) proposed to call it the Angara fauna. Another important area of orthopteran evolution in grasslands is in Anatolia (Uvarov, 1929) where some endemic genera of the tribes Drymadusini and Platycleidini and many endemic species occur. Mountain grasslands are populated by endemic genera and species of the tribes Platycleidini, Drymadusini, Conophmatini, Melanoplina, Hypernephini.

Orthopteran populations in arid grasslands and forest regions are distributed locally, as islands. Species abundance is low in each habitat. There is also a wide variety of habitats into which Orthoptera may spread (in some cases anthropogenic biotopes). In the steppes, a diversity of favourable conditions allows populations of many orthopteran species to coexist at high level of abundance. Abundant species are associated with steppe habitats. They are usually replaced one by another due to climatic fluctuations and human activity.

In each habitat local populations of all species comprise a local community (an assemblage) of orthopteran insects. The abundance, biomass, and other features of communities define the role of Orthoptera in every ecosystem. In temperate Eurasia, orthopteran biomass is higher in dry continental regions (south Siberia, Inner Mongolia). In general, every geographical region has its own type of community distribution and composition. These differences result in spreading through anthropogenic habitats. In some cases, centres of taxonomic diversity and areas of high densities and biomass coincide or overlap. This means a real contradiction between main goals of conservation and pest management.

Key words: endemism, biomass, population, conservation, pest.

## **Spatiotemporal Analysis of Grassland Grasshopper (Orthoptera: Acridoidea) Density and Environmental Factors in South-eastern Buenos Aires, Argentina: Application of Remote Sensing and GIS. Poster 43**

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The temporal dynamics of an insect population take place within a spatial context. Grasshopper outbreaks are typical examples of large-scale spatial dynamics that are affected by local conditions. Factors affecting grasshoppers' densities fluctuations are usually variables that have both spatial and temporal characteristics and can be mapped. The objective of this study is to determine the environmental factors which are more closely related with changes in grasshopper densities in Benito Juarez county. Grasshopper density data (all species together) and species specific relative abundance data collected throughout Benito Juarez from 1996 to 2001 were examined.

A geographic information system (GIS) and appropriate statistical techniques were utilised to analyse the geographic overlap of grasshopper density with soil properties (types and textures), land use, landscape and weather conditions for the county of Benito Juarez, in the southern pampas region. Geostatistical methods and GIS techniques were used to create continuous distribution grasshopper density maps from point survey data. Satellite images (Landsat TM) were used to create a land use layer for the study area. The soil and landscape layers were obtained from Atlas INTA-Aeroterra. Because GIS technology provides a method to summarize and analyze data that are spatially related it showed to be a useful technique to help in the understanding of the ecological factors that affect grasshopper population dynamics in the southern pampas.

Keywords: Geographic information system, population dynamics, insect outbreaks.

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## **Grasshopper (Orthoptera: Acridoidea) and Plant Community Relationships in the Argentine Pampas. Poster 42**

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Grasshopper and plant community relationships were examined in southeastern Buenos Aires province. Twenty seven sites were selected in 2000 representing a variety of native and exotic plant communities, with different degrees of disturbance history. Grasshopper mean density, species relative abundance and species composition were estimated at each site. Plant community at each site was estimated evaluating percentage canopy of ground cover of native perennial grasses, introduced perennial forbs, annual pastures, halophilous species, perennial pastures, native perennial forbs, introduced annual forbs, and plant species richness. Based on vegetation variables sites were classified into five disturbance categories: native grasslands, halophilous communities, pastures, moderately disturbed pastures and highly disturbed pastures. Grasshopper communities on sites dominated by introduced species (introduced forbs, seeded grasses and dicots), were characterised by relatively high densities and high proportion of potential pest species. Native grassland sites showed lower grasshopper densities, while halophilous communities had high densities, but with low proportion of potential pest species.

Key words: grasshopper species diversity, plant communities, disturbance.

## Chemical Control of Desert Locust (*Schistocerca gregaria*) in Environmentally Sensitive Areas in Eastern Africa. Poster 41

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Chemical control of Desert Locust (DL) is carried out over large areas of land covering a range of different landscapes and ecosystems. Due to the emergency character of DL control, the control can be performed by untrained personnel, and dosage and choice of compound are often not optimal. There are no real restrictions or guidelines for spraying in or close to environmentally sensitive areas and the awareness of this issue has not always been present among people involved in DL control. However, concern about environmental issues in connection to DL control is growing and clear instruments and guidelines are badly needed. The study has included the following countries: Egypt, Sudan, Eritrea, Ethiopia, Djibouti and Somalia. The objectives of the study were to identify and delineate areas particularly sensitive to pesticide contamination. These areas will be matched with the probability of actual pesticide treatment against DL. The following sensitive areas have been delineated: protected areas, wetlands, populated places, oasis and areas with a high concentration of migratory birds. A database containing about 1,500 observations on chemical control of DL between 1986-1998 in the region has been created. The database contains the following information: location, year and month, area, chemical compound and stage of the locust. The conclusion that can be drawn is that chemical control has occurred in environmentally sensitive areas, especially wetlands (e.g. temporary waters and mangroves), close to human settlements and to some extent in or near protected areas. There is also a risk that migratory birds can be affected through depletion of food items. Chemical control of DL will probably continue in the future and possibly increase in certain areas.

Key words: protected areas, wetlands, migratory birds

**Do the Allelochemicals in *Calotropis procera* Plant have any Effectiveness on the Food Utilization of *Poeciloceris bufonius* (Acrididae: Orthoptera)?** Poster 58

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The nutritional indices were studied in third instar females of the locust *Poeciloceris bufonius* when those fed on dried leaves of *Calotropis procera* containing the alkaloids or wheat-seedlings as control plant. Analysis of the main and interactive effects of feeding on *C. procera* and the plant allelochemicals indicated that nymph performance was adversely not affected by the alkaloids in *C. procera*. The rate of consumption and assimilation on *C. procera* was increased as compared with wheat-seedlings and also the increase of weight gain of the nymphs on *C. procera* was correlated to higher assimilation. Relative consumption rate (RCR), and relative growth rate (RGR) were significantly higher in nymphs fed on *C. procera* than in those fed on wheat-seedlings. Feeding on wheat-seedlings significantly reduced the approximate digestibility (AD), efficiency of conversion of ingested food (ECI), and efficiency of conversion of digested food (ECD). During the experiment, feeding on wheat-seedlings resulted in 30% mortality before the moulting to the fourth instar nymph.



**Etude de Certains Aspects Biologiques, Ecologiques et Comportementaux d'*Ocneridia volxemi* (Pamphagidae: Orthoptera) dans la Région de Sétif (Nord-est d'Algérie).** Poster 59

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*Ocneridia volxemi* appelé communément "Boukrouma" du fait de son pronotum bombé, est un Pamphagidae, considéré comme l'une des espèces acridiennes la plus nuisibles aux céréales dans la région de Sétif et d'autres régions céréalières de l'Algérie. Lorsqu'il pullule, il provoque d'importants dégâts sur les céréales qui peuvent atteindre les 95 % de pertes. Pour protéger les champs de céréales, les services concernés (Institut National de la Protection des Végétaux), sont obligés de traiter chimiquement des milliers d'hectares. Pour mieux connaître cette espèce, nous avons entrepris une étude sur six années consécutives de 1994 à 1999 dans différentes localités de la région d'étude. Elle a porté sur les aspects biologiques (cycle de vie), écologiques (les facteurs de pullulation) et comportementaux (sexuel et alimentaire).

Mots clés: *Ocneridia volxemi*, céréale, bioécologie, pullulation.

**Production of Acridid Biomass and its Utilisation for Human Welfare. Poster 84****Das, Amlan, Sarasi Das, & P. Haldar**

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Acridids normally have high reproductive potential. Some of them are capable of producing a huge amount of population, which in turn can yield a great amount of biomass. They are also good sources of protein and other nutritive elements. Scientific and hygienic practice in mass culture can provide a greater amount of biomass. The obtained biomass can be utilised as a non-conventional source of animal protein supplement to chick rations, fisheries, etc. or it can be served in delicious dishes for human consumption, if processed. *Oxya fuscovittata* (Marschall) is such a multi-voltine widely distributed species found throughout the year in India that can be cultured for its biomass production. The ovipositing frequency, growth rate and adult survivability of this species is very high, where as the egg and nymphal mortalities are restricted to near about 5% and 31% respectively at room temperature and humidity. Their gregariousness in habit has also a great impetus on their mass culture in smaller space and it was found that total number of 1000 individuals can be cultured in about 0.05 m<sup>3</sup> space where least nymphal mortality was recorded (16.1%). The culturing time is restricted to 73 &#61617; 11 days including a 34 &#61617; 9. 5 days of egg diapauses period. Food plants supplied for their culture are very common grasses such as *Cynodon dactylon* and *Cyperus kyllingia* of family Poaceae and Cyperaceae respectively which can be easily procured from the adjacent areas. An estimated number of 8.33 lacks populations with an amount of nearly 283 kg. of wet biomass can be obtained from four generations completed in one year, from only a single pair of individuals. Biochemical studies revealed that the protein content of this species is remarkably favourable (~16%) for preparation of poultry or fish meal as supplementary animal protein rich ingredient with least sanitation, labour and expenditure.

Keywords: Acridid mass culture, biomass, protein source, utilisations.

**Labrum Sensilla in Moroccan Locust: Relationship with its Polyphagous Diet. Poster 64****El Ghadraoui, L. <sup>1</sup>, D. Petit <sup>2</sup> & F. Picaud <sup>2</sup>**<sup>1</sup> Laboratoire de Biotechnologie Végétale. Faculté des sciences et Techniques Fès-Saïss. B.P. 2202. Morocco.<sup>2</sup> EA3176, Faculté des sciences, 123 av. A. Thomas. F-87060 Limoges Cedex. France. dpetit@alpha1.unilim.fr

The Moroccan locust, *Dociostaurus maroccanus*, is a pest species, which is regularly harmful to pasture and agricultural productions in numerous circum-mediterranean regions and particularly in Morocco. The acridian species belonging to the same subfamily (Gomphocerinae) are mostly grass feeding oligophagous and very few species are monophagous or polyphagous. *D. maroccanus* is characterised by a wide spectrum polyphagy. The diet of juveniles and adults is diversified. This polyphagy seems to be linked to nutritional needs, the mandibule types and chemoreceptor organs related to taste (e.g. labrum sensilla). In the present work, we studied first the genesis of type A sensilla along the different stages of *D. maroccanus*. Secondly, we tested if the variation of sensilla number depends of the systematic position of the genus or of diet nature. As sensilla plates are correlated with labrum width, we eliminated this bias source with linear regression statistics. The comparisons concerned the relative numbers of different sensilla categories within several species of Acridians. As for development, A1 and A2 numbers are strictly proportional to labrum width. The adults present a weaker value of A3 and an excess of A10 relatively to juveniles. The number of A1 is close to the one observed in polyphagous Oedipodinae; the number of A2 and A3 in *Dociostaurus* is richer than in the other studied Gomphocerinae and Oedipodinae. Therefore, alimentary diet seems to be the preponderating effect for A1 number. Among the studied species, *D. maroccanus* is the richest for A10 sensilla.

## Robust Hair Sensilla Used for Sound Production in New Zealand Giant Wetas: a Novel Mechanism. Poster 65

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Sound production in New Zealand wetas (Orthoptera: Anostomatidae) is normally accomplished by a femoro-abdominal mechanism. Additionally giant wetas are known to produce a ticking sound when alarmed (mechanism unknown). However in two species of giant wetas (*Deinacrida rugosa* and *D. parva*) we have found a third mechanism on the dorsal overlapping surfaces of abdominal tergites. This tergotergal stridulatory organ consists of bilaterally paired patches of short curved spines on the dorsal anterior margins of tergites II, III, IV and V. These are rubbed by apposing patches of articulated hair sensilla on the underside of the posterior margin of each overlapping tergite. The hair sensilla appear to be modified mechanoreceptors which are extremely robust, articulated at a very acute angle and inserted into raised bases which greatly restrict any movement. They rub sideways or at an angle against the underlying spines. Sound production occurs as the apposing patches are engaged during telescopic contraction of the abdomen. This mechanism normally accompanies defence leg kicking stridulation. Movement analysis showed that the abdominal tergites contract simultaneously rather than sequentially during stridulation, with the greatest contraction occurring in the most distal tergites. Sound is produced during both phases of movement. While femoro-abdominal sound is characterised by loud sudden clicks of broadband sound principally below 10 kHz, the tergotergal sound is a high frequency hiss spreading broadly from 10 kHz to above 20 kHz, and is often repeated in a series of three to four contractions when the alarmed weta is disturbed. We propose that this sound enhances the deterrent quality of the stridulatory defence behaviour, particularly against large avian predators. The use of mechanosensory hair sensilla for sound production appears to be a novel mechanism.

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## Initial Data on the Acoustic Behaviour and Sound Production of *Rhammatocerus pictus* and *Rhammatocerus brunneri* (Orthoptera: Gomphocerinae). Poster 67

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*Rhammatocerus pictus* and *Rhammatocerus brunneri* are neotropical gomphocerines inhabiting meadow and high, dense and humid grasslands, throughout central and southern South America. *R. pictus* and *R. brunneri* have a similar morphology although they differ as regards the shape of the spermatheca, and the color of the body, femora and hind tibiae.

We studied specimens of *R. pictus* and *R. brunneri* from different areas of Uruguay, in the north both species are predominant.

We studied their behaviour in captivity, for which they were kept in glass cages with metallic respiration grills measuring 15 x 20 x 30 cms. Fresh gramineae were provided as food and changed daily. The sounds they emitted were recorded on a UHER 4000 recorder fillet with a remote-controlled dynamic microphone (UHER M518). Their captivity behaviour was recorded by a JVC GR-AXM23 video camera. The morphological study was carried out by conventional and scanning electron microscopy.

Sounds corresponding to three different behavioral situations were recorded: spontaneous male song, courtship song and interaction between individuals. Although the general structure of the songs is similar in both species, clear differences existed in the number of syllables and, particularly, the syllable emission rate, both being considerably higher in *R. brunneri*. There are also clear differences in the morphology of the stridulatory row and their components between the two species studied. Supported by the Programa Conjunto de Investigación con Iberoamérica of the Spanish Government

Key words: Acrididae, Uruguay, stridulatory row, song

**Extended Life Cycle of the Alpine Grasshopper *Stenobothrus coticus* (Orthoptera: Acrididae): A Response to the Unpredictable Alpine Growing Season. Poster 89**

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At high elevation, the short and uncertain alpine growing season imposes deep selective forces on life cycles of alpine grasshoppers. Development from egg to adult is accelerated such that sexual maturity is attained and, in case of the female, oviposition is completed before the onset of cold conditions. Abbreviated cycle by reduction in the number of larval instars is another adaptation to the narrow window growing season. Extended life cycle is also an alternative response to environmental uncertainty for species in which more than one year is needed to complete a single generation. A 15-year survey of alpine grasshoppers populations *Gomphocerus sibiricus* and *Stenobothrus coticus* was carried out in the National Park of Mercantour in French South Alps. This study was conducted in a grazed pasture at 2300 m elevation. To avoid effect of sheep grazing on grasshoppers population dynamic, an enclosure was erected. Population density and age structure for *G. sibiricus* and *S. coticus* were recorded from July to August by sampling with a 3m<sup>2</sup> box quadrat at weekly intervals. Up to 1988 only scarce specimens of *Stenobothrus coticus* occurred in grazing and non-grazing plots. In 1989 population reached a density of 1.7 m<sup>-2</sup> and 1.3 m<sup>-2</sup> respectively in the two plots and on every two years the density ranges between 4.8 m<sup>-2</sup> and 21 m<sup>-2</sup>. On the contrary, the population remained at low level in 1990 (0.2 m<sup>-2</sup> and 0.1 m<sup>-2</sup>) and so on as expected in a biennial cycle. The occurrence of such fluctuations are well-known in grasshoppers population dynamic, but they are not so regular from generation to generation. By comparison the study of *Gomphocerus sibiricus* population in the same area doesn't show such fluctuations every two years. Existence of a life longer than one year is not easily determined for wild population. This survey shows that eggs from South Alps acridid *Stenobothrus coticus*, pass through two winters before hatching.

Key words: Orthoptera, life-cycle strategies, altitude, Alps.

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**Riley Was Right: Ectoparasitic Mites Reduce Survivorship and Fecundity in Host Grasshoppers. Poster 60**

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Parasitengone mites can be important natural enemies of insects, but are frequently overlooked by entomologists. In North America, larvae of the mite *Eutrombidium locustarum* attack acridid grasshoppers, including the common agricultural pest *Melanoplus sanguinipes*. I present evidence that, contrary to previous reports, parasitism by *E. locustarum* larvae significantly reduces survivorship and fecundity in *M. sanguinipes*. I present data from observations of naturally infected individuals in field cages and artificially infected individuals maintained in controlled conditions. These data indicate that even a modest level of parasitism by mites can significantly decrease grasshopper survivorship in males and females, and reduce egg production in females. Post-larval stages (deutonymphs and adults) of *E. locustarum* are predators of grasshopper eggs, making this species a potentially important natural enemy of North American Acrididae.

Key words: Acari, Acrididae, *Melanoplus*, Parasitism, Natural Enemy.

## The Number of Spermatophores Transferred Correlates with Mating Duration in *Melanoplus differentialis* (Orthoptera: Acrididae). Poster 82

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In the laboratory, *Melanoplus differentialis* mated an average of nine hours, although matings lasting up to 36 hours were observed. In order to investigate the timing of spermatophore transfer in these animals, virgin females were allowed to mate for a known period of time, then sacrificed by being placed into a -70°C freezer. The mating pair was then separated and the white bundle containing spermatophores removed from the external genitalia of the female. Spermatophores were teased apart onto slides with dissecting pins and counted by three different observers. Although there was considerable variation in the number of spermatophores transferred during matings of a similar duration, there was a statistically significant linear regression ( $p=0.001$ ) between the number of spermatophores transferred and copulation duration. On average, two spermatophores were transferred per hour of copulation. There was no initial delay in spermatophore transfer, suggesting that the time spent in copulation was used more for sperm transfer rather than mate guarding. Pair formation in this species will also be described and compared to other *Melanoplus* spp.

Key words: sperm transfer, copulation, pair formation, mate guarding.

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## Locomotory Activity Measurements in the Light of Phase Transition. Poster 72

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For many years people have been working on phase transition in locusts. Until today the key or causal factors, which are responsible for the switch to more gregarious or solitary features are not fully known. Obvious differences between the animals of both phases are found on morphometrics and color. The most conspicuous difference is the behavior, with gregarious phase individuals aggregating, often into enormous and mobile swarms, whilst solitary phase individuals shun each other's company. Generally, gregarious animals are more active than solitary ones, as shown in several investigations. Up to now, no simple method has been described to register activity levels. A new and easy assay to measure spontaneous locomotory activity of adult locusts by using rectangular arenas and measuring the number of 'wall hits' is proposed. Experiments were performed on grouped and isolated reared ('solitarised') individuals of *Locusta migratoria migratorioides* and *Schistocerca gregaria*. To characterize the phase status morphometrical studies and canonical discriminant analysis were used.

As expected, the activity was found to be rather low for solitarised locusts and high for animals reared in a group. This difference could be observed in both species. The reason for this peculiar solitary behavior and applications for the 'activity assay' are discussed in detail. This assay along with morphometric measurements might be useful for rapid screening of compounds, possibly interacting with behavior and thus phase transition.

Key words: *Locusta migratoria*, *Schistocerca gregaria*, locust phase, behavior, morphometrics.

**Parental size Influence on Offspring Phenotype in *Schistocerca americana* (Orthoptera: Acrididae).** Poster 83

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In the following study, we tested if parental size was correlated with offspring size in *Schistocerca americana* under controlled conditions. If true, such a correlation might explain, in part, the benefit females accrue when preferentially mating with large males (Kosal & Niedzlek-Feaver 1997). Field-caught males and unmated females were placed together in lab cages so that a single female was paired with either a large male or a small male (based on femur length). These animals were allowed to mate freely and egg pods were removed after they were laid. The offspring of one pod or cohort was raised in a separate cage, with each cohort being reared under identical regimes: long days (12 hours of light) and unlimited feeding. In total, 40 pairs of parents produced 30 cohorts (1083 individuals). Nymphal and adult development were monitored; femur, body, tegmen, and pronotum lengths and weight were determined. Cage density did not seem to influence offspring size, but density did influence the number of surviving adults. No significant correlation was detected between the mother's size and that of her offspring; however, the father's size was found to positively correlate with the adult size of both his sons and daughters. For example, the father's femur length positively correlated with the femur length of both his adult sons and daughters.

Key words: size correlation, inheritance, femur length.

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**Behavioural Study on *Calliptamus barbarus*: First Notice on its Sound Production.**  
(Orthoptera: Acrididae: Catantopinae). Poster 66

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*Calliptamus barbarus* is a widely distributed species throughout the Palaearctic region. In the Iberian Peninsula it appears anywhere, occupying a great environmental diversity, although it seems to prefer those physiognomical types of vegetation which hold the species *Artemisia campestris*. Like other Catantopinae, *C. barbarus* shows a very pronounced chromatic polymorphism, related to the inner surface of hind femora, which has been proved as associated to morphometric variation (Clemente et al. 1987) and related to a possible isolation process of the different populations. These populations inhabit quite different environments. Formerly, the genitalia was considered one of the main mechanical reproductive mechanisms, but now it is considered that the genitalia characteristics are directed to improve the copulation, not meaning a reproductive barrier, (Otte, 1970). The behavioural differences are considered an effective prezygotic reproductive isolating mechanism. Because of that, in order to prove if, from a behavioural point of view, there are any differences between both two existing chromatic varieties, a study of their behaviour and of their acoustic emissions, which are mentioned and described for the first time. During the study some behavioural units have been set up, and it has been observed their presence or not, as well as their appearance frequency, in different situations, both with male and female individuals and with specimens with different chromatic pattern in hind femora. The possible behavioural sequences and the interactions between individuals have been set up. The acoustic emissions have been recorded from males and females belonging to the two chromatic varieties, which has allowed a comparative study of sounds.

Key words: behaviour, acoustic, grasshopper.

## Ingestive Conditioning in the Grasshopper *Zonocerus variegatus* (Orthoptera: Pyrgomorphidae). Poster 80

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The preferences of *Zonocerus variegatus* among five of its potential food plants are modified by a single food diet imposed during two days, two weeks or two months before the experiment. The longer the single diet is applied the stronger is the conditioning. The effect is different for each plant species. After two days on a single plant, the choice of the grasshoppers is composed of only two or three plants species among the five offered to them. But, after a longer time spent on a single diet, the choices increase and after two months the grasshoppers consume the five plant species and the choice is divided among the five plants offered. The use of food choice experiments to determine natural preferences of grasshoppers and/or attractivity of plant species for these grasshoppers should consider the existence of such a conditioning. New protocols using preliminary rearing of the grasshoppers on single diets are to be developed to enhance the results of laboratory studies.

Key words: insect-plant relationships, food selection, ingestive conditioning, *Zonocerus variegatus*, Acridoidea, grasshopper, West Africa.

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## Postembryonic Development of *Stiphra* sp. (Orthoptera: Proscopiidae) Feeding on *Psidium guajava* L. (Myrtaceae) Leaves, in Laboratory. Poster 88

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Proscopiidae is an orthopteran family endemic of South America and is classified as an eventual pest in drought areas of Northeastern Brazil. As the studies on biological features are rare the purpose of this study is to establish the duration, in days, of the post-embryonic development periods, mortality along this period, sex ratio and sexual proportion of *Stiphra* sp. (Orthoptera: Proscopiidae) a univoltine species, a potential pest of guava tree orchards in backyards and commercial orchards in the Northeastern Region of Brazil. The bioassays were carried out under mean room conditions of 67.44% relative humidity and 26.70 °C. Pieces of fresh leaves of guava were replaced daily inside glass vials (300-500 mL) covered with organdy (one species per vial) fixed with a rubber band. A sample of adults was deposited at the Entomological Collection of Museu Nacional do Rio de Janeiro. The duration for the five instar nymphs specimens was determined for the sample, male and female, respectively: the post-embryonic period 83.48, 83.72 and 86.22; N1 20.10, 20.67 and 19.93; N2 15.33, 15.29 and 15.81; N3 14.44, 14.66 and 13.78; N4 15.61, 15.16 and 16.22 and N5 18.23, 17.39 and 20.67. The final survival was 83.41% from neonate nymphs to adult emergence. The higher mortality was on the first nymphal instar (89.11%). The sex ratio was 0,4583 and the sexual proportion 1 female : 1,21 males (total of 168 adults). Supernumerary instars were registered mainly on females.

Key words: Bioecology, life cycle, sex ratio.

## Why Do Males of Some Phalangopsidae (Orthoptera: Grylloidea) Present Metanotal Prominences? Testing Two Hypotheses with Scanning Electron Microscopy. Poster 79

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Several cricket species present sub-metanotal glands whose secretion is offered to mating females as post-copulatory courtship. Recently metanotal prominences were found in two phalangopsid genera, *Vanzoliniella*, and an undescribed genus from Minas Gerais State, both from Brazil. We tested two complementary hypotheses to explain the occurrence of these structures: (1) the structures cover secretory glands; (2) these glands secrete some non-volatile substance. We photographed the prominence of the new genus in a Scanning Electron Microscope (Zeiss DSM 940 A), with secondary and back-scattered electrons. We found pores throughout the surface of the prominences, showing several bright corpuscular bodies apparently coming out of them. We observed electron-dense regions in the layer below several of these pores, with a greater diameter than the pores themselves. We concluded that the metanotal prominences do indeed cover secretory glands, and that these glands secrete a non-volatile substance. The substance is probably offered as post-copulatory courtship to females. As far as the males of this cricket do not possess stridulatory veins, and that none of the sexes possess tympana, it is possible that the sub-metanotal glands secrete also some volatile pheromone, to attract females. Support: NAP/MEPA - ESALQ/USP & UEEC/UFV.

Key words: metanotal gland, post-copulatory courtship, back-scattered electron micrographs, secondary electron micrographs.

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## Leichhardt's Grasshopper *Petasida ehippiger* - A Northern Australian Icon. Poster 57

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Australia's most spectacularly coloured grasshopper is found in three National Parks within the wet/dry tropics of the Northern Territory. Public awareness of the grasshopper is widespread, with tourist operators, National Parks, Australia Post and the Australian Entomological Society all using the grasshopper in promotional material. Populations are thought to be threatened by frequent fire in the dry season (May to October). As very little is known of the biology of the grasshopper a study is being carried out at Mt. Borradaile in western Arnhemland, where fire is actively excluded.

The aims of the study are to confirm the life history of the grasshopper and determine its mobility between three isolated populations. The study commenced in January 2000 and will run for approximately twenty four months. An average of 84 plants of the host *Pityrodia jamesii* (Chloanthaceae) were selected and numbered at each of three sites, isolated from each other by lack of host plant or by intermittently running streams. All marked plants were visited at six weekly intervals.

Onset of juvenile hatching commenced in April 2000 and 2001 and each juvenile was measured for size and height in the shrub at each visit. In April 2001 only one of 25 juveniles was found on a shrub previously inhabited by a mature female (Nov. 2000) - indicating possible extended diapause of the eggs. It was previously thought that juveniles were plant faithful but this appears not to be the case, although aggregation did occur during late stage development (40mm).

Maturation occurred during the months of September, October and November and only 77 out of 142 juveniles survived to maturity. Most of this mortality occurred at just one of the sites, in part due to predation by mantids and spiders. Queen Bee labels were used to mark individual adults and one only survived through to March 2001. To date mobility between the populations could not be assessed, due to the inaccessibility of sites during the rainy season.

Key words: Pyrgomorphidae, northern Australia, fire, National Parks, biology.

## Effect of Starvation, Rearing Density and Mating on the Morphology and Development of Oocyte and Follicle Resorption Bodies in the Lubber Grasshopper, *Romalea microptera*.

Poster 87

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Follicle resorption bodies and oocyte resorption bodies can be used to determine the past ovipositional and environmental history of females of the Lubber grasshopper, *Romalea microptera* (= *guttata*). The resorption body is deposited at the base of each ovariole following each gonotrophic cycle and remain distinct for at least 8 weeks and three ovipositions. In laboratory conditions, healthy well fed *R. microptera* resorb about a quarter of their developing oocytes. Starvation or other environmental or physiological stress increased the rate of oocyte resorption. In comparison to locusts, *R. microptera* were relatively slow to initiate oocyte resorption following starvation. By counting the number and type of resorption bodies in each ovariole, we determined the number of times a female had laid, the number of eggs in each egg-pod during each oviposition, and the relative environmental stress during each gonotrophic cycle. Adult virgin females maintained at low density, with no male contact, resorbed fewer oocytes than females maintained at higher densities with males, suggesting that high densities or continual harassment stressed females.

Key words: reproduction, physiology, grasshopper.

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## Fluctuating Asymmetry, Developmental Instability and Reproductive Success in Crickets.

Poster 81

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Males of the gryllid cricket species *Gryllus bimaculatus* and *Gryllodes sigillatus* modulate the sperm content of their spermatophores in relation to both apparent competition and fluctuating asymmetry in limb size. They also increased the amount of sperm transferred when an apparent male competitor was present. This increase in number is regardless of the species of the apparent competitor, but increased significantly more with a conspecific competitor in *G. sigillatus*. Changes in sperm number were in excess of those predicted by associated changes in ampulla size. In this species the relative size of the spermatophylax also increased with apparent competition, while time to spermatophore transfer decreased with competition in *G. bimaculatus*. Sperm counts showed opposite relationships with limb asymmetry in the two species, increasing with asymmetry in both sexes in *G. bimaculatus* but decreasing with increasing asymmetry in male *G. sigillatus*. Male *G. bimaculatus* also transferred more sperm when paired with a larger female. Relationships between sperm number and asymmetry in both species were reflected in relationships with antennation rates during interactions. Associations with limb asymmetry were significant regardless of competition in *G. sigillatus* but only in presence of competition in *G. bimaculatus*. These differences in associations may reflect the additional burden of producing a spermatophylax in *G. sigillatus*.

Key words: *Gryllodes sigillatus*, *Gryllu bimaculatus*, sperm transfer, competition.

## Changes in Recombination, Morphological Variation and the Central Marginal Distribution of *Dichroplus pratensis* (Melanoplineae: Acrididae). Poster 77

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The grasshopper *Dichroplus pratensis* is polymorphic and polytypic for a complex Robertsonian system. In this species, centric fusions induce changes in the number and position of chiasmata of the involved chromosomes thus, potentially affecting intrachromosomal genetic recombination, and the release of genetic variability. Males and females from 67 natural populations covering most of the geographic range of the species and comprising 22 degrees of latitude, were studied. We analysed chiasma frequency in all populations in relation to variability of six exomorphological characters (as expressed by their coefficient of variation). The chromosomal polymorphisms of *D. pratensis* have a widespread geographic distribution, showing a central-marginal pattern, in which central populations (which occupy ecologically optimal habitats) show high mean frequencies of different fusions per individual (F) up to F= 3.0, with chiasma frequencies as lower as X= 8.98 per cell, while populations near the margins of the distribution range (central Patagonia and the Andes), show very low levels of chromosomal polymorphisms (down to F=0.00 in most geographically marginal locations), with monomorphic karyotypes and high chiasma frequencies (X=11.66, in the southernmost population [Rada Tilly, 45°57'S] and X=12.01 in the northernmost one [Volcán, 23°55'S]). Increasing chiasma frequencies towards the margins of the species range are positively correlated in a statistically significant way, with increasing levels of morphological variability.

We hypothesize that the decrease in fusion polymorphism towards marginal areas, with the consequent increase in genetic recombination (both inter- and intrachromosomal), is a result of natural selection in favour of higher levels of variability, which could be adaptive to ecologically harsher and changing environments.

Key words: grasshopper, Robertsonian polymorphism, chiasmata.

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## Variation of Body Size in *Dichroplus pratensis* (Melanoplineae: Acrididae): A Case of the Converse Bergmann's Rule. Poster 78

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Many studies of geographic variation in body size of insects and other ectotherms indicate that they follow the converse of Bergmann's rule (Mousseau 1997. Evolution 51(2): 630-632); that is, individuals tend to be significantly smaller as the environment becomes cooler and harsher.

We tested this hypothesis in 23 natural populations of the highly chromosomally polymorphic grasshopper *Dichroplus pratensis* in Argentina, spanning 22 degrees of latitude, and between sea level and 2000 metres above sea level (asl). Six exomorphological characters were measured in ca. 25 specimens of each population: Total Body, Femur 3, Tibia 3, Tegmina and Pronotum length, and Pronotum height. The species is sexually dimorphic with females being larger than males; this dimorphism is constant throughout the whole geographic range. Nevertheless, a highly significant negative correlation between all six morphological characters and latitude and altitude, occurs. Extreme latitudes and altitudes correspond to the geographic and ecological margins of the species distribution, and share comparable strenuous environmental conditions (Martí & Bidau 1998. Cytogenet. Cell Genet., 81(2): 131).

Central populations are represented by Olavarría (36°55' S) where total body length of males and females are respectively 22.57 and 24.34 mm. Extreme populations regarding latitude and altitude show significantly lower values and represent the end of a continuous gradient: Rada Tilly in Patagonia (45°57' S, 10 m asl), 18.91 mm (M) and 23.17 mm (F) and Volcán in the Andean Puna (23°55' S; 2000 m asl), 22.36 mm (M) and 23.34 (F). However, variability of the six morphological characters is positively correlated with both latitude and altitude as indicated by the coefficient of variation of all six measurements. Considering that the latitudinal and altitudinal morphological gradients are also correlated with gradients for chromosomal polymorphisms (centric fusions), genetic as well as environmental factors are probably influencing Bergmann's rule inversion in *D. pratensis*.

Key words: grasshopper, environmental gradients, morphological traits.

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## Song Function in Male Ambidextral Grigs (Orthoptera: Haglidae: *Cyphoderris*). Poster 70

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We studied the response of males to the singing of nearby male conspecifics in two species of the orthopteran genus *Cyphoderris*, a primitive relative of crickets and katydids.

Lone *C. buckelli* males, stridulating in a large cage, made a phonotactic approach to a nearby speaker broadcasting conspecific calling song. But in field experiments no phonotaxis to song broadcasts occurred: rather, a significant number of *C. buckelli* males increased their chirp duty cycle and pulse rate. There was no change in their carrier frequency.

*C. monstrosa* calling males were exposed in the field to: 1) playback of a synthetic calling song at a typical conspecific pulse rate, 2) to relayed broadcast of their own call and 3) to random noise. Call duty cycle decreased significantly in response to noise but was unaffected by the other models.

Singers of *C. buckelli* were marked individually and their perches flagged over successive nights. We observed low site fidelity and extensive male displacement. Such behaviour is inconsistent with defense of topographically-fixed singing territories and concurs with the absence of fighting in this species. Chirp duty cycle of some males increases significantly in *C. buckelli* in response to the nearby singing of conspecifics, but unlike *C. monstrosa*, this higher duty cycle plays no role in overt aggression and may maintain a male's relative attractiveness to females.

## **The Influence of Various Host Plants on the Distribution and Development of *Oedaleus nigeriensis* (Orthoptera: Acrididae) in Nigeria. Poster 61**

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*Oedaleus nigeriensis* is widely distributed in the moist grassland habitats of Nigeria. Although this area is used for intensive agricultural activities providing more than 90% of the grains needed in the country, the insect has been reported to cause only minor damage to agricultural crops. Various field studies have shown that *O. nigeriensis* is polyphagous, graminivorous and geophilous with special preference for short grasses and paths. The reason for the minor pest status is unknown and only adequate study of the insect/host plant relationship will provide some clues.

Nymphs and adults of *O. nigeriensis* were reared on selected food plants, which include *Axonopus compressus*, *Cynodon dactylon*, *Eleusine indica*, *Seteria gracilipes*, used singly and as a mixture of all four. Development of the nymphs was generally optimal when rearing was on mixed diet. Hence, developmental period was short (60 days compared to 105-127 days for single host plants). Rearing the adults on *S. gracilipes* promoted faster oocyte development than the other treatments.

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## **Hungarian and Greek Males of *Stenobothrus fischeri* Use Different Courtship Songs.**

Poster 68

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Acoustic communication plays a key role in the mate finding behaviour in most species of Gomphocerinae grasshoppers. Isolated males produce calling songs to elicit the response or attract conspecific females and long, complicated courtship songs when close to a female. Generally these song types vary surprisingly little throughout wide geographic ranges showing rather uniform, species specific amplitude modulation pattern. We have analysed the song of some males of *Stenobothrus fischeri* from central Hungary (Dabas) and from central (Kalambaka) and southern (Taygetos) Greece. Our results show that the male calling songs are principally the same in Hungarian and Greek males, but their courtship songs differ conspicuously. In both region the courtship song consists of two parts, but in Hungarian specimens during part I. a cyclic alternation of two phases can be observed in contrast to the Greek specimens where part I. contains only phase 1. The lack of phase 2. during part I. makes the rate of alternation between part I. and II. in Greek specimens comparable to the alternation rate of phase 1. and 2. in the courtship song of Hungarian specimens. At present the taxonomic value of this difference is not clear, nevertheless it indicates that the Hungarian and Greek population diverged from each other in a component of their mate recognition system, which may be able to maintain reproductive isolation between them.

Key words: acoustic communication, geographic song variability, mate recognition system.

## On the Relationship between Vegetation Structure and Morphology in Grasshopper Assemblages (Orthoptera: Acrididae). Poster 63

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Vegetation structure may affect not only the species composition and species-abundances of the inhabiting insect community but also its body size distribution. The present study is based on the light-permeability profiles measured in the vegetation of 10 sampling locations of the Aggtelek Karst region (NE Hungary) and 10 sampling locations of the Kiskunság (Central Hungary) and on the grasshopper samples collected from the same sites. Light-permeability profiles show the vertical change of the density of vegetation in terms of its permeability for the sunlight. We measured 11 morphometric characters both in males and females. We have found in both sexes that the average width/length ratio of the hind femur is lower in grasshopper communities which live in taller and more dense vegetation. Furthermore in those assemblages the average head-shape shows a more acute profile in both sexes and in males the average eye-diameter is lower. Our results are in good accordance with the hypothesis that a more gracile body with longer legs may be useful for grasshoppers moving in dense and tall vegetation while in habitats covered by short-grasses and bare soil surface a more stocky body, with shorter and stronger legs may be more advantageous.

Key words: body size distribution, morpho-adaptation, vegetation structure.



## Embryonic Development Strategy of *Dociopterus maroccanus* at Two Different Latitudes. Poster 85

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The embryonic development of *Dociopterus maroccanus* is the largest phase of its life cycle. Eggs are deposited in a pod in the top 1-3 cm of soil, during late spring and early summer, but hatching is delayed until the following spring by embryonic diapause. This synchronizes the life cycle to ensure eggs hatch in the spring as soon as conditions are suitable for survival of nymphs. We have determined, for this species, that temperature is the environmental key factor for induction, maintenance, and termination of embryonic diapause although, before hatching, soil moisture is also necessary. Because the latitude has a clear influence on the temperature regime we have studied the embryonic development of *Dociopterus maroccanus*, at two permanent breeding areas located at different latitudes, one in Canary Islands at El Hierro (27°50' N 17°55' W) and other in the Iberian Peninsula at La Serena (38°55' N 5°29' W). In both localities females lay eggs at the same time. In the Canary Islands females look for altitude to lay eggs, ensuring the temperature regime that allows the pre-diapause development, the diapause development and the post-diapause one in a similar way than in Iberian Peninsula; thus hatching occurs in spring. This behaviour assures the univoltinism of the Mediterranean locust.

## Why do Crickets (Orthoptera: Grylloidea) Fall in Pitfall Traps? Poster 76

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Leaf litter crickets fall in pitfall traps. We collected 1202 adult nemobiine crickets (Orthoptera: Grylloidea: Trigonidiidae) and 264 adult phalangopsid crickets (Orthoptera: Grylloidea) in a total of 756 pitfall traps, distributed in 18 forest remnants. There were four kinds of trap, three baited (banana, carcass and feces), and a fourth type with no bait. We tested the hypothesis that crickets fall in pitfall traps because the baits attract them. If our hypothesis was correct, the number of adult crickets caught in all or some of the baited traps should be greater than that in the unbaited traps. We compared two taxonomically and functionally different groups, nemobiine and phalangopsid, through two independent statistical analyses. We used the number of adult crickets per pitfall area as the response variable, and the kind of trap as the explanatory factor, with four levels. We adjusted a generalized linear model, analogous to one-way ANOVA, with Poisson errors. There was no difference in the number of adults collected by either kind of trap for both cricket groups (Nemobiinae,  $n = 140$ , 3 d.f., Chi-squared = 0.26,  $P = 0.97$ ; Phalangopsidae,  $n = 132$ , 3 d.f., Chi-squared = 0.03,  $P = 0.99$ ). We concluded that both cricket groups were not attracted nor repelled by any of the used baits. Therefore, there is no need to use baits to increase collecting efficiency by pitfall traps. Support: CAPES; UEEC/UFV.

Key words: Nemobiinae, Phalangopsidae, sampling, baits.

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## Effects of Moisture on Egg Survivorship and Hatching Time in Two Species of Lubber Grasshopper. Poster 86

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In this experiment, we compared the egg survivorship at different moisture levels of two closely related species of lubber grasshopper. The eggs of both species demonstrated the ability to survive a wide range of soil moistures for an extended period of time. *Romalea microptera*, from the Florida Everglades, showed the best survivorship at higher moisture levels, while *Taeniopoda eques*, from the Chihuahuan desert, exhibited a greater survivorship at low to moderate soil moisture levels. However, the time to first hatch for both species was less at dryer soil moistures.

Key words: Romaleidae, *Romalea*, *Taeniopoda*, hatching success.

**The Relationship Between Density-Dependent Aposematism and Density-Dependent Gregariousness in Palatable and Unpalatable *Schistocerca emarginata* (=lineata) Grasshopper Populations.** Poster 75, Oral pres., Wed. 1630

**Sword, Gregory A.**

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Many insects exhibit phase polyphenism in response to changes in their rearing density. Increases in local population density can elicit physiological responses that manifest themselves as phenotypic changes in behavior, color, metabolism, development, and morphology. This phenomenon is particularly common in locusts. *Schistocerca emarginata* (=lineata) grasshopper populations in central Texas, USA are host specific as juveniles on either *Ptelea trifoliata* (Rutaceae) or *Rubus trifoliata* (Rosaceae). *Ptelea*-feeding grasshoppers derive gut content-mediated unpalatability to vertebrate predators from their host plant while grasshoppers from *Rubus*-feeding populations do not. Unpalatable *Ptelea*-associated grasshoppers exhibit an extreme density-dependent nymphal color polyphenism that results in warning coloration (aposematism) at high density. Palatable *Rubus*-feeding grasshoppers should not benefit from the expression of aposematism, and as expected, they exhibit a markedly reduced density-dependent color change.

Gregariousness and aposematism are commonly associated in insects. At least one locust species, *S. gregaria*, exhibits both density-dependent aposematism and density-dependent gregariousness. Gregariousness has been shown to enhance predator neophobia and avoidance learning of aposematic prey suggesting that color and behavioral phase polyphenism may function in unison as an anti-predator strategy. Gregariousness has also been thought to promote the evolution of aposematism, however, phylogenetic analyses indicate that gregariousness commonly evolves after aposematism. To determine if an association between density-dependent aposematism and density-dependent gregariousness exists in *S. emarginata* grasshoppers, I investigated the expression of density-dependent behavioral phase polyphenism in grasshoppers from both aposematic (*Ptelea*-feeding) and non-aposematic (*Rubus*-feeding) populations. I found no difference in the expression of density-dependent behavioral phase polyphenism between the different populations. The behavior of first instars from both populations was unaffected by rearing density, while final instars from both populations exhibited an increase in activity but not aggregation under high density rearing conditions. These results suggest that density-dependent gregariousness is not a prerequisite for the evolution of density-dependent aposematism.

Key words: phase polyphenism, color, behavior, host plant, predator.

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**A Molecular Technique for the Analysis of Grasshopper Host Plant Use.** Poster 74

**Sword, Gregory A. & Laura B. Senior**

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An understanding of the ecology and evolution of grasshopper-plant interactions requires knowledge of the specific plants that grasshoppers consume in natural populations. As a group, grasshoppers are considered generalist feeders and individual grasshoppers often consume a number of different, unrelated plant species. Microscopic techniques that involve matching the epidermal characters of plant fragments found in grasshopper crops or fecal pellets with those from known plant specimens have been used for the last 40 years to identify components of grasshopper diets. This process can be laborious and sometimes ambiguous, particularly when morphologically similar plants such as grasses are eaten by early instars. We set out to develop a reliable molecular technique using highly-variable, non-coding plant chloroplast DNA (cpDNA) to identify plants found in grasshopper crops and/or fecal pellets. Here we demonstrate that cpDNA from plants found in the crops and feces of grasshoppers as young as first instars can be extracted and ampli-

fied via PCR. We compare and contrast two techniques to detect mixtures of cpDNA that may be found within individual grasshopper diets. Fragment Analysis (FA) allows grasshopper diet to be determined by matching unknown cpDNA fragments of a given length extracted from crops or feces with fragments from known plants collected in the grasshopper habitat. Denaturing Gradient Gel Electrophoresis (DGGE) segregates different cpDNA sequences from crops or feces as distinct bands on a polyacrylamide gel. The bands can be removed from the gel, sequenced, and then matched to known cpDNA sequences from plants collected in the grasshopper habitat. Both FA and DGGE techniques are able to detect mixtures of plants within individual grasshopper diets. The use of these cpDNA-based protocols holds promise for future analyses of grasshopper diet in the field.

Key words: chloroplast DNA, Fragment Analysis, Denaturing Gradient Gel Electrophoresis

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## **Movement Patterns of Local Orthopteran Assemblages in a Naturally Fragmented Habitat.**

Poster 73

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Field investigations were made in Hungary, in 2000, on a hilly woodland area to analyse the movement patterns of orthopteran assemblages living on forest clearings. I assumed that the local assemblages are parts of a metaassemblage. The aim of this study was to detect the metapopulation structure at this scale. To investigate the above, I made a mark-capture experiment with group-marking the orthopterans present on six nearby forest clearings of an average of 400 square meters and having mesoxeric-xeric steppe-meadow vegetation. On six clearings 23 Orthoptera species (9 Tettigonoidea, 13 Acridoidea, and 1 Tetrigoidea) were detected. Following the first marking in June, marks and captures were made every two weeks until September. Specimens captured at any time got a new, time- and clearing-specific paint mark. During 3 months 3054 specimens were marked, and the number of re-sights was 2180. The extent of isolation of clearings was calculated on the basis of their distances from each other. The ratio of migration between clearings was considerable (13.3% of re-sights). While the ratio of migration between clearings connected with corridors was 8.9%, migration between clearings isolated by forest was only 4.4%. On clearings with smaller Orthoptera assemblages the ratio of emigrations/immigrations was significantly higher than on clearings with larger ones. On two clearings the ratio of immigration was higher than that of emigration. Migration between clearings by 7 dominant species showed a significant negative correlation with the isolation of clearings. However, from the point of view of migration between remote and nearby clearings, these species behaved differently. Based on their movement patterns, local orthopteran assemblages living on clearings investigated appear to be parts of a metaassemblage composed by strictly connected local orthopteran populations.

Key words: Clearings, migration, isolation, metaassemblage.

## Amplified Fragment Length Polymorphism for the Analysis of Genetic Structure in Grasshopper Populations. Poster 71

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A recently developed polymerase chain reaction (PCR)-based assay, amplified fragment length polymorphism (AFLP; Vos et al., 1995), has proved to be useful for assessing phylogenetic relationships and the genetic structure of populations in many organisms including insects. Several selective primer pair combinations, with three selective nucleotides, have commonly been used for AFLPs. However, preliminary studies show that the procedure does not work well in Acridid grasshoppers, since it leads to very large numbers of indistinct bands. This is probably due to the large size of the genome. It means that one cannot recognise the homologous bands properly. Although we adopted the common procedure for several populations of the meadow grasshopper *Chorthippus brunneus* and *C. jacobsi*, the results were the same in all cases.

To overcome this drawback, we developed long primer sets, with four selective nucleotides, and used these for the above two species. This approach has allowed us to reduce the number of bands, so that we can compare homologous bands easily. We will present the details of these techniques, including the principle behind AFLP analysis, and report the results concerning the degree of genetic differentiation between *C. brunneus* and *C. jacobsi* in northern Spain.

Key words: AFLP, genetic differentiation, *Chorthippus brunneus*, *Chorthippus jacobsi*, Acrididae.



## The Structure of Spermatodeses in Shield-back Bushcrickets (Tettigoniidae: Tettigoniinae: *Platycleis* & *Metrioptera* spp.). Poster 62

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Many aspects of the reproductive anatomy and physiology of tettigoniids have been studied extensively. These include the large, externally visible spermatophores and the feather-like aggregations of sperm, known as spermatodesma. However, spermatodeses seem to have been almost completely overlooked: their structure has not been described since 1913 and they have subsequently received only passing mention in the literature, with the exception of one study which used spermatodesa counts to estimate the degree of polyandry in Mormon crickets (*Anabrus simplex*). Spermatodeses are spermatophore-like structures found within the spermatheca. Each time the female mates, a separate spermatodesa is formed. Here I use photographs, from light-microscopy, of whole and sectioned spermatodeses to describe the external and internal ultrastructure of spermatodeses of *Platycleis albopunctata*, *P. tessellata* and *Metrioptera brachyptera*. Up to ten spermatodeses were found per female in *Platycleis albopunctata*, seven in *P. tessellata* and two in *M. brachyptera*. The structure of the spermatodeses was very similar for the three species. Each spermatodesa was pear- or onion-shaped and consisted of a thin outer layer, enclosing a thick, gelatinous inner layer. A large sperm mass occupied the bulbous end of the spermatodesa, while a thin sperm-tube lead from the sperm mass, along the centre of the elongated neck of the spermatodesa and appeared to exit at the pointed-tip of the spermatodesa. Feather-like aggregations of sperm (spermatodesma) were clearly visible within the sperm mass and also appeared to be present within the sperm-tube. The wall of the sperm tube appeared to be composed of material similar to that of the outer-layer of the spermatodesa. The possible function of spermatodeses is discussed: it is proposed that they have evolved as a result of sexual conflict and function to protect the sperm from being destroyed by the female while in storage.

## **Hybrid Zone between Closely Related Grasshopper Species of the *Chorthippus albimarginatus*-group (Orthoptera: Gomphocerinae). Poster 69**

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The courtship songs of the sibling parapatric species of the gomphocerine grasshoppers *Chorthippus albomarginatus* and *Ch. oschei* are extremely elaborate and differ in many temporal parameters. In spite of the different courtship signals, the species were found to hybridize in nature. In the territories of Ukraine and Moldova, the two species overlap in their distribution over a distance stretching for about 200 km. The analysis of the song and leg-movement recordings revealed the males with intermediate song characteristics. However, in seven localities studied in this area, the specimens singing strictly intermediate pattern were in minority. In each biotope, most of the specimens sang the songs of a parental type. The songs recorded in this area showed a high degree of inter- and intra- variability, as compared to the rather narrow variability range of the songs recorded in allopatric populations. The specimens of *Ch. albomarginatus* and *Ch. oschei* collected from allopatric populations have been hybridized in the laboratory. F1-hybrids sang either parental-like songs or intermediate song patterns. Intermediate song pattern of the laboratory hybrids was quite similar to the pattern recorded in the natural hybrid zone. The reaction of a receptive female towards the conspecific and heterospecific courting male was studied. The females collected from both allopatric and hybrid populations mated assortatively. We suggest that assortative mating in *Ch. albomarginatus* and *Ch. oschei* can be a result of sexual selection through female choice. Analysis of the hybrid intermediate patterns and their comparison with parental sound and leg-movement patterns reveals a homology of different parental song elements. The more elaborate courtship song of *Ch. oschei* is suggested to evolve from the song of *Ch. albomarginatus*.

Key words: courtship song, temporal pattern, assortative mating, sexual selection.



## Crowding effects on Morphometric, Biologic Characteristics of *Locusta migratoria* under Laboratory Conditions. Poster 99

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The migratory locust, *Locusta migratoria*, is widely distributed throughout Africa, Europe, Asia and Australia. Subspecies identification is based on gregarization and isolation characteristics (Uvarov, 1977), therefore, this research was carried out to examine crowding effects on 28 characteristics of morphometric, biologic and also colour on migratory locust under laboratory conditions. Males and females collected from sugarcane fields and hatchings were obtained from eggs that had been laid by females to named F1. Hoppers were subjected to six different densities (1,3,6,15,50,100 per cage). Crowding effects were found in F/C, H/C ratios, hopper coloration, adult longevity, number of egg pods per female, number of eggs per pod, and percentage of activity per adult. This research was continued through the F2 generation and showed that crowding effects appeared low and late in population of *Locusta migratoria* in Khuzestan province. The results obtained in laboratory agreed with field research, therefore characteristics solitary form is enough for subspecies identification.

Key words: sugarcane, egg pod, hopper, Khuzestan.

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## Population Dynamics, Biology and Ecology of the Central American Locust (*Schistocerca piceifrons piceifrons*) in Southern México. Poster 96

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The Central American locust (*Schistocerca piceifrons piceifrons*) has increased its populations in South the State of Tamaulipas, northern México, in the past three years. The species occurs normally in this region, however, population densities had never been so high, reaching at present up to 30-40 adults/m<sup>2</sup>. The State Plant Protection Service requested laboratory and field studies of the species in this particular region. Field surveys and laboratory studies were initiated in September, 2000. Second generation adults were collected in Cd. Mante, Tam. on November 24th/2001, for this date about 90% of the population was fledging, while 10% approximately were nymphs in the 7th instar. A laboratory culture has been established and regular field trips are carried out to complement laboratory data.

*S. piceifrons piceifrons* is bivoltine, adults of the second generation undergo an imaginal diapause from October/November to March/April every year, i.e., dry Winter Season; during this period adults fly actively but do not form swarms, they remain sexually immature on native host plants, Johnson grass mainly (*Sorghum halepense* L.), decreasing to a minimum the level of food consumption. With the onset of the rainy season, i.e., April-May, adults start mating and laying, giving place to nymphs of the first generation by end May-June, adults are present by July-August. Compared to the second generation, adults of the first generation will mature very quickly, in about three weeks, nymphs pass through six/seven instars and second generation adults appear again by October/November.

Major locust damage is caused to sorghum, soy bean, maize, peanut, sugar cane, onion, carthamus, citrus and mango, amongst other crops. Chemical control operations, using organophosphates such as malathion or fenitrothion, are carried out from September to March and during summer. However, the experimental use of *Metarhizium anisopliae* as part of an Integrated Control Programme, is in progress.

## Phase Induced Regulatory Responses and Foraging Strategies in the Desert Locust, *Schistocerca gregaria*. Poster 97

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The desert locust has the genetic potential to exist in either a cryptic ‘solitarious’ phase, or a conspicuously coloured, swarm-forming ‘gregarious’ phase. In the field, nymphs of the two forms also differ in the types of nutritional environments they experience. For example, because solitarious nymphs are relatively sedentary and plant diversity in their habitats is often low, the range of nutritional variation they are likely to encounter is relatively narrow. In contrast, gregarious nymphs tend to be highly mobile, often moving great distances, and experience broader nutritional variation because they encounter greater plant diversity. Recently we have begun to explore how both the nutritional make-up and spatial distribution of foods the two phases encounter might influence nutritional regulatory responses and foraging strategies. Throughout our studies we focus on two key macro-nutrients, protein and digestible carbohydrates. When locusts were provided with pairs of nutritionally unbalanced but complementary synthetic foods, both phases regulated their intake of protein and carbohydrate to a statistically similar point. However, when they were confined to foods that were unbalanced, gregarious nymphs overate relative to solitarious insects, ingesting more of whichever of the two macro-nutrients (protein or carbohydrate) was in excess. As such, gregarious nymphs suffered less of a deficit in the intake of the limiting macro-nutrient. Gregarious nymphs also converted ingested protein and carbohydrate to growth with lower efficiency and survived less well than did solitarious insects. Results from experiments manipulating spatial distribution of nutritionally complementary foods also demonstrate differences in the foraging strategies between the two phases. Overall, our results are consistent with the hypothesis that differences between phases in their nutritional regulatory responses and foraging strategies have evolved to trade-off the cost of eating excess of a nutritionally unbalanced diet against the probability of encountering foods of complementary composition in the near future.

Key words: Locusts, Nutrients, Diet Mixing, Rules of Compromise, Trade-offs.

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## Outbreaks of *Schistocerca interrita* (Scudder, 1899) in Northern Peru. Poster 95

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Peru is intermittently threatened by locust outbreaks. Two *Schistocerca* species, belonging to the *Schistocerca americana* (Drury, 1773) complex, are mainly involved: *Schistocerca piceifrons peruviana* Lynch Arribalzaga, 1903 (found in southern and central parts of the country) and *Schistocerca interrita* Scudder, 1899 (found in northwestern Peru).

A major locust outbreak attributed to *Schistocerca interrita* took place in Lambayeque department in 1982-1983. Few bioecology data are available to confirm that this was actually the species involved. Based on information obtained on the last two outbreaks, it seems that when there is abundant rainfall due to exceptional events (El Niño phenomena), Lambayeque desert becomes covered with abundant vegetation and thus suitable for *Schistocerca interrita* upsurges and gregarization during summer. Swarms then move up into the neighboring mountains during the dry season. They subsequently breed in the valleys during the next rainy season. The locusts reach sexual maturity around December, egg laying begins in January on the footslopes (at around 400-600 m elevation), and the eggs hatch some 20 days later. Hopper development then begins and seems to last 2-3 months, with the hoppers gradually moving up the slopes to reach biotopes located above 2 500 m elevation by the last molt. When the populations are large enough, hopper bands form which decimate the vegetation they pass through. Swarms form around the peaks during the dry season. The life cycle then begins again with increased vigor when the species encounters suitable ecological conditions to ensure its survival and reproduction, which is often the case in the mountains west of Cajamarca. No appropriate control or accurate predictions are clearly possible until more data are collected on this species, especially since it lives in remote hard to reach areas.

Key words: Locust, *Schistocerca americana*, South America, bioecology.

## Characterization of the Vegetation of the Multiplication and Gregarisation Biotopes of *Schistocerca gregaria* (Acrididae: Orthoptera) in the Algerian South. Poster 94

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By their feeder characters, plants play a determinant role in the spatial distribution of the vegetarian animals, in their physiology, their reproduction and their swarming. The presence of *Schistocerca gregaria* in certain sites is often, if not all the time, correlated with the presence of plants preferably consumed by the ravager or serving its physiological and behavioral needs. This work, basing on the identification of these plant species, tries to specify those constituting the biotope associations where *S. gregaria* reproduces and becomes gregarious. This locust is indeed able to generate biological disasters since long ago. This study is based on a multivariable analysis (analyzes factorial correspondances) and an ascending and hierarchical classification.

Key words: the Algerian Sahara, locust pilgrim, biotopes, gregarisation, multiplication.

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## Effets de l'alimentation en *Peganum harmala* (Zygophyllaceae) sur le tube digestif du criquet pèlerin *Schistocerca gregaria* (Orthoptera: Acrididae). Poster 90

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Toxics effects of *Peganum harmala* (Zygophyllaceae) were tested on the locust *Schistocerca gregaria*. Histological study of midgut showed a reduction of the external circular musculature which provokes a relaxation of the intestine and a reduction of the intestinal epithelium. This latter showed a reduction and a striped epithelium as well as some typical signs of necrosis.

Key words: *Schistocerca gregaria*, *Peganum harmala*, midgut, toxicity.

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## Shifts in the Outbreak Area of the Brown Locust in Southern Africa. Poster 93

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The Brown Locust, *Locustana pardalina*, the most economically important locust species found in southern Africa, is endemic to the semi-arid Karoo of South Africa and southern Namibia. Its short life cycle, drought resistant egg stage, high frequency of outbreaks and swarm persistence makes it a constant threat to food security within the southern African region.

The effects of environmental conditions on the distribution and abundance of locusts, their breeding success and migration patterns, form the basis of developing a Brown Locust Early Warning System (BLEWS) that could alert control teams to the danger of impending outbreaks. Part of the development work has involved examining the frequency and distribution of outbreak changes over time, using historical records of Brown Locust occurrence collected since the start of the Twentieth Century (e.g. Faure & Marais, 1937).

A comparison of the Brown Locust outbreak area as defined by Lea (1958) and Kieser (2001) reveals a significant westward shift in the eastern boundary of the outbreak region, which has led to the closure of the Middleburg locust control depot and its relocation to Upington. At the same time, the south-western limits of the outbreak region have expanded while elsewhere, boundary changes are more irregular. The reasons for these shifts still need to be investigated fully, but preliminary work suggests that in the Karoo:

1. increased rainfall in the east has resulted in a higher humidity, which is detrimental to the survival of first instar hoppers, whereas increased rainfall in the west has favoured hatching conditions;
2. vegetation cover has altered due to changes in land use, which has affected the distribution of suitable breeding sites; and
3. a decline in systematic surveying of the outbreak area in the west due to farms being vacated, means that locust populations are not recorded until they have gregarised and moved further west/south-west.

Key words: control; rainfall; forecasting; land-use; survey.

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### **Analysis of Environmentally Related Changes in Behaviour of Semi-Field Populations of Desert Locust Hoppers *Schistocerca gregaria* (Orthoptera: Acrididae) in the Central Breeding Area of Mauritania. Poster 98**

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Earlier field reports and recent studies have indicated that environmental structures influences behavioural change and hence phase state of desert locust. In the present investigation we analysed under semi-field conditions the effect of environmental patterns on the dynamic of behavioural change of a given-size population of desert locust in its natural habitat. Experiments were carried out in the central breeding area in Mauritania from December 1997 to January 1998. Gregarious-reared hoppers were maintained in the research station of Akjoujt and were released in a crowd in a particular habitat and therefore their interactions with the environmental resources were considered. The results show how age structure and density of crowd-reared hoppers, population size and vegetation patterns as well as meteorological conditions can influence the distribution and the locomotory activities of desert locusts. Smallest size population of crowd-reared hoppers moved slowly and were intermittently subjected to dispersion. Meanwhile, when a large population of crowd-reared hoppers encountered consumable and abundant vegetation, their locomotory activities were subsequently altered. Change in locomotion caused by environmental pattern has been interpreted as foraging strategies for heterogeneous environments. The diurnal movement of crowd-reared hoppers were naturally affected by meteorological conditions. Field observation has showed that predation by vertebrates, especially birds, has affected the preservation, survival and displacement of crowd-reared hoppers and has contributed in the extinction particularly of a small populations of desert locust. Environmentally related changes in behaviour at the smallest spatial scale is a key component in monitoring strategies.

Key words: *Schistocerca gregaria*, behaviour, environmental resources, interaction, predation.

## Analysis of the Upsurge Dynamics of the Desert Locust *Schistocerca gregaria* in Mauritania (1993-1995). Poster 92

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An analysis of Desert Locust invasions using available data on natural conditions, observations of population evolution and ecological factors have demonstrated an ecological complementarity between the reproduction zones of the Desert Locust in Mauritania and those of the Western and Central Regions. The recent upsurges and invasions observed in Mauritania (1993/94 and 1995) have a similar origin to those of 1987/88. These were based on populations of Desert Locusts that had found favourable conditions in certain zones of the country which permitted them to survive and breed. The spatial and temporal distribution of Desert Locust is a function of the success of the breeding of swarming populations, of both indigenous and arriving populations. Populations arrive principally from the east due to the prevailing winds and as a result of the movement of the Intertropical Convergence Zone. The spatial and temporal limits of the survival and breeding zones were identified using data on the appearance of Desert Locust hopper bands between 1993 and 1995 (2111 records); each record had corresponding ecological data.

This study has highlighted the following points:

- The distribution of the Desert Locust is tied to precipitation and the presence of plant species that provide food and shelter.
- The existence of two reproduction areas has been confirmed, but the extent of each zone remains unclear.
- Breeding and survival in the north of the country is a function of rainfall, but it also depends on the success of reproduction in the summer breeding area in the south of the country and on the arrival of swarms from Mali from the east and north-east.
- Finally, there is evidence to suggest that locusts can exist in the extreme north-east of Mauritania, which was previously unknown.

This work has thrown new light on the dynamics of locust populations in Mauritania, and will contribute to improving preventative actions.

Key words: Occidental région, locust, vegetation, rainfall.

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## The Search for Solitary Desert Locust (*Schistocerca gregaria*) Habitat During Winter Breeding in the Plains of the Sudan Red Sea Coast. Poster 91

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Field surveys were conducted in the Red Sea coastal plains of Sudan to determine the spatial distribution of the solitary locusts in relation to environmental factors. Surveys were carried out in a strip of land of 90 km along the coast. The strip was 15 km wide and covered the following sequence of four vegetation types between the mountains in the west

and the sea in the east: gravel areas with scrub vegetation; millet with patches of *Heliotropium* on fine sandy soils; *Panicum* dominated grasslands on coarse sand; and *Suaeda* shrubs growing on silt soils with a high salt content. A five-km grid was sampled on nine occasions between 7 December 1999 and 11 February 2000. Solitary locusts were mostly found in the croplands being situated on fine sandy soils with relatively good moisture availability in the upper 0-15 cm soil layer. The locust densities in the other vegetation types were much lower suggesting that vegetation and soil data may be used as indicators of areas where solitary locusts are most likely to be found, yielding potential savings in survey effort. The generality of these findings, and the usefulness of using such indicators in surveys, will be further assessed.

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## Fungal Entomopathogens For Locust Control. Poster 110

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Orthopteroid insects are constant pests in Georgia. Recent Locust outbreak (1994-1998) caused great damage to crops in Georgia. Location of agrocenosis near locust and grasshopper habitats significantly increases the danger. Necessity of using pesticides every year promotes environment pollution and threatens people's health. Our aim is to find new effective environmentally safe biological agents for locust and grasshopper control. An epizootic of *Calliptamus italicus* was observed in the Kacheti region in 1998. About 65% of the population of *Calliptamus italicus* was infested and died. Dead individuals were collected and a microscopic analysis was conducted in the laboratory. Isolated were identified as the fungi *Entomophora grylli* (80%), *Beauveria bassiana* (20%) and *Aspergillus* sp.(12%). *Calliptamus italicus* and *Dociostaurus marrocanus* were sprayed with aqueous suspension of spores of *Entomophora grylli* and *Beauveria bassiana*. During the test the relative humidity of air was 80-85%. The most aggressive pathogen was *Entomophora grylli*. Under laboratory conditions it demonstrated high pathogenicity and showed an excellent shelf life up to two years at 5 C. Laboratory tests of a water-based formulation of spores caused a high mortality against hoppers and adults of *Calliptamus italicus* and *Dociostaurus marrocanus*. Mortality peaked 5-7 days after application and varied from 55-85%. The study showed that isolated fungi from *Calliptamus italicus* is pathogenic for *Dociostaurus marrocanus*. Fungal pesticides can be a suitable alternative to chemical pesticides for controlling insects. The potential of fungal pathogens for biological control is obvious. Developing a mycopesticide based on aggressive fungal entomopathogen isolated from the Georgian population of *Calliptamus italicus* and the possibility of integration of this mycopesticide in a locust control strategy will be discussed.

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## Contact Efficacy of Extracts from Roots of *Mucuna pruriens* (Fabaceae ex. Papilionaceae) against Migratory Locusts. Poster 108

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The bio-efficacy of extracts of *Mucuna pruriens* (Fabaceae ex. Papilionaceae) was evaluated in comparison with three other plant extracts from *Calotropis procera* (Asclepiadaceae), *Adenium obesum* (Apocynaceae) and *Azadirachta indica* (Meliaceae) against the migratory locust, *Locusta migratoria* Linné. Water and water/ethanol (50:50) extracts were prepared for each plant. A completely randomized design was used in each case. For each extract, 10 2nd. instar nymphs were sprayed directly. Another 10 nymphs of the same stage were sprayed with water or water/ethanol to serve as control. To ensure thorough coverage of the insect body, three droplets of alkylphenol oxethylene were added as a surfactant before application. Sprayed nymphs were transferred to new cages and fed wheat seedlings. All treatments were replicated six times. The insects were observed once every 24 h to record mortality, time to death and moulting

into 3rd nymphal instars. The knockdown effect was recorded 1 h after spraying. These laboratory investigations clearly revealed that *M. pruriens* scored the highest mortality rate of 100% and 98.8% in water and water/ethanol extract, respectively, with 93.3% and 91.7% scored by *A. indica*, which was used as standard botanical insecticide. A field survey was conducted in two states in western Sudan by interviewing 104 local people who used *M. pruriens*. An informal group discussion was created to determine the common viewpoint. All interviewees agreed on the insecticidal property of *M. pruriens* which is used to control lice on animals. Provided further field studies are undertaken, *M. pruriens* extracts could be used as a botanical insecticide to control locusts and grasshoppers.

Key words: *Locusta migratoria*, Locust control, Sudan, botanical insecticide.

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## Laboratory Evaluation of the Stomach Action against Migratory Locusts of Extracts from Four Plants used Traditionally in Sudan for their Pesticide Properties. Poster 109

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Water and water/ethanol (50:50) extracts from four plants used by some local people in Sudan for their pesticide properties were evaluated in the laboratory for their stomach action against 2nd nymphal instars of *Locusta migratoria* Linné. The candidate plants were *Adenium obesum* (Apocynaceae), *Azadirachta indica* (Meliaceae), *Calotropis procera* (Asclepiadaceae) and *Mucuna pruriens* (Fabacea ex. Papilionaceae). Each plant extract was applied to approximately 20 wheat seedlings grown in small pots by dipping them in the extract solution for 2 min. For the control, seedlings were sprayed and dipped in water or water/ethanol solution only. Three droplets of surfactant were added to ensure complete coverage of seedlings. One hour after dipping, the pots were transferred to new cages, two pots/cage, and 10 2nd instar nymphs deprived of food for 4-5 h were introduced. Six replicates were carried out per treatment. Mortality rates, percentage visual damage to seedlings, moulting into 3rd nymphal instars and time to death were recorded. For the water/ethanol treatments, *M. pruriens* showed the highest mortality rate (98.6%) after 2.8 days, followed by *A. indica* (93.3%) after 2.7 days, while *C. procera* and *A. obesum* gave random results. Concerning water extracts, *A. indica* gave the highest mortality rate (98.6%), *C. procera* and *M. pruriens* gave 30% each, but locusts survived longer on *C. procera* (5.1 days) compared to *M. pruriens* (3.9 days), while *A. obesum* gave no mortality. A bioassay test with water/ethanol extracts of the four plants was conducted to investigate feeding behavior when a choice between treated and untreated wheat seedlings was offered. For each test, two pots of seedlings were introduced in the same cage, one treated with a plant extract and the other only treated with water/ethanol as control. Damage was assessed daily by visual estimation. *A. indica* gave the best protection to wheat seedlings, with less than 5% damage over 5 days, *C. procera* over 2 days and *A. obesum* and *M. pruriens* only 1 day. In the latter case, hoppers were found to cut the seedlings rather than eating them.

Key words: Locust control, botanical insecticide, *Adenium obesum*, *Azadirachta indica*, *Calotropis procera*, *Mucuna pruriens*.

Illustrations: 1- Map of Sudan showing areas from where the plant materials were collected. 2- Graphs showing the scale of damage in each treatment. 3- Graph showing the mortality rates in each treatment. 4- Photograph showing the extent of damage to each plant. 5- Photograph showing treated versus untreated plants for the choice bioassay experiment. 6- Photograph of plant materials.

**Advances in Biological control of Locusts and Grasshoppers in México.** Symp. 4, Wed. 0945**Barrientos Lozano, Ludivina <sup>1</sup>, Víctor M. Hernández Velázquez <sup>2</sup>, & Richard J. Milner <sup>3</sup>**<sup>1</sup> Instituto Tecnológico de Cd. Victoria. Blvd. Emilio Portes Gil No. 1301. Cd. Victoria, Tam., México. ludivinab@terra.com.mx<sup>2</sup> Centro Nacional de Referencia de Control Biológico SAGARPA-DGSV. Km 1.5 Carretera Tecomán-Estación FCC, Tecomán, Colima, 28130. México.<sup>3</sup> CSIRO Entomology, GPO box 1700, Canberra ACT2601, Australia.

Biological control is not a new strategy in México, its history extends over more than 60 years. This technique has been implemented successfully to reduce populations of diverse pests below economic importance levels, including *Aleurocanthus woglumi*, *Eriosoma lanigerum*, *Anastrepha ludens* and *Spodoptera frugiperda*. In 1993, laboratory and field studies were initiated to develop a biological control strategy for locusts and grasshoppers. Major activities of this programme include: local surveying for entomopathogenic fungi, laboratory screening of isolates to identify more virulent strains, improve massive production quality of virulent strains, formulation and field evaluation of entomopathogenic isolates.

The National Centre for Biological Control (Centro Nacional de Referencia de Control Biológico-CNRCB) has, in its entomopathogen collection, 35 isolates of *Metarhizium* spp. (*M. anisopliae*, *M. anisopliae* var. *acridum* and *M. flavoviride*) obtained from the Central American locust (*Schistocerca piceifrons piceifrons*) in the states of Colima, Michoacán, Chiapas and Revillagigedo Island in the Pacific Coast. The isolates MaPL39, MaPL35 and MaPL40 are amongst the most virulent with median lethal times (MLT) of 5.5, 5.3 and 5.0 days, respectively. A comparative analysis on Random Amplified Polymorphic DNA patterns between two Mexican isolates of *Metarhizium*, MaPL40 and MaPL32, and the Australian isolate of *Metarhizium anisopliae* var. *acridum* (FI985), showed that the Mexican isolates and the Australian isolate have similar DNA fingerprints and belong therefore to the same variety.

Mexican isolates have been formulated in mineral and vegetable oils. Citroline mineral oil (derived from petroleum) gave the highest viability of *M. anisopliae* conidia at 7 and 27°C, causing 100% mortality 7 days after application. Field trials using oil formulations of the MaPL40 and MaPL32 isolates against 3rd-4th instar nymphs of the Central American Locust (*Schistocerca piceifrons piceifrons*), applied at a rate of 50g of conidia in 1 litre oil per hectare, provided excellent results, giving <90% mortality 10 days after treatment. MaPL32 results were slightly better than MaPL40, but the difference was not significant. Comparative studies between the Mexican and the Australian isolates were conducted over a range of temperatures, results are reported in detail.

Mass production of isolates MaPL32 and MaPL40 is in progress to carry out more extensive field trials against the Central American locust from October 2001 onwards.

Key words: locust, grasshoppers, biological control, Mexico.

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**Grasshopper Control: No Treatment at All ... Any Possible Advantages?** Symp. 1, Mon. 1615
**Belovsky, Gary E.**

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I have demonstrated experimentally at the National Bison Range (Montana, USA) that a grasshopper (*Melanoplus sanguinipes*) can increase annual net primary production by speeding up the cycling of nitrogen that limits primary production. This occurs primarily by the grasshopper preferentially feeding on plants whose litter decomposes slower than the litter from plants that are not preferentially consumed, which increases the average rate of plant litter decomposition and the release of nitrogen in the environment. Furthermore, because the plants producing the faster decomposing plants are competitively favored when nitrogen availability is increased, the abundance of the plants

producing faster decomposing litter is increased relative to the abundance of plants producing slower decomposing litter, which further enhances the rate of nitrogen cycling. The result is a positive feedback that leads to a different plant species composition in the environment than would be observed without the grasshopper's herbivory, and this new plant community is more productive.

The grasshopper studied is considered by many the principal grasshopper pest in North America and has been the subject of control efforts in western US rangelands, where grasshopper damage and control efforts average 100's of millions of dollars each year. However, my results question whether this species should be considered a pest warranting control and actually suggest that consumption of plants by this species may be beneficial to the long-term maintenance of rangeland productivity at least in some areas. In fact, past control efforts in these areas may actually have been detrimental to rangeland productivity.

Additional experiments are addressing the conditions, which would cause grasshopper consumption of plants to be detrimental to plant production and warranting control, if it can be economically and environmentally justified. For grasshopper consumption to be detrimental, the plant producing faster decomposing litter must be preferentially consumed. We are beginning to address how frequently these two scenarios may occur in western US rangelands.

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## **The Potential and Extension Effect of Diflubenzuron (IGRís) on the Reproduction and Feeding Behaviour of Desert Locust *Schistocerca gregaria* (Orthoptera: Acrididae).**

Poster 107

**Bouaichi, A. & J. Chihrane**

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The effect of diflubenzuron on the reproduction and feeding behaviour of desert locust has been investigated under laboratory conditions. Pre-reproductive females were fed regularly on wheat seedlings sprayed with Diflubenzuron (Dimilin<sup>®</sup> OF-6) using a hand held spinning disc sprayer at a rate of 60 g a.i. ha<sup>-1</sup> compared with untreated controls. In the meantime, 4th instar nymphs were put together with pre-reproductive females and fed on treated wheat in order to establish the biological toxicity of the IGRís formulation. Mortality in 4th instar nymphs fed on treated wheat reached 65 % six days after treatment then achieved 85 % ten days afterwards, compared with control mortality of only 25 %. Diflubenzuron showed a significant persistence in activity against newly introduced 4th instar nymphs (85 % mortality) fed on three weeks previously treated wheat. Mortality among pre-reproductive females was not evident, given the fact that Diflubenzuron acts only against nymphs; however the effect of diflubenzuron was later expressed on the offspring arising from eggs laid by treated females. The breakdown of hatching has reached 95 % in treated females compared with 20 % among untreated controls. Female fecundity, rate and period of oviposition and the oocyte resorption rate were not affected by Diflubenzuron. The impact of diflubenzuron on feeding was observed by means of histological analysis of the peritrophic membrane in the mid-gut. Slides prepared from female fed on treated wheat showed slight weaknesses of the peritrophic membrane, probably due to the reduction of chitin compared with untreated females. There is thus potential for the use of diflubenzuron as an environmentally friendly control agent against locusts and grasshoppers.

Key words: *Schistocerca gregaria*; Diflubenzuron; reproduction; hatching; feeding behaviour.

## New Ecotoxicity Data on Green Muscle“. Smp. 4, Wed. 1015

Everts, James <sup>1</sup>, Abdoulaye Danfa <sup>2</sup>, Apha O. Diallo <sup>2</sup> & Wim C. Mullié <sup>1</sup>

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In general, biopesticides represent a lower environmental risk than synthetic compounds. However, their non-target toxicity, even when low, should be well known, in order to enhance the selectivity of applications to a technical maximum. All insecticides used against locusts that are evaluated by the Pesticide Referee Group of FAO, are submitted to tests with non-target species from the target habitat and field tests. In the present study first tier challenge tests were carried out with Green Muscle“, (active ingredient: acridian pathogen *Metarhizium (flavoviride) anisopliae var. acridium*) on five non-target organisms: a fish (*Oreochromis niloticus*), an aquatic hemipteran (*Anisops sardeus*), two terrestrial coleopteran natural enemies of locusts (*Pimelia senegalensis* and *Trachyderma hispida*), a parasitic hymenopteran (*Bracon hebetor*) and a termite (*Psammotermes hybostoma*). The tests were carried out according to Standard Operation Procedures for synthetic chemicals adapted for testing with pathogens, with the exception of *P. hybostoma*. The latter species was tested in a controlled field setup. Results indicated that at extreme exposure Green Muscle“ may be infective for *O. niloticus* and *A. sardeus*. The hemipterans are, irrespective of the dose, affected by the solvent (a mixture of mineral and organic oil) which partly covers the water surface, hampering breathing. In a field test, environmental factors (especially wind) appeared to attenuate this effect. *P. senegalensis* and *T. hispida* proved insensitive to direct exposure. *B. hebetor* was infected both through direct exposure as well as exposed as a larva in a host (*Ephesthia kuehniella*). The semi-field test with *P. hybostoma* indicated that the termites may be sensitive to the pathogen.



## Biological Efficacy of *Metarhizium flavoviride* on Locusts in Morocco. Poster 106

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For the first time a Moroccan strain of *Metarhizium flavoviride* (Deuteromycotina: Hyphomycetes) has been discovered and isolated from the Moroccan locust *Doclostaurus maroccanus*. In laboratory, this strain has been tested on adults of *Schistocerca gregaria* with the following concentrations 5,8.10<sup>9</sup>; 2,5.10<sup>11</sup> and 2,5.10<sup>13</sup> conidia/l. The results obtained in term of medial survival time (MST) were respectively: 14, 13 and 11 days. Good results were also obtained on larva by ingestion after 3 days (MTS) at 1,6.10<sup>8</sup> cd/l. On the field, adults of *Doclostaurus maroccanus* treated with a solution of 3,5.10<sup>11</sup> cd/l showed, 6 days later, 50 to 100% mortality respectively of adults and larva.

Key words: Biological control, Metarhizium, Flavoviride-locusts, Morocco.

## Activité Biologique d'un Dérégulateur de Croissance le Téflubenzuron (TFB) sur les L5 de *Locusta migratoria* (Orthoptera: Acrididae): Efficacité et Effet sur la Cuticule, les Métabolites Hémolympatiques et Ovariens de ce Locuste. Poster 104

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Notre travail a porté sur l'utilisation d'un dérégulateur de croissance des insectes, le Téflubenzuron (TFB), un produit synthétique inhibant la synthèse de la chitine, appartenant à la famille des benzoyphenylurées, sur des L5 âgées de moins de 24h et des L5 âgées de 4 jours de *Locusta migratoria*. Les traitements ont été effectués par trempage de l'aliment. *Penisitum purpureum*, dans des solutions du TFB à trois doses: 0,66 ml / L., 0,33 ml / L et 0,16 ml / L et qui a été présenté ensuite aux insectes. On a déterminé les TL50 pour chaque dose et qui sont respectivement de 5 j., 4j. et 3j. ainsi que la DL50 qui s'évalue à 0,35 ml / L.

L'effet du TFB sur le contenu de la cuticule en chitine et en protéines ainsi que sur les métabolites hémolympatiques et ovariens a également été évalué chez ce locuste. Les taux de chitine et de protéines cuticulaires ont significativement diminué, dès le premier jour après traitement, aussi bien chez les L5 jeunes que les L5 âgées. Parallèlement, nous avons noté une baisse dans les concentrations des protéines, des lipides et des glucides de l'hémolymphe de ce locuste. L'effet du TFB sur les concentrations des métabolites ovariens, notamment les protéines, les lipides et les glucides, entraînent une nette diminution de ces constituants chez les jeunes imagos issus des L5 traitées au 4<sup>ème</sup> jour.

Mots clés : *Locusta migratoria*, Téflubenzuron, dérégulateur de croissance, cuticule, hémolymphe, ovaires.

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## Effet de deux Entomopathogènes, *Beauveria bassiana* et *Metarhizium flavoviride* (Hyphomycète: Deuteromycotina) sur l'Hémogramme de *Locusta migratoria* (Orthoptera: Acrididae). Poster 105

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Ce travail a porté sur l'utilisation de 2 entomopathogènes, *B. bassiana* et *M. flavoviride* sur le 5<sup>ème</sup> stade larvaire et les adultes de *L. migratoria*. Les individus du criquet migrateur proviennent de la région d'Adrar, oasis située à 1600 km au sud d'Alger. Les champignons entomopathogènes sont de provenances différentes: *B. bassiana* a été isolée à partir de cadavre d'adulte de *Schistocerca gregaria* échantillonné à Adrar en décembre 1996. *M. flavoviride* est une souche isolée à partir de *Locusta migratoria* originaire de Madagascar. L'inoculation s'est réalisée par injection de 25 ml de l'entomopathogène dont les doses sont de  $6,60 \times 10^2$  spores / ml et  $2,34 \times 10^4$  spores / ml respectivement sur les L5 et les adultes. Les frottis chez les témoins et les traités sont faits selon la méthode de GUZO et STOLTZ (1987).

Chez les témoins, nous avons enregistré une différence significative du nombre d'hémocytes entre les L5 et les adultes de *L. migratoria* avec respectivement 82 à 150,4 hémocytes. Chez les larves et les adultes traités, le nombre d'hémocytes toutes catégories confondues diminue suite au traitement au *B. bassiana* et au *M. flavoviride* passant de 82 à 55,8 chez les L5 traitées au *M. flavoviride* et à 40,8 chez les traitées au *B. bassiana*. Chez les adultes ils atteignent 98,8 et 89.

L'hémogramme et l'identification des hémocytes des larves et des adultes du criquet migrateur montrent l'existence de 3 types cellulaires à savoir les prohémocytes, les plasmocytes et les granulocytes.

Le nombre des prohémoocytes compté dans 4 ml d'hémolymphe du criquet migrateur chute suite au traitement passant de 39,6 chez les L5 témoins à 26,2 chez les L5 traitées au *B. bassiana* et à 18 chez celles traitées au *M. flavoviride*. Chez les adultes, ce nombre passe respectivement de 55,6 à 44,8 et 34,4. Une diminution dans le nombre et dans le taux de plasmatoocytes a été aussi enregistré au 3<sup>ème</sup> jour après traitement. De même une diminution significative du point de vue nombre et taux est observée pour les granulocytes après traitements.

Nous constatons donc que les champignons entomopathogènes utilisés perturbent la cytologie du sang de *L. migratoria* de manière qualitative et quantitative dont la fonction phagocytaire est sévèrement réduite.

Mots clés: Hémolymphe, prohémoocytes, plasmatoocytes, granulocytes, *Beauveria bassiana*, *Metarhizium flavoviride*, *Locusta migratoria*.

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## **Evaluation de l'Activité Biologique de *Metarhizium flavoviride* et de *Beauveria bassiana* (Hyphomycètes: Deuteromycotina) vis avis de *Locusta migratoria* (Orthoptéra: Acrididae).**

Poster 103

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La méthode de lutte contre les ravageurs au moyen d'agents microbiens utilise des organismes trouvés en milieu naturel et généralement beaucoup plus sélectif et moins polluant que les pesticides chimique. C'est dans ce sens que nous avons apporté notre contribution par une étude comparative de l'effet insecticide de deux champignons entomopathogènes *Metarhizium flavoviride* et de *Beauveria bassiana* au laboratoire contre la sauterelle migratrice *Locusta migratoria*. Administré par voie tégumentaire (pulvérisation) à différentes doses 106spores/ml; 105 spores/ml; 104 spores/ml et 103 spores/ml les deux cryptogames manifestent une action directe avec une relation doses réponses les données observées ont fait l'objet d'une analyse e la variance et d'une analyse probit, les DL50et TL50 sont estimés. L'analyse statistique révèle des effets doses et temps hautement significatifs. Les deux entomopathogènes présentent la même efficacité vis avis des criquets traités selon les mortalités enregistrés qui sont assez proches pour *M flavoviride* les doses létales (DL50) obtenues s'évaluent à: 1,67.102 spores/ml; 4,17.102 spores/ml; 1,77.105 spores/ml; 4,59.106 spores/ml; 3,62.107 spores/ml et enfin 9,40.107 spores/ml chez respectivement les L1 ; L2 ;L3 ; L4 ; L5 et les imagos quant au *B. bassiana*, les doses étales estimées sont de l'ordre de 4,02.102 spores/ml pour les L2; 7,07.105 spores/ml pour les L3; 1,31.106 spores/ml pour les L4 ; 5.107 spores/ml pour les L5et 9,4.107 spores/ml chez les imagos. L'inoculation des propagules infectieux a engendré plusieurs caractères maladifs chez notre sauterelle qui commençaient à se manifester 24h après l'infection la symptomatologie a été régulièrement suivi.

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**Biocontrol Place in Acridid IPM in Australia. Symp. 4, Wed. 1000**

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## Twenty Years after the Introductions of *Nosema locustae* for Grasshopper Control in Argentina: An Update. Symp. 4, Wed. 1100

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*Nosema locustae* is a spore-forming pathogen (Microspora) of the adipose tissue of orthopterans that was selected and developed in the USA as a microbial control agent of grasshoppers. When its development was well advanced but as early as two years before its registration in the USA (1980), a series of introductions into grasshopper communities began in Argentina that extended from 1978 to 1982. These applications were the first use of the pathogen outside of North America, and although considered experimental at the time, they were actually of a rather large-scale magnitude. Using inoculum of North American origin (spores produced either by the USDA laboratory in Bozeman, Montana, or by BioEcologists in Colorado) and following standard application procedures (spores on bran baits delivered to third-instar nymphs), *N. locustae* was introduced in a total of nine localities, seven in the Pampas region (Casbas, Gorchs, Lamadrid, Macachín, Pringles, Santa Rosa, Suárez) and two in northwestern Patagonia (Gualjaina, Zapala). Unfortunately, after the last introductions the work lost continuity. The short-term impact (control within seasons of applications) of the introductions will remain unknown because reports were not produced and data on infectivity and density reductions are not available. Similarly, the long-term outcome of the introductions was unknown for years until the pathogen was re-found in 1991 parasitizing three species of grasshoppers. Since then, every single opportunity for monitoring the presence of *N. locustae* in grasshoppers of the country is used. Up to now, establishment of the agent was observed in two well-defined areas: Gualjaina in Patagonia, and an area in the western Pampas surrounding three of the application sites. Infections were diagnosed in 14 species of grasshoppers, while 30 others, including some known to be experimentally susceptible and some occurring in sites where infection is present, were never found to be infected. Ten out of the 14 species with infections were melanoplines (Melanoplineae), two were gomphocerines (Gomphocerinae), and two romaleids (Romaleidae), which agrees with host range observations obtained in North America. Maximum geographic dispersion of the pathogen recorded was 160 km. Prevalences registered were normally much higher than in areas where *N. locustae* is known to be native (North America, India, South Africa), and unusually high prevalences (epizootics) of up to 75 % were not uncommon.

Although *N. locustae* was originally employed in an inundative manner, expecting some short-term effects, it became a typical example of the colonization (introduction-establishment) approach of using entomopathogens. It is also an example of neoclassical biological control, in which an exotic agent is used to control a native pest. The establishment, spread and possible effects of a new disease over large areas in not just one but many hosts of different susceptibilities is a subject of high complexity. Even more so when quantitative data on abundances of hosts prior to the introductions are not available and some scenarios are also greatly influenced by other forces, like habitat disruption. In this context, the case of *N. locustae* in Argentina poses more uncertainties than answers, and it is prone to much speculation. However, some interesting points can be raised: 1) given the levels of occurrence of *N. locustae* and knowing the negative effects well-documented on hosts, the pathogen must be somehow affecting grasshopper communities in Argentina; 2) in areas where *N. locustae* became established problems with grasshoppers have never since been reported, and they were recurrent and serious before the introductions. Similar areas in terms of climate, physiography, land uses, and composition of grasshopper communities, but with absence of *N. locustae* continue to suffer recurrent outbreaks; 3) no other microsporidium is known where *N. locustae* became established while establishment apparently did not occur where a native microsporidium, *Perezia dichroplusae*, is present; 4) as transmission is the key factor governing the epizootics of a pathogen, *N. locustae* appears to be operating in accordance to its efficient horizontal transmission, in contrast to the way *P. dichroplusae* does, which exhibits vertical transmission as its main mode of persistence.

The original concept for the use of *N. locustae* was “to augment natural control factors for the long-term suppression and maintenance of grasshopper densities”. Later commercial development obscured this initial concept, and most people falsely expected rapid reductions of pest grasshoppers. Although out of its native land, *N. locustae* appears to be operating in Argentina very much like the way it was originally conceived. In this sense, it would be of much interest to monitor for the presence of *N. locustae* in areas of introductions that have been conducted in other countries, like Mali, Niger, Cape Verde and Australia.

## Large-scale Environmental Impact of Biological Control and the Future of Grasshopper Control in the Sahel. Symp. 4, Wed. 0830

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After many years of research and large scale field testing, isolates of the fungus *Metarhizium anisopliae* are now commercialized as the most effective biocontrols for grasshoppers and locusts available. In the context of the development of Green Muscle®, most of the early large scale field testing was carried out in the Sahel and particularly in Niger. As a part of field testing, the ecotoxicological impact of the novel product was compared with standard synthetic insecticides. The results show that Green Muscle® had no negative impact on non-target Hymenoptera and on soil dwelling non target arthropods. However, concerning Hymenoptera the studies also revealed the limits of field testing, even at a scale of 800ha plots, where data variability becomes a problem. With the limitations of ecotoxicological studies in mind, developing future grasshopper control strategies should be designed in a way, that even potential environmental hazards are avoided. Not only direct environmental impact needs to be studied, but also impact of food depletion on important grasshopper natural enemies or rare species. Particularly in the Sahel, where authorities are still following curative control strategies, and where the average annual area sprayed may be the largest world-wide, better control strategies are needed.

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## Are Preventive Actions Possible? Recent Progress in Desert and Migratory Locust Management in Africa. Symp. 1, Mon. 1400

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Locust control in Africa has been the focus of considerable controversy over the last 15 years. Many aspects were called into question following the last large plagues of 1987-88 (Desert Locust) and 1996-2000 (Malagasy Migratory Locust), starting with the hitherto recommended preventive strategy, along with the environmental impact of insecticides used, and even the real socioeconomic importance of the locusts. Many projects were launched to improve survey and control methods and find alternative solutions to chemical pesticide treatments. Recent progress is reviewed. Survey and application techniques suffered dramatic improvements with GIS, GPS technology and precision spraying. Barrier applications are again available thanks to new persistent pesticides. Biological control with mycopesticides now appears very promising and undoubtedly the technique will gradually be adopted. The environmental aspects are taken into better account. An IPM approach is now possible. The EMPRES program of FAO is committed to reinforcing national early warning and early reaction capacities for preventive control of the Desert Locust. In Madagascar a new National Locust Center has been recently set up. Everywhere local research capabilities are improving. However, certain very fundamental aspects remain unsolved. Among others, the sustainability of preventive control systems is an important concern. Many affected countries are amongst the poorest in the world. They currently do not have sufficient financial resources to fund intensive control campaigns, nor even the basic minimum to ensure prevention. A realistic solution to prevent locust plagues requires stronger commitment of governments and donors, sustainable light but flexible national locust control units for prevention, and especially the creation of emergency action plans ready to quickly mobilize and organize complementary resources in the event of an upsurge. Emergency funds are thus essential and should be created. Locust control seems now to depend more on political and institutional choices than on scientific and technological innovations.

Key words: Acrididae, locust control, outbreaks, Desert Locust, Migratory Locust.

## Can We Make Locust and Grasshopper Control Sustainable? Symp. 1, Mon. 1430

**Lockwood, Jeffrey A.<sup>1</sup>, Allan T. Showler<sup>2</sup> & Alexandre V. Latchininsky<sup>1</sup>**

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Scale is the fundamental conceptual problem in assessing the sustainability or value of controlling grasshoppers or locusts. Using case studies from North America (United States: Wyoming), Africa (Eritrea), and Asia (Russia: Irkutsk), we analyzed the viability of control programs. There are at least four dimensions to the question of scale in acridid pest management, and how one constrains these parameters largely determines if a control action is worth undertaking. First, the spatial scale is of central importance and ranges from the geopolitical unit of an individual farm/ranch through the surrounding region up to the international community. Second, the human scale recognizes that the purposes of an intervention are highly varied, encompassing personal needs, corporate profits, food security, balance of trade, environmental integrity, political stability and human dignity. Third, the interest scale acknowledges that various, potentially competing desires interact in assessing the value of intervention, including economic, environmental, and cultural values. Fourth, the temporal scale represents the time-frame — from daily to intergenerational perspectives — of costs and benefits which is central to assessing whether control is sustainable.

A number of intriguing differences and commonalities emerged from such a cross-cultural analysis. For example, as the scale decreases, the perceived value of control generally increases, often in a non-linear manner that suggests changes in quantity may result in qualitative changes in perceived valuation and discontinuities in sustainability. Interventions tend to generate conflict when the scales of benefit and cost are mismatched (e.g., individualized benefits with collectivized costs or vice-versa). Decentralized pest management systems tailored to local opportunities and obstacles generally lead to toward systemic inefficiencies, but site specificity more closely aligns the scales of costs and benefits. Thus, these appear to be economically imperfect but politically viable ways of creating a system of complex, adaptive — and ultimately sustainable — acridid pest management programs.

Key words: scale, spatiotemporal, values, decentralization.

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## What Is the Place of Biological Control in Acridid Integrated Pest Management? Symp. 1, Mon. 1545

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Control of grasshoppers and locusts has traditionally relied on synthetic insecticides, and for emergency situations, this is unlikely to change. Most locust control operations in Africa are conducted in ‘crisis mode’, and are affected by military situations which leave little room for flexibility. Nevertheless, there is a growing awareness of the environmental impact of acridid control operations, and the demand for a biological product is strong.

A decade of research on the entomopathogenic fungus *Metarhizium anisopliae* var. *acridum* has led to some astonishing field results. Contrary to some of the more pessimistic scenarios envisaged at the outset of the development projects, trials in Niger and Australia have shown that the fungus can be formulated and applied under standard operating conditions, and that control is effective and long-lasting. Most importantly, the products are highly selective, safe to use, and we have not been able to detect any side-effects. This means that the natural enemy fauna is preserved and may be contributing to control. Certainly, birds are unaffected by *Metarhizium*. *Metarhizium*, like many biopesticides, thus offers a way of controlling pest outbreaks, without upsetting natural enemy populations. *Metarhizium* is a ‘good’ IPM technology which should lead to stabilisation of pest populations.

We can see an emerging IPM framework, based on good detection and prediction, chemical pesticides for swarm control and real emergencies, and *Metarhizium* for outbreaks with no immediate risk of crop damage. With *Metarhizium* established as part of the IPM portfolio, there will be scope to explore further biocontrol options, such as the microsporidian *Nosema locustae* and the hymenopteran egg parasitoids *Scelio* spp.

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### The Use of *Metarhizium anisopliae* var. *acidum* against the Grasshopper *Rhammatocerus schistocercoides* in Brazil. Symp. 4, Wed. 1115

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The control of grasshoppers in Brazil has been based exclusively on chemical insecticides (fenitrothion and malathion). However, as these products are known to be harmful to the environment their massive use have caused concerns. To face the pressure against the use of chemical insecticides to control grasshoppers, the development of alternative methods became imperative. Some species of entomopathogenic fungi can supplement or even replace chemical insecticides in the control of grasshoppers. An integrated research project was initiated in Brazil in 1993 at Embrapa (Brazilian Agricultural Research Corporation) Genetic Resources and Biotechnology with the specific objective of developing bioinsecticides based on entomopathogenic microorganisms, specially fungi, to control grasshoppers. Our activities were centered in surveys, characterization, production, formulation, and field evaluation. Emphasis has been given to develop the fungus *Metarhizium anisopliae* var. *acidum*, the most promising candidate as biocontrol agent against grasshoppers. It has been demonstrated that this pathogen can be used efficiently in the control of *R. schistocercoides* in Brazil. We are now verifying its effects on non-target organisms including other Orthoptera, Diptera and Hymenoptera.

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### Recent Developments with the Use of Fungi as Biopesticides against Locusts and Grasshoppers in Australia. Symp. 4, Wed. 0900

Milner, Richard J & David Hunter

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Since October 2000, the commercial product Green Guard® (conidia of *Metarhizium anisopliae* var. *acidum* in oil), produced by SGB Pty. Ltd. Wodonga, Victoria, has been used by the Australian Plague Locust Commission for operational control of the Australian plague locust, *Chortoicetes terminifera*. Between October 2000 and January 2001 over 23,000 ha were treated at doses between 12 and 25 g/ha in 500 ml of oil. Under sunny mild conditions in October, treatment even with the very low dose of 12 g/ha gave over 90% control in 12 days. In November, a combination of hot days and cool nights resulted in delayed mortality with 80% control taking 2-3 weeks irrespective of the dose. Later still in the season, hot days and mild nights provided ideal conditions and over 90% control was achieved in 10-14 days even at 17-25 g/ha. The factors which make Green Guard® attractive for locust control in Australia include the low cost, the absence of environmental effects especially on aquatic organisms and its suitability for use in organic beef areas and where the use of chemical pesticides is undesirable. Large-scale field trials against migratory locusts, *Locusta migratoria*, have shown that doses of 50-75 g/ha are effective against this species. Spur-throated locusts, *Austracris guttulosa*, are very susceptible in the laboratory but field trials have proved difficult to assess because of the high mobility of the adults and the absence of a banding nymphal stage. Results with wingless grasshopper, *Phaulacridium vittatum*, have been variable with control being difficult to achieve during cool weather. Laboratory studies on *Beauveria bassiana* have shown that isolates of this fungus derived from field infected grasshoppers are very virulent and will kill under cool conditions. It is hoped that comparative field trials with Green Guard® will be done in the 2001/2 season.

Key words: *Metarhizium anisopliae* var. *acidum*; biological control; Australian plague locust; *Chortoicetes terminifera*; *Beauveria bassiana*.

## Demonstration of Deterrent and Toxic Effects of *Glinus lotoïdes* on Nymphs of the Desert Locust *Schistocerca gregaria* (Orthoptera: Acrididae). Poster 102

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The potential effect of *Glinus lotoïdes*, a plant widespread in temporary ponds, on the Desert Locust feeding behaviour and survival has been explored under laboratory condition in comparison with *Citrillus colocyntis*, a plant known for its toxicity. *Schistocerca gregaria* were reared under semi-field condition in the central breeding area of Mauritania and *G. lotoïdes* were daily collected from a temporary salty wetland. *G. lotoïdes* and *C. colocyntis* were offered separately while untreated locusts were fed with wheat seedlings. Food uptake has been calculated using the digestive coefficient (C.U.D.) and the efficiency of conversion (E.C.D.) of food by locusts. The results showed that the mortality reached 100% in 4th instars fed with *G. lotoïdes* within a period of 10 days and only 10% with *C. colocyntis* and 0% for those fed with wheat seedlings. Nymphs reared on *G. lotoïdes* eat less food and subsequently their C.U.D. is less than those fed on *C. colocyntis* or wheat. The efficiency of conversion of *G. lotoïdes* is insignificant; in the meantime a sensible loss of weight is noticed on nymphs. Those results confirm the feeding avoidance behaviour of Desert Locust under field condition, probably because of allelochemical compounds in *G. lotoïdes*.

Key words: *Schistocerca gregaria*, *Glinus lotoïdes*, *Citrillus colocyntis*, survival, feeding behaviour.

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## Can the Environment Support Any More Locust Control Campaigns ? Symp. 1, Mon. 1515

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Contrary to ordinary agricultural pests, locusts are usually controlled in natural or semi-natural landscapes, exposing structurally and functionally diverse communities not adapted to, or co-selected by, agro-chemicals. This suggests that perturbations of communities may be severe. On the other hand, with highly mobile locust targets in space and time, exposure of non-target biota at any one location tends to be erratic, and locust control can be seen as yet another component in a canon of irregular, natural or human-induced environmental catastrophes and selective forces shaping communities and ecosystems. Moreover, habitat loss is by far the most important single threat to biodiversity, so why should doubt be cast on the potential and resilience of populations to recover from occasional pesticide stress?

Several arguments can be put forward to show that there is reason for concern. First, in most locust-affected countries we know very little about biodiversity resources and their spatial and temporal distribution. Inventories of habitat types and the fauna exposed to pesticides are rare, let alone studies on their vulnerability. Second, the rational of preventive control demands focused and repeated control operations in locust recession areas, which often support high biodiversity, thereby increasing pesticide exposure. Third, other environmental stressors, chemical and physical, increase in magnitude and scale world-wide, thereby reducing the capacity of populations to tolerate additional pesticide stress.

Ecological risks of locust control remain a matter of controversy unless these topics are adequately addressed in environmental assessments. This requires a commitment of scientists, decision makers and donors (1) to bridge the schism between merely technical (hit the target) or environmental (spare the non-target) mind-sets in locust management, (2) to conduct and support long-term field studies designed to meet structural and functional peculiarities of locust habitats, and (3) to acknowledge and apply the precautionary principle in decision-making and risk management.

Key words: locust control, pesticide stress, environmental impact, biodiversity.

**Worldwide Control of Locusts and Grasshoppers with Diflubenzuron (Dimilin®).**

Poster 101

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Dimilin® Insect Growth Regulator (diflubenzuron) has been extensively tested, both as blanket and barrier treatments, for control of locusts, grasshoppers and Mormon crickets. It proved to be very effective in controlling all nymphal stages of locusts and grasshoppers at low dose rates.

Diflubenzuron inhibits the deposition of chitin in the insect's exoskeleton upon ingestion of treated vegetation. First symptoms of intoxication are slow and uncoordinated movement, loss of legs and reduced feeding. These non-lethal effects make nymphs vulnerable to predation by insects, birds and mammals. As the new exoskeleton is weakened by this unique mode of action, mass-mortality occurs at moulting.

Recent research indicates that adult females feeding on residues of diflubenzuron have reduced egg hatch, resulting in substantial population reduction in the subsequent generation.

Diflubenzuron exhibits very low mammalian toxicity and thus low operator exposure hazard. It will not harm birds, reptiles and fish, and it has been shown not to impact adult populations of various ground-dwelling and flying non-target arthropods. Moreover, diflubenzuron at field rates has also been shown to be safe to immature stages of many predatory and beneficial insects, including bees. Although diflubenzuron is quickly degraded in water and soil, it is relatively persistent on foliage (up to 30 days) and thus available for migrating hopper bands, delayed hatching nymphs and later hatching species.

Diflubenzuron is registered for locust and grasshopper control, as blanket and/or barrier application, in all major locust areas of the world. In a number of problem areas it has become a standard for barrier-type applications.

Key words: Mode of action, Residual activity, Barrier treatment, Blanket treatment, Safety to user and environment, Control of locusts and grasshoppers with Dimilin®.

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**Biological Control of Locusts and Grasshoppers in Southern Europe. Symp. 4, Wed. 1045**
**Santiago-Alvarez, Cándido <sup>1</sup>, Pablo Valverde-García <sup>1</sup>, Enrique Quesada-Moraga <sup>1</sup>, Matt Thomas <sup>2</sup>, Simon Blanford <sup>2</sup>, Javier Celma <sup>3</sup> & José Luis Collar <sup>3</sup>**
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Locusts and grasshoppers are key pests in several parts of Europe and the neighbouring regions. The Moroccan locust, *Doclostaurus maroccanus*, has been recorded as an important pest of pasture and crops in Spain for several centuries. Outbreaks also occur in other Mediterranean areas such as southern Italy, Crete, Sardinia, Morocco, Algeria and Turkey, as well as parts of eastern Europe and the former Soviet Union.

Chemical insecticides have to-date provided the only means for ensuring wide-scale control of locust and grasshopper outbreaks. The widespread use of such chemicals and their associated detrimental effects on the environment, combined with the hazard they represent to users and livestock, remains a major drawback to continued reliance on their use.

In light of this, in early 2000 a collaborative European research project entitled, 'Protecting Biodiversity through the Development of Environmentally Sustainable Locust and Grasshopper Control' (ESLOCO), was initiated. Its aim is to reduce the environmental impact of locust and grasshopper control operations through the development of a new environmentally sustainable strategy, based on the use of *Metarhizium anisopliae* var *acridum*. Here we report on the first field trials conducted in Spain as part of the ESLOCO project. The results demonstrate that *M. anisopliae* var *acridum* is highly infective to both Moroccan locust and Italian grasshopper, the two most important acridid pests in the region.

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## Effect of the Fungus *Metarhizium anisopliae* var. *acridum* on Non-target Arthropods in Brazil, with Special Reference to Orthopterans. Poster 100

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A biopesticide based on the fungus *M. anisopliae* var. *acridum*, isolate CG 423, has shown to be efficient against the plague grasshopper *Rhammatocerus schistocercoides*. In order to assess the effects of this biopesticide on non-target arthropods, field tests were carried out in Mato Grosso State, in natural vegetation, during the period of occurrence of young nymphs of *R. schistocercoides*. The experimental protocol consisted of 4 blocks, each one of them possessing two 0.49 hectare parcels (70 x 70m). In each block, one of the parcels was sprayed with a dosage equivalent to 4.2x10<sup>12</sup> viable conidia per hectare, and in the neighboring parcel no application was made. Immediately before and in regular intervals after spraying (4, 7, 10, 13, 16 and 19 days), the densities of nymphs and adults of non-target orthopterans were evaluated in each parcel by visual estimations made over fifty 1m<sup>2</sup> squares. Seven days after the application (DAA) it was possible to observe a decrease in the density of nymphs in the sprayed parcels. Although significant differences were observed only at 16 DAA (P=0.015), the density of nymphs during the whole period of experiment suffered a 28.8% reduction in parcels sprayed with the fungus, and an increase of 4.1% in the control parcels. For orthopteran adults, the effect of the mycoinsecticide was more obvious at 13 DAA. Although this evaluation was the only one in which the density of adults was significantly inferior than in the parcels sprayed with the fungus (P=0.021), the reduction in adult densities in the sprayed parcels was of 59.7%, whereas in the control it was observed an increment of 5.8%. The results demonstrate that the biopesticide for the control of *R. schistocercoides* can affect populations of non-target orthopteroids. Data analysis regarding other insect orders, from an evaluation performed over two 4 hectares parcels, are in progress. Preliminary results suggest a negligible lethal effect, with the likely exception of some Diptera from family Asilidae.

Key words: *Rhammatocerus schistocercoides*, Acrididae, biopesticide, environmental impact.

**Development and Management of the 1999/2000 Outbreak of the Australian Plague Locust (*Chortoicetes terminifera*) in Eastern Australia - Why Locusts Are Worth Controlling.**

Poster 111, Oral pres. Wed. 1645

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The 1999/2000 season saw the development, for the first time in living memory, of a major outbreak of the Australian plague locust (*Chortoicetes terminifera*) on both sides of the Australian continent in the same year. This paper describes the events leading up to the outbreak in eastern Australia and its subsequent collapse. The justification for locust control in Australia is discussed. The cause of the outbreak is attributed to the exceptional rain that fell in the arid and semi-arid zones between November 1999 and February 2000 that allowed widespread breeding of *C. terminifera* to occur. Early intervention control of the spring and summer generations significantly reduced the densest infestations but could not prevent the large-scale invasion of swarms into the agricultural zone during autumn. Extensive laying of overwintering eggs followed and continued well into winter. By spring 2000, South Australia faced its largest locust outbreak since 1955, while New South Wales and Victoria the largest in ten years. Over A\$11 M of emergency and contingency funds to control spring hatchings were put in place by these three States in addition to the A\$5.6 M made available to the Australian Plague Locust Commission (APLC). Control of the spring generation began in early September 2000 and finished in mid-December 2000. The APLC aerially treated bands and swarms infesting 1781 km<sup>2</sup> while the South Australian and Victorian governments treated another 4149 and 23 km<sup>2</sup> respectively. This control, in combination with that conducted by landholders and local councils, was highly successful at preventing damage to agricultural industries and no significant losses were reported. Breeding of residual locust populations continued in some pastoral areas in January and February 2001 but further preventive control by the APLC and dry conditions during the remainder of the season led to the collapse of the outbreak.

Key words: locust, plague, Australia, *Chortoicetes*.

## On the Importance of the Swarming Risks of *D. maroccanus* (Orth. Gomphocerinae) and *L. migratoria* (Orth. Oedipodinae) in Relation with the Anthropized Environments in the Algerian Semi-arid and Sahara. Poster 117

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Among the intermittent acridid ravagers, *Shistocerca gregaria* and *Dociostaurus maroccanus* are still the most fearsome in Algeria. If multiple efforts are deployed in prevision and control of the first species, *D. maroccanus* and *L. migratoria* remain not less dangerous endemic locusts. Whereas the moroccan cricket, a monovoltine species, billets in gregarious seats situated in the higher stages of the Algerian semi-arid; *Locusta migratoria* has become endemic in the central Sahara since the introduction of the irrigated perimeters which are cultivated in the ancient oasis or under pivots.

Surveying and anti-locust control services have indicated infestations of this species from 1994, on cereals pivots at Adrar (central Sahara). Quantitative researchs carried out on fields, show that swarming of both locusts occurs after an intense anthropization making them more adapted to their biotopes, in relation to not only the structure but also the quality of the vegetable cover.

Density and spatial distribution of the individuals of the moroccan cricket are all the more high since the vegetation is closely cropped and overpastured. Likewise, *L. migratoria* activity increases when cereal plots present an important weed cover rate. Most often, damage is observed on sorghum.

Key words: ecological control, anthropization, biotopes, locusts.

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## Etude qualitative et quantitative de la prise de nourriture de *Calliptamus barbarus* dans le bioclimat semi aride (Djelfa). Poster 116

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L'étude qualitative du régime alimentaire de *C. barbarus* est réalisée selon la méthode classique de l'analyse des fèces. Bien qu'intéressante, elle ne permet pas de quantifier les plantes nourricières ingérées par une espèce d'orthoptère donnée. Ainsi avons nous jugé utile d'aborder le problème des préférences trophiques de l'acridien en utilisant la méthode dite de la fenêtre, initiée par nous même et Doumandji (1993). En plus de la quantification, un indice d'attractivité est calculé pour chaque espèce végétale à partir des surfaces foliaires ingérées par chacun des individus. Il s'avère que cet indice n'est pas en relation systématique avec le recouvrement des plantes dans le milieu d'une part, et d'autre part les espèces nourricières les plus consommées ne sont pas obligatoirement les plus attractives. Les espèces botaniques qui attirent l'acridien peuvent se classer en 3 catégories. La première catégorie regroupe les plantes dont l'indice d'attractivité est supérieur à 100. Il s'agit de *Crepis vesicaria* et *Vulpia myuros*. La deuxième catégorie se distingue par des plantes ayant des indices d'attractivité compris entre 0,5 et 2,47; elle se compose de *Plantago serraria*, *Bellis sylvestris*, *Scabiosa arenaria* et enfin *Bellis annua*. La dernière catégorie contient les plantes très faiblement attractives; ce sont par ordre préférentiel: *Eryngium tricuspdatum*, *Scolymus hispanicus*, *Verbascum sinuatum*, *Cynoglossum creticus*, *Satureja mentoefolia*, *Dactylis glomerata*, et *Lolium multiflorum*.

## Effects of the Timing and Intensity of Livestock Grazing on Grasshopper Population Dynamics during a Natural Grasshopper Outbreak. Poster 124

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Grasshopper outbreaks can cause major depletions of range vegetation. Grazing management appears able to reduce grasshopper outbreaks in some grassland ecosystems and has received little attention. The timing and intensity of livestock grazing can impact grasshopper population dynamics in a number of ways by changing host plant quantity and quality, habitat structure, or microclimate conditions for grasshoppers. An experiment was conducted in eastern Montana to determine how the timing and intensity of livestock grazing (season long, early summer, late summer, no livestock grazing) affects grasshopper population dynamics and vegetation characteristics; and, to determine if there are interactions between grazing treatments and grasshopper densities. Screen cages were stocked at 33% and 100% of field density in a factorial design. Field densities of grasshoppers at stocking were 120 grasshoppers per square meter. The dominant grasshopper species at the site were *Melanoplus sanguinipes* and *Phoetaliotes nebrascensis*.

Although livestock grazing significantly affected both vegetation biomass and grasshopper densities over time, the specific grazing treatments did not differ in their effects. In addition, there were no significant interactions between livestock grazing and grasshopper density. Both high cage grasshopper densities and livestock grazing appeared to increase grasshopper food limitation. Since grasshopper stocking densities were high in all treatments, it appears grazing management may not have large effects when initiated during periods of high grasshopper densities. The results indicate that experimental approaches can be used to provide insights on interactions between livestock grazing and grasshopper population dynamics. Similar experiments are needed with lower grasshopper densities and varying climate conditions to more fully examine the interactions between grazing and grasshopper population dynamics.

Key words: Orthoptera, grazing management, Melanoplinae, Acrididae, population dynamics.

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## Régime alimentaire d'*Anacridium aegyptium* (Orthoptera: Acrididae) à Dergana. Effet d'extraits de plantes sur cet Acridien. Poster 122

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Le régime alimentaire d'une population d'*Anacridium aegyptium* a été étudié dans la région de Dergana située à une trentaine de kilomètres à l'est d'Alger. Les épidermes des espèces végétales consommées ont été déterminés dans les fèces des larves et des adultes de cet acridien. L'analyse des fèces de 40 individus, 20 larves et 20 adultes montre que sur les huit espèces végétales dont dispose l'acridien dans son biotope, seule *Inula viscosa* a été consommée avec des fréquences de 100%.

Dans le cadre d'une lutte biologique, l'efficacité de trois plantes (*Inula viscosa*, *Melia azedarach*, et *Nerium oleander*) ont été testées sur *Anacridium aegyptium* d'une part à l'état frais et d'autre part sous forme d'extrait aspergé sur une plante témoin, *Stenotaphrum americanum* ( le gazon ). Le criquet égyptien ne consomme pas le Méliá et le Laurier rose présentés à l'état frais, cependant les individus de cet acridien mis en présence de l'Inule visqueuse la consomment. Les extraits des trois plantes à différentes doses, aspergés sur la plante témoin provoquent les mêmes effets chez les individus de cette espèce. Selon les doses appliquées, des taux de mortalités allant jusqu'à 100% ont été atteints au bout de 144 heures.

Mots clés: Régime alimentaire, extraits de plantes (*Inula viscosa*, *Melia azedarach*, *Nerium oleander*), *Anacridium aegyptium*.

## Survey of Certain Arthropods Associated with Soybean and Maize in Various Intercropping Systems. Poster 123

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The surveyed arthropods on soybean plants and polyculture of soybean and maize at two locations representing Middle Egypt revealed the presence of 119 insect species belonging to 59 families from 11 orders (of which 1 species of order Orthoptera belonging to 4 families), classified as 44 phytophagous species of economic importance (37.0%) and 33 insect species as visitors, pollinators, non-pest and saprophagous (28.0%). However, natural enemies (predators and parasites) were presented by 42 species (35.0%) and Acarina by 4 species (2 of them were classified as phytophagous mites and the others as predators). In maize/soybean intercropping systems, maize is infested mostly with same pests, where a partial taxonomic list shows that the insect fauna consists of 43 families from 11 orders in addition to mites (3 families); pest species were classified as: 9 species as foliage feeders, 3 as stem borers, 2 as root feeders, 5 as ear feeders, 1 as leafminers, 10 as sap-suckers and 22 as natural enemies (13 predators and 9 parasites). Four species of Acarina belonging to 3 families (2 phytophagous and 2 predators).

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## Thermal Requirements, Age-Specific Life Table Parameters and Demographic Statistics of *Thrips tabaci* (Thripidae: Trypanoptera) on Cotton. Poster 127

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Thermal thresholds and requirements as well as age-specific life table techniques were applied to field collected data to examine the effect of favorable and unfavorable temperature conditions on life table parameters of *Thrips tabaci* on cotton. Lower and higher temperature extremes were found to delay development and shorten longevity as well as exhibiting a marked effect on reproduction and mortality schedules. As a consequence, the gross reproductive rate (GRR), net reproductive rate ( $R_0$ ), intrinsic rate increase ( $r_m$ ) and finite rate of increase ( $\lambda$ ) were reduced whereas the population doubling time (D) lengthened as compared with the same demographic statistics under more favorable temperature conditions. Values of the life table parameters varied among temperature regimes when times were expressed in days but converged somewhat when times were expressed in degree-days (DD).

Key words: Thermal requirements, age-specific life table, demographic statistics, *Thrips tabaci*, cotton.

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## Farmers' Perceptions in Relation to Control of Armoured Bush Crickets *Acanthoplus* Spp. (Orthoptera: Tettigoniidae: Hetrodinae) in Botswana. Poster 121

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Armoured bush crickets (ABC) are sporadic pests of cereal crops in semi-arid areas of southern Africa. During outbreaks,

*Acanthoplus discoidalis*, the principal pest species in Botswana, invades farmers' fields at the time of panicle emergence, and then inflicts crop damage by feeding on the developing grains. A survey of farmers revealed that ABC is considered the second most damaging pest in eastern Botswana (after quelea). However, despite the fact that ABC are conspicuous, slow-moving and easily killed, approximately half of all farmers do not attempt any control measures. The reasons for this relate to several misconceptions concerning the behaviour of ABC, leading to the widespread belief that attempted control is futile. In particular, when an ABC is crushed others are attracted to cannibalise the corpse, leading to the perception that such direct control methods are counterproductive, causing an increase in ABC numbers in the field.

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## Study of the Diet of Mooccan Locust *Dociostaurus maroccanus* in the Region of Aures (Eastern Algeria). Poster 115

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The region of Aures (eastern Algeria) count more than ten gregarian homes of *Dociostaurus maroccanus*. All these homes are characterized with a semi-arid climate, a hilly landscape and a herbaceous vegetation dominated by *Hordeum murinum*, *Bromus rubens*, *Malva parviflora*, *Ormenis praecox* and *Peganum harmala*. The study of this acridien diet by the method of feces analysis allowed us to know its preferences and behaviour in case of aridity. In 1993, the study showed the presence of 17 botanical species among the 19 listed. The compounds, in particular *Ormenis praecox* is the most consumed in the first embryonic stages. The last embryonic stages and adults are attracted by grasses. In 1994, the aridity obliged most of the individuals to migrate towards the cereal fields which are in the neighbourhood of homes. The individuals which stayed on the seat, found only the dung of cows and horses to provide to their necessities. Fragments of animal origin; wings, antenna, mouth pieces of insects and even complete individual of greenflies are observed in their stools. The two plants, *Peganum harmala* and *Malva parviflora* which it has refused to consume in 1993, has added to its menu in 1994.

Key words: feces analysis, semi-arid, diet.

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## *Tristira magellanica* (Orthoptera: Tristiridae) Harboring a New Microsporidium (Microspora). Poster 125

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Microsporidia are highly specialized, spore-forming unicellular eukaryotes, living only as obligate intracellular parasites of other eukaryotes. As a group, insects are the most common hosts of microsporidia. In spite of the recognized role in contributing to the regulation of natural populations of insects, little is known about the diversity of microsporidia associated with species of Orthoptera, especially when compared with the state of knowledge available on microsporidia affecting other groups of insects, such as Diptera, Lepidoptera or Coleoptera. Only 15 species of microsporidia have been unmistakably recorded from Orthoptera world-wide (Acrididae: 10, Gryllidae: 2, Pyrgomorphidae: 1, Tettigoniidae: 2), a small figure that asserts the scant attention the group has received. A microsporidium was discovered and isolated from specimens of *Tristira magellanica* a species endemic to southern Patagonia, collected in southwestern Santa Cruz province, Argentina. Members of the family Tristiridae are considered "primitive grasshoppers" that, according to some authors, occupy an intermediate position between the two main groups of Acridoidea: Chasmosacci and Cryptosacci. Infections were found in nymphs and adults of both sexes. Prevalence of infection was unusually high for a

microsporidium, reaching up to 80 %. Development of the microsporidium takes place in epithelial cells of the gut and gastric caeca, apparently causing subtle histopathologies only in heavy infections. Spores are released with the feces of the host. Preliminary observations on the developmental stages of the parasite suggest that the new microsporidium has a complex life-cycle, peculiar in several respects, and different from all known orthopteran microsporidia. It has been suggested that complex life-cycles in microsporidia are ancestral rather than more recently acquired. The ancient and endemic origin of tritirids would be in line with the apparent complexities and peculiarities of the new microsporidium, and warrants the need for a full characterization.

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## World-wide Survey of Regulations Affecting Biopesticides. Poster 112

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Biological pesticides (biopesticides, microbial control agents, microbiological pest control agents) are regulated in different ways in different countries. The Organisation of Economic Co-operation and Development (OECD) has conducted a survey in developed countries, and the International Institute of Tropical Agriculture (IITA) is in the process of conducting a survey in developing countries.

While some countries have developed specific regulations covering biopesticides, many countries use the basic legislation developed for chemical pesticides. *Bacillus thuringiensis* has been registered in this way in many countries. The specific issues associated with the registration of natural living organisms are quite different from those affecting chemical pesticides; microbial pesticides are not likely to cause pollution or non-target effects, but they are capable of reproduction in the field. Through many years of experience, the organisms commonly used in microbial pesticides are known to be safe to man, but more research is needed to determine their environmental impact when used repeatedly on a large scale. This impact is not likely to be pronounced; we might expect to see a temporary replacement of the indigenous micro-flora with the biopesticidal strain and a reduction in susceptible insect populations. Nevertheless, more research should be carried out, probably in the context of monitoring of operational-scale applications.

In general, the first-time importation of non-indigenous microbial control agents must conform to the FAO Code of Conduct on the Importation of Biological Control Agents, or equivalent national or regional (EPPO) regulations. These regulations are normally focussed at the species level, and most microbial pesticides are based on micro-organisms that are commonly isolated in all countries of the world, so in principle there should be no problem. However, authorities are tending to take a cautious line in agreeing to import exotic strains until more information is available on their potential environmental impact.

Microbial pesticides based on oil formulations of *Metarhizium anisopliae* var. *acridum* are currently being developed. Green Guard, an oil formulation of an Australian strain (FI-985) is registered provisionally for organic use in Australia, and Green Muscle, an oil formulation of a strain from Niger (IMI 330189) has provisional registration in South Africa and in CILSS (Sahelian) countries. Green Muscle appears also on the FAO list of approved products for locust control.

Key words: microbial control, registration, *Metarhizium*.

## Developing Integrated Pest Management Strategies for Control of the Armoured Bush Cricket, *Acanthopplus Discoidalis* (Orthoptera: Tettigoniidae). Poster 120

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Armoured bush crickets (ABC) of the genus *Acanthopplus* are sporadic pests of grain crops in central-southern Africa. In Botswana, *Acanthopplus discoidalis* (Setswana name: “Setotojane”) is the single most important insect crop pest, attacking sorghum, millet and maize during outbreaks. A range of control measures are sometimes employed by resource-poor farmers against the ABC, including hand picking, digging trenches at field margins, clearing an area around the field, weeding fields, and traditional rituals. These control methods are time consuming, require a lot of labour and are not always effective. The present study has evaluated and augmented certain of these control methods. Trench depth was found to be critical in the retention of ABC attempting to enter the field. By placing small quantities of a carbaryl bran bait at intervals within the trench, mortality levels of >90% were achieved when trench depth exceeded 300mm. Spraying a 2.5m wide barrier of Fipronil around the field reduced the infestation by 4 fold compared to the control plots. These results indicate that baited trenches and insecticide spray barriers can make a significant contribution to control of the armoured bush cricket.

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## Factors Influencing Oviposition Site Selection by the Armoured Bush Cricket, *Acanthopplus discoidalis*, and Egg Pod Predation by the Ant *Dorylus helvolus*. Poster 119

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The armoured bush cricket *Acanthopplus discoidalis* (Tettigoniidae: Heteroptera) oviposits directly into the soil, after first probing the substrate with its ovipositor valves. Oviposition was studied in the laboratory, where gravid females were allowed the choice of clay, silt and sandy soil types. The number of probe holes did not differ significantly between soil types, but females expressed a strong preference for ovipositing in silty soil. Subsequent studies investigated the relationship between soil composition and *A. discoidalis* egg pod abundance at six field sites, sampling both in natural Acacia and field-crop vegetation types. The incidence of egg predation by the red ant *Dorylus helvolus* (Hymenoptera: Formicidae) was also assessed. Egg pod abundance in this case was not related to soil particle size. High egg pod abundance was, however, associated with Acacia vegetation type. Vegetation type, site and the interaction between vegetation type and site each made significant contributions to the overall model. Predation of egg pods by *D. helvolus* was greatest in soils with small particle size and with crop vegetation, particularly where the two occurred together. In this case, vegetation type, soil type, and the interaction between soil type and the vegetation type made significant contributions to the model. In the field, therefore, *A. discoidalis* exhibits a preference for oviposition in areas with Acacia bushes regardless of the soil type. Both vegetation and soil types predict the amount of egg pod damage by *D. helvolus*, which favours soils with a low sand component such as predominate in most crop fields. The implications of egg mortality for cricket population dynamics are discussed.

## Impact of Grasshopper Feeding on Selected Cultivars of Cruciferous Oilseed Crops.

Poster 118

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With the trend towards crop diversification, there has been a gradual increase in production of crucifer oilseed crops (canola and mustard) in the Prairie Ecozone of western Canada. Developments in germplasm, Brassica and Sinapis species, have resulted in cultivars with improved drought resistance, making them more acceptable for production in the more arid regions of the prairies. This, in turn, has resulted in greater and greater overlap in areas of grasshopper infestation and oilseed production. Grasshoppers are the most chronic insect pest of annual crops in the Prairie Ecozone. The primary threat to production of annual crops arises from migration of the hatchling populations into crop land from roadsides, headlands and field margins. As a result, grasshopper damage is most acute at the early stages of crop growth.

In this study, the impact of early-season grasshopper feeding on canola and mustard crops was quantified in field studies, 1996-1998. Immatures of *Melanoplus sanguinipes* (the lesser migratory grasshopper) were allowed to damage (50% defoliation) eight Cruciferae cultivars from four species: *Brassica juncea* (AC Vulcan and J92-223), *B. napus* (AC Excel and Midas), *B. rapa* (AC Parkland and Echo) and *Sinapis alba* (AC Pennant and Ochre). The overall yield of defoliated plants were 27.8% less than control plants ( $P=0.0001$ ). Yield reductions were greatest for AC Excel (47%) and least for AC Vulcan (19.6%). The results are discussed in the context of grasshopper management strategies.

Key words: crop damage, *Melanoplus sanguinipes*, canola, mustard.

## Comparative Study of Mediterranean Locust Populations from Different Latitudes.

Poster 113

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The south-westernmost permanent breeding areas of the Mediterranean locust, *Doclostaurus maroccanus*, are on the Canary Archipelago. Very few data concerning these populations have been published until now. We have undertaken the study of these populations to compare with those on the Iberian Peninsula. Here we present the morphometric characterization of three populations from Canary Island, two from El Hierro, one from Tenerife and three from the Iberian Peninsula, la Serena (Badajoz), los Monegros (Zaragoza) and Chinchilla (Albacete). Adults from Canary Islands are significantly smaller in size than those from the Iberian Peninsula. It is noticeable that the length of tegmina and hind femora of adults from El Hierro and Tenerife are significantly smaller than those of adults from the three locations in the Iberian Peninsula. We discuss the meaning of the ratio between the length of tegmina and length of the hind femora (E/F index) of the populations from Canary Islands.

On the other hand, after dissection of the females and males, it was determined that the number of ovarioles were significantly fewer in the females from Canary Islands. Furthermore, the mean number of oocytes was higher, although the difference was not statistically significant. The number of testicular follicles was smaller in males from Canary Island but the difference was not statistically significant; nevertheless the volume of the testicles was significantly smaller.

Because the distance between El Hierro and Tenerife and the Continent make difficult the exchange of individuals from populations of that origin, the inbreeding of these insular populations is the responsible of the phenetic differentiation. The study of the possible genetic differences are in progress in our laboratory.

**Morphometric Variability of the Italian Locust During an Outbreak in the Kulunda Steppe (West Siberia). Poster 114**

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In the Kulunda steppe, the Italian locust (*Calliptamus italicus*) outbreak began in 1999. We studied some characters (densities, morphometric, phenotypic and cytogenetic traits) of local populations of the species in this area. One of the main studied traits is a ratio of forewing (tegmen) length to hind femur length. This index shows a phase polymorphism status of every local population.

We compared data for 9 local populations of the Italian locust for 1999 and 2000. These populations settled different steppe and fallow field habitats of the Kulunda region. Average level of density changed from 0.04 to 6.6 per sq m. The status of all populations should be determined as intermediate (transiens) between solitary and gregarious. The ratio varied from 1.386 to 1.576 (females) and from 1.390 to 1.621 (males). In general, the average values were higher in 1999. This pattern is not evidently associated with the level of abundance of the Italian locust. These studies were partly supported by the Russian Federal Programs "Integration".

Key words: density, population, solitary, gregarious.

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