METALEPTEA

THE NEWSLETTER OF THE ORTHOPTERISTS' SOCIETY

President's Message

By ALEXANDRE V. LATCHININSKY
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Dear Fellow Orthopterists, dear friends,
First of all, I would like to wholeheartedly wish all of you a fruitful and successful year 2018! This year promises to be a very busy one for the Society – as every pre-Congress year is. I am very pleased to share with all of you the news about our next meeting. In the previous months, the Organizing Committee met several times and significant progress in preparation for the 13th International Congress of Orthopterology has been made. The dates of the Congress are set for March 24-28, 2019 in Agadir, Morocco, which means that there are only about 13 months before it starts. The overall theme is "*Challenges in front of climatic and environmental changes.*" On page 3-4, in the letter from the President of the Organizing Committee, Prof. Amina Idrissi, please find more information regarding the Congress, including important deadlines for Symposia submissions.

Next, I am going to touch upon another very important subject for the Society: its website. I would like to thank our previous web-master Dr. Piotr Naskrecki for his long-term successful work and welcome our new web-master Dr. Derek A. Woller. Derek is the successional leader of the USDA-APHIS Rangeland Grasshopper and Mormon Cricket Management Team in Phoenix, Arizona. I wish Derek good luck making the Society

website functional, attractive, and resourceful.

In November 2017, the Orthopterists' Society organized a Symposium in the framework of the Annual Meeting of the Entomological Society of America in Denver, Colorado. You will find the summary report on this event (led by omnipresent Dr. Derek A. Woller!) on page 31-42. Several -members of the Society involved in applied orthopterology will also participate in the 9th International Integrated Pest Management Symposium in Baltimore, Maryland, on 19-22 March 2018. And on April 12-14, 2018, a Global Locust Initiative will be launched from Arizona State University in Tempe. For more information about this exciting event see page 4-5.

Once again, best wishes for the new 2018 year to all!

The Theodore J. Cohn Research Fund:
Call for applications for 2018
(Deadline : March 31, 2018)

By **MICHEL LECOQ**
Chair, Theodore J. Cohn Research Fund Committee
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Dear fellow Orthopterists, Once again I have the pleasure to announce a new call for applications for The Theodore J. Cohn Research Fund. As you know, this research grant is primarily to fund research projects in Orthoptera (*s.l.*) by young researchers, often as part of a masters or Ph.D., though post doctorates may also be funded. A total amount of $15K per year is available and it is possible to fund research grants for up to $1,500 per grantee.

In 2017, 11 research projects were funded (out of 14 proposals received) and we regularly publish with pleasure and interest the reports of beneficiaries from previous years that enrich the various issues of *Metaleptea*.

I'm sure, for this call, we will receive again a lot of interesting and high quality proposals. As with the last year, I strongly encourage students and young researchers from Africa and Asia to submit a project. I hope that our regional representatives can relay my call to arouse more project applications from these continents. The committee will consider all requests with the same attention and benevolence. The quality of English will not be a criterion and we are ready, at the level of the Committee, to help the students of these countries to better formulate their projects in English if necessary. In the end, the intrinsic quality and originality of the research project will be the only criteria.

The proposals should be in the following format and restricted to the indicated number of pages:

DESCRIPTION (one page)

1. TITLE

2. SIGNIFICANCE, stressing the new ideas and aspects of the proposal, expected contribution to theory, relation to previous work, etc. (applicants should emphasize the nature and significance of their proposal to provide the judges with the basis for weighing different projects, especially in fields outside their expertise)

3. RESEARCH PLAN, including the particular orthopterans to be studied, methods, logistics, etc.

4. TIMETABLE, even if approximate, to give the judges some idea of feasibility.

CURRICULUM VITAE (half page) including name, full address, present position or years in graduate school, education, number of papers published or completed, citation of selected publications pertinent to the proposal to aid the judges.

BUDGET (half page) including justification of items where appropriate (i.e. why special equipment is necessary unless clearly obvious), other funding for the project, etc. Overheads cannot be provided for on Society grants.

The Committee prefers proposals applicable to broad biological problems, even though the actual research may be narrower in scope. Proposals also should include clearly stated hypotheses and aims, and the nature of the evidence to be gathered to test the hypothesi(e)s and possible outcomes. But taxonomic projects may also be funded, particularly coming from African countries.

Proposals from graduate students must include a simple recommendation from their major professor or advisor. Those not affiliated with an educational or research institution should indicate where the work is to be done.

A short report will be required from the successful applicants. It will be written for our newsletter, *Metaleptea*, and be suitable for both orthopterists and non-specialist readers.

Proposals should be submitted to the Chair at the following address:
Michel Lecoq
e-mail: **mlecoq34@gmail.com**

Start writing!

Grants supporting the Orthoptera Species File

By MARIA MARTA CIGLIANO
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The OSF grants committee received eighteen applications from fifteen countries (Algeria, Austria, Brazil, Cameroon, China, Croatia, Cuba, France, Germany, Hungary, India, Pakistan, Russia, Serbia, and Singapore) from which the following ten proposals listed below were funded. The proposals were selected based on the relation to the amount of data (images, specimen records, etc.) expected to be added into the Orthoptera Species File or to any other Species File within Polyneoptera. It was also considered if the proposal was related somehow to a taxonomic research project and also the candidate's expertise.

OSF grants funded for 2018:

1. **Dhaneesh Bhaskar (Kerala Forest Research Institute, Kerala, India) and Josip Skejo (Croatia)**
    Title: Taxonomy and distribution of Scelimeninae Bolivar, 1887 & Cladonotinae Bolivar, 1887 from Southern India and digitization of Tetrigidae types stored in MNHG Geneva (Switzerland)

2. **Ivković Slobodan (University of Novi Sad, Belgrade, Serbia) & Laslo Horvat (Austria)**
    Title: Orthoptera of Serbia and Montenegro - further research on poorly investigated areas and little known taxa.

3. **Jiajia Dong (China)**
    Title: Taxonomic review, distribution and exploration of the *Cardiodactylus* crickets (Orthoptera: Gryllidae: Eneopterinae) in New Guinea

4. **Lucas Denadai de Campos (Universidade de São Paulo, Brazil)**
    Title: Photographic database of Tafaliscinae sensu Desutter, 1987, Podoscirtinae and Phalangopsidae (Ensifera, Grylloidea) type specimens deposited in the Academy of Natural Sciences of Philadelphia (ANSP)

5. **Martin Husemann, Lara-Sophie Dey (Centrum für Naturkunde, University of Hamburg, Germany)**
    Title: Digitization and Imaging of Oe-dipodinae in Russian Collections

6. **Michael Sergeev (Russia)**
    Title: Re-inventory of grasshoppers (Acrididae: Gomphocerinae: Hypernephiini) of North and Central Asia

7. **Nicolas Moulin (France)**
    Title: Contribution of distributional and taxonomical data of Mantodea species and photos of live individuals from West Central Africa

8. **Ranjana Jaiswara (Department of Zoology and Environmental Sciences, Punjabi University, Patiala Punjab, India)**
    Title: Photography of male genitalia of Gryllinae (Orthoptera, Grylloidea) type specimens at MNHN Paris

9. **Sheila Young (Museo de Historia Natural "Tomás Romay", Santiago de Cuba, Cuba)**
    Title: An inventory of the Orthoptera of the Eastern Sierra Maestra Range, Cuba

10. **Ming Kai Tan (National University of Singapore), Jessica B. Baroga & Sheryl A. Yap**
    Title: Advancing biodiversity informatics of Orthoptera from the Philippines

13th International Congress of Orthopterology
"Challenges in front of climatic and environmental changes"
Agadir, Morocco: March 24-28, 2019

By AMINA IDRISSI
President
Local Organizing Committee of ICO 2019
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Dear Colleagues and Friends,
We are delighted to have the opportunity to invite you to participate in the 13th International Congress of Orthopterology. The congress will be held in Agadir, Morocco, from the 24th to the 28th of March, 2019.
The Local Committee would like to invite orthopterists and the scientific community working on different aspects related to orthopteran species to participate. The first important date to note is the closing of symposia proposition, which will be **the 28th of February, 2018**.
The overall theme of the congress will be to address *the Challenges in front of climatic and environmental changes*. Some plenary lectures, symposia, oral presentations, and poster sessions will be organized to let orthopterists exchange ideas and advances under this overall theme. We strongly encourage symposia proposals in a wide variety of topics, such as biodiversity and phylogeny, invading species, systematics and molecular taxonomy, functional genomics, biology and behavior, plant-orthopteran interactions, orthopterans as key indicators, evolution and population dynamics, chemicals and environmental impacts, modelling and management,

environmental protection, biological control, and new pesticides.

Symposia are supposed to focus on a common theme with at least three participants from different institutions. Presentation length must be between 15 and 25 minutes with time for questions and at least 10 minutes at the end of the symposium allotted for discussion time. A symposium will typically last 2 hours, but could be extended if planned at the time of proposition. For a symposium of normal length, a maximum of 7 speakers is expected, but here again the organizing committee will consider other forms of propositions. The sympo-

sium organizer should make sure that the speakers submit an abstract during the call for abstracts and fulfill the registration to the congress.

Symposia propositions should be sent by email (orthoptera2019@uiz.ac.ma) as PDF document and include: **1)** The title; **2)** Organizer(s) name(s), affiliation and complete contact information, including email address; **3)** Justification and description (maximum 1 page); **4)** List of speakers (name, affiliation and email) and presentation titles; **5)** Logistic requirements (specific needs for internet or something else).

It is the responsibility of organizers of each symposium to obtain funding for their own expenses and those of their invited speakers or participants. The local organizing committee is not responsible to support speakers' travel expense to the meeting. Preference may be given to proposals for which organizers can demonstrate that funds are likely to be available.

If your working group has further

propositions of workshops or special meetings, please do not hesitate to contact us providing all information before the 28th of February, 2018. We will try our best to accommodate appropriate requests.

For the moment, please note these important dates in your agenda:
- Deadline for Symposia submissions or other propositions: **February 28, 2018**
- Deadline for Abstract submissions: **September 30, 2018**
- 13th International Congress of Orthopterology: **March 24-28, 2019**

A website about the congress will open soon and will convey all necessary information for registration, payment, accommodation, and venue of the congress.

As president of the Local Organizing Committee of ICO 2019, I will be happy to welcome you in our warm city of Agadir and hope you will join us to make this 13th edition a large success.

Global Locust Initiative Notes from the Field!

By ARIEL RIVERS
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As we gear up for the official launch of the Global Locust Initiative (GLI) at Arizona State University's Tempe campus now during April 12-14, 2018, we want to share some recent developments about the initiative and some of our activities! Please feel free to email Ariel Rivers or Arianne Cease at any time for more details, with questions, or to be a part of the GLI!

We now have a live website at locust.asu.edu. On the site, we have information about the initiative, upcoming events and news (including job postings and opportunities for stu-

dents). There is a contact inquiry form (in English and Spanish) that we ask all interested partners to complete. We use this information to guide the activities of the GLI and connect people who may be interested in working together. Please also email Ariel if you have any questions or information you would like to share with the GLI community!

In early November, Ariel and Arianne attended a three-day workshop in Cordoba, Argentina, with partners from Argentina, Bolivia, and Paraguay. In response to the unprecedented outbreak of *Schistocerca cancellata* in the region, the three countries are establishing protocols

and strategies to increase cooperation across country boundaries, conduct collaborative research, and identify pathways for effective monitoring and management. David Hunter presented information regarding the history of *S. cancellata* monitoring in Argentina via skype, Mario Poot-Pech discussed the various strategies for monitoring acridids using unmanned aerial vehicles and management strategies for *S. piceifrons*, Ariel promoted the GLI and the official launch, and Arianne shared information regarding locust research and management globally. Local partners also updated the group on the current situation in each country, producers presented

Participants in the Tri-Country Workshop on the Management of *Schistocerca cancellata* in Cordoba Argentina, November 2017.

their concerns, and Argentine policy-makers were present to listen to the concerns of various stakeholders. The meeting was very productive and provided many opportunities for continued dialogue for acridid research and management in Latin America. Several partners from South America will be present at the official launch in April.

The GLI also hosted an informal discussion session at the Entomological Society of America's (ESA) annual meeting on November 7, 2017. As a member-based initiative, the GLI incorporates feedback from our stakeholders to guide our activities, vision, and values. As we position GLI to be complementary to existing organizations, the many members of the Orthopterists' Society who were present at the discussion provided valuable feedback on ways the GLI can effectively support our members without overlapping our efforts with other groups. The attendees discussed ways to productively use the website, future workshop and network opportunities, and other ways members can contribute to making GLI successful and sustainable. Based on these events and discussions, we aim to host a locust forecasting and monitoring workshop in 2019.

Finally, we are hosting the official GLI launch at ASU on April 12-14, 2018! The event promises to be a productive three days, with a public outreach event (including tours of the ASU locust rearing facilities with 5 species of grasshoppers and locusts!), research presentations, posters, and discussions. As a direct outcome of the event, we will draft a scholarly review comparing the structure and function of organizations and institutions working in the locust/grasshopper space, and a policy brief directed towards influencers in the U.S.-based policy realm. All interested individuals are welcome to attend. Please see our website for more details and to RSVP. Please email Ariel with any questions or if you would like to present a poster.

Participants in the ESA discussion identifying activities and future plans for the GLI. November 2017.

Visit to Argentina to Discuss Methods of Management of the Upsurge of the South American Locust

By **DAVID HUNTER**
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As outlined by Medina et al. (2017) in the most recent *Metaleptea* (37(3): 17-21), there has been a dramatic upsurge in populations of the South American locust, *Schistocera cancellata* in the past several years. A preventive management system, implemented since the 1950s (Gastón 1969, Hunter & Cosenzo 1990), had kept the number of bands and swarms to a minimum, but an upsurge began in 2015 with the appearance of a number of swarms. In spite of continuing treatment programs, locust numbers have increased further.

Following an international workshop on managing the upsurge in late October, which included participants from Argentina, Bolivia, Paraguay, U.S.A. and Australia (myself via Skype), I was invited to visit Argentina for discussions on the current upsurge. The trip was funded by IICA (Inter-American Institute for Cooperation on Agriculture) and, after a delay due to an airline strike, I was able to visit some of the areas with

David Hunter with the producers in the field.

many locusts in northwest Argentina. There were dense bands in a number of locations and treatments were being carried out by landholders and local government officers. A number of meetings and discussions were held with landholders and government officials regarding the importance of finding and treating locust bands to avoid further substantial increases in locust numbers. There were also discussions concerning some of the special problems involved in managing these locusts, particularly when many of them are in scrublands (monte) where access is difficult. I

gave several presentations on key aspects of locust management programs in various parts of the world and these were followed by further discussions on how to implement relevant parts into the management program for the South American locust.

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Medina H., Cease A., Trumper E. 2017. The resurgence of the South American locust (*Schistocerca cancellata*). Metaleptea 37(3): 17-21.

Band of the South American locust roosting on shrubs and fence post.

Orthopterists' Society Support for the AAIS Meeting (October 23-26, 2017)

By **DAVID HUNTER**
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The 22nd meeting of the African Association of Insect Scientists (AAIS) was held in Wad Medani, Sudan during October 23-26, 2017. The theme of the conference was "Towards securing human welfare through management of insect diversity in a changing world". As part of increasing the visibility of our society and encouraging presentations on Orthoptera at larger meetings, the Orthopterists' Society gave a grant of $1,000 to support those giving presentations on Orthoptera as part of this conference. This support was suggested by Mohamed Abdellahi Ould BABAH EBBE, our regional representative for North and West Africa and the Sahel and was undertaken in liaison with the Executive Secretary of the AAIS. As a result of this support for presentations on Orthoptera, the AAIS proudly displayed a grasshopper (*Zonocerus variegatus*) on the front cover of its book of Abstracts, giving grasshoppers and the Orthopterists' Society pride of place!

Abstracts on Orthoptera were from Cameroon, Kenya, Uganda, and Pakistan, and covered varied topics, including biodiversity and conservation, life histories, and orthopterans as a source of nutrition. The funds were used for travel and accommodation for several of the participants who provided very successful contributions to the conference.

Regional Reports - What's happening around the world?

Western Europe

By **GERLIND LEHMANN**
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Undoubtedly a milestone for Europe is the compilation of the Red List of European Orthoptera (Hochkirch et al. 2016). Using a structured process based on the criteria of the International Union for the Conservation of Nature (IUCN), a pan-European team has evaluated all 1,082 species. Around a quarter of them are classified as threatened in Europe. Even in a much-studied area as Europe, there are 107 species (or 10%) that cannot be evaluated due to deficient data. Population trends are even more alarming, as four times more species show declining than stable population trends. As over 70 percent (or 739 species) of European species are endemic, the countries have a global responsibility to protect them. Biodiversity hotspots of European endemic species are the Iberian Peninsula, Italy, and the Balkan, with a lesser proportion in large mountain areas as the Alps, Pyrenees, or Carpathians. Major threats are habitat loss, degradation, and fragmentation resulting from agricultural land use. With an ever-increasing land-use intensity, habitats are converted into cropland, degraded by overgrazing, the use of fertilizers, and heavily impacted by pesticides. Therefore, the authors conclude that conservation strategies for the European Orthoptera species should be developed and implemented, and the Common Agricultural Policy should support traditional low-intensity agricultural land use systems as pastoralism. A reduction of the use of pesticides and fertilizers is necessary! Much-needed is a pan-European monitoring program for Orthoptera species, which might be feasible by merging the multitude of existing recording schemes.
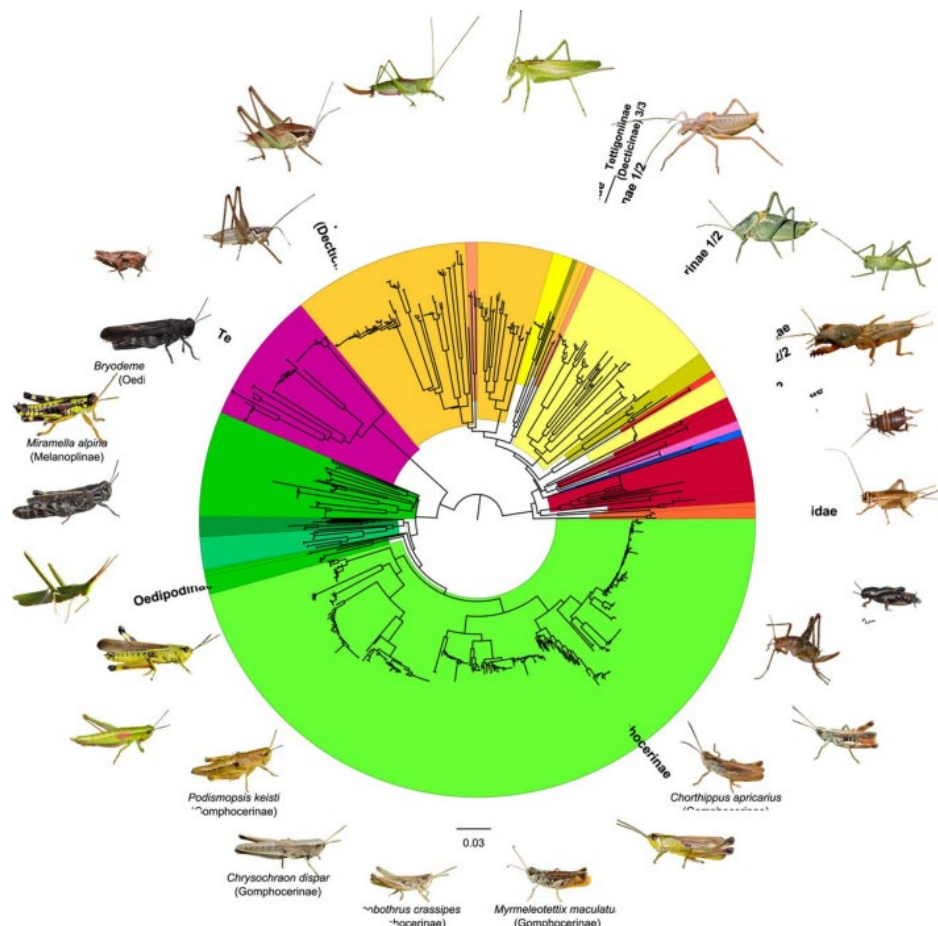
Figure 1. The Barcode tree of 122 Central European Orthoptera species (see Hawlitschek et al. 2017).

The brand-new book on the Orthoptera of Austria (Zuna-Kratky et al. 2017) is a fantastic example of the results from a country-wide recording scheme in the Center of Europe. The authors managed to analyze more than 300,000 records, brought together by over 1,500 observers. The 880 pages are packed with distribution maps, pictures, and a sorrowful update about the faunistic situation in the country between the Alps and the Pannonian steppe region.

Faunistics and conservation are not the only fields in which multinational cooperation is pushing our knowledge. A combined effort of colleagues from Germany, Switzerland, and Austria (Barcoding Fauna Bavarica, Germany, German Barcode of Life, Austrian Barcode of Life, and Swiss Barcode of Life) have compiled the first comprehensive barcoding database (Hawlitschek et al. 2017). The data set includes 748 COI sequences from 127 of the 162 taxa (78.4%) recorded in the three countries involved (see Fig. 1). Ninety-three of these 122 species (76.2%, including all Ensifera) can be reliably identified using DNA barcodes. The remaining 26 Caelifera species (families Acrididae and Tetrigidae) form ten clusters that share barcodes. Species sharing barcodes are phylogenetically young and some are known to hybridize in nature. The database will allow for the development of approaches for automatic monitoring as using metabarcoding from trap samples.

It is worth mentioning that the lead-author of this study will be a keynote speaker at the upcoming meeting of the German Society of Orthopterol-

ogy (DGfO) to be held March, 2018 in Potsdam. This conference will celebrate the 30th anniversary of this German Orthopterology Society and is organized in cooperation between the Natural Museum Potsdam, the Orthoptera working group of the federal states Brandenburg and Berlin and the Humboldt University Berlin. One and a half days of talks, posters, and society meetings will give the latest overview about German orthopterology and provide ample room for exchanging thoughts and ideas with other Orthoptera-fellows. The plan is to present the upcoming "Distribution atlas of Brandenburg" during this event, and updated regional red lists of Brandenburg and Berlin. All necessary information can be found at the newly designed website of the Ger-

man Society: http://dgfo-articulata.de/downloads/tagungen/2018_15_jahres-tagung_dgfo_potsdam.pdf.

We hope to welcome a lot of our Colleagues in March in Potsdam!

Publications (2017)
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Theodore J. Cohn Research Grant Reports

Tolerance of groundhoppers' eggs to dehydration – why do females of genus *Tetrix* search for mossy patches?

By DAVID MUSIOLEK
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Groundhoppers (Orthoptera: Tetrigidae) belong to one of the most overlooked groups among Orthoptera. Although we know some details about their life histories, many patterns remain unexplained. One remarkable feature in groundhoppers of the genus *Tetrix* is their affinity for mossy habitats, which is even superior in females compared to males (Hochkirch et al., 2007; Musiolek & Kočárek, 2016). Groundhoppers are mainly detritivorous and moss represents only about 20% of their food (Kuřavová & Kočárek, 2015). Individuals occurring on mossy stands are under a higher predation risk compared to individuals inhabiting non-mossy stands (Karpestam et al., 2013). Therefore, the ecological

Figure 1. Model species used for the study. (A) Adult female of *Tetrix tenuicornis*; (B) adult female of *T. subulata*; (C) a sand pit – typical secondary habitat for both studied groundhopper species. *T. tenuicornis* occupies relatively dry slopes covered with sparse vegetation, whereas *T. subulata* is especially abundant on wet shorelines of the water body.

Figure 2. Setup of the experiment. (A) A cup with three-section cover substrate (moss, sand, detritus) for oviposition choice determination; (B) cups with non-living (left) and living (right) moss substrates for testing of egg incubation success. (C) a clutch of eggs of *T. subulata*; (D) a cup with freshly hatched nymphs; (E) a setup for monitoring substrate humidity.

advantage of preference for mossy patches is unclear.

Groundhoppers' reproduction takes from early spring to summer in temperate regions when females lay clutches of eggs a few millimetres under a substrate surface. The eggs absorb water during their development and hatch after 3–4 weeks (Hartley, 1962). I hypothesized that (1) females use moss as an oviposition substrate that provides sufficient humidity thanks to the high water-retention ability of mosses, thus decreasing the egg mortality caused by dehydration; (2) a choice of oviposition substrate has higher fitness consequences for groundhopper species inhabiting relatively dry habitats than for species living in wet habitats; (3) egg hatching is more successful in living

moss compared to other incubation substrates because of antiseptic and antimicrobial properties of mosses. To test these three assumptions, a laboratory experiment was undertaken with two groundhopper species, *Tetrix subulata* L. and *T. tenuicornis* (Sahlberg, 1891). Both species are common in Central Europe and have similar life histories, but *T. subulata* is more hygrophilous, inhabiting marshy habitats, whereas *T. tenuicornis* inhabits slightly dryer habitats (Fig. 1).

A total of 180 adult females from 10 distinct populations (18 females per population) of *T. subulata* and a total of 162 adult females of *T. tenuicornis* from 9 distinct populations (18 females per population) were individually kept in 500-ml transparent plastic cups and one clutch of

eggs was obtained from each female. The cups were filled with a pressed sand-coconut fibre basic substrate (sand:coconut-fibre, 1:3, v:v) of a particular humidity level and covered with a particular surface substrate. For each groundhopper population, a total of 18 cups were used. Five cups contained three equal surface sections (thickness of 1–2 cm) of living moss, detritus, and sand with low humidity basic substrate (25±5%) and five cups contained the same cover with medium humidity basic substrate (50±5%) (Fig. 2A). Eight cups contained a basic substrate with medium humidity covered with a single substrate type: sand only (two cups), detritus only (two cups), living moss only (two cups), and non-living moss only (two cups) (Fig. 2B). The same charge of basic and cover substrates was used for all cups. Detritus was a mixture of topsoil and decaying plant debris (hummus). Sand was fine siliceous river sand (1–2 mm particle size). The living moss was *Ceratodon purpureus* Hedw. The non-living moss was *C. purpureus* macerated for 30 min in 80 °C fresh water and drained to normal humidity. All surfaces were slightly strewn with food (mossy and detritus particles). The plastic cups were covered with a dished lid allowing slight ventilation and preventing desiccation (Fig. 2E). All cups were placed in a laboratory with temperature of 20±1 °C and a 12 h L:D photoperiod provided by linear LED tubes placed 30 cm above the cups. The LED tubes provided with light of ~6000 K colour temperature and intensity of 4500±200 lx.

Each cup was visually inspected every second day for a presence of egg clutch (Fig. 2C). If a clutch was found, the female was excluded from the experiment, the position (substrate) and date of finding were recorded, and the clutch was incubated in specific conditions. Those clutches laid in cups with the single cover substrate (eight cups per population, see above) were incubated in non-

changed conditions to determine if some substrate type provides hatching advantage against another substrate type. Those clutches laid in cups with the three-section cover substrate (five with low humidity and five with medium humidity, see above) were replaced into new 500-ml cups half-filled with the pressed basic substrate with one of the five humidity categories: "dry" (5±5% substrate humidity), "medium-dry" (25±5%), "medium" (50±5%), "medium-wet" (75±5%), and "wet" (95±5%, i.e., maximum water content in the substrate) to determine the eggs' tolerance to a humidity gradient. All clutches were visually inspected every second day for hatching (Fig. 2D). The number of hatched nymphs as well as the number of both hatched and unhatched eggs in each clutch were counted. The substrate humidity was measured via soil moisture sensors (Vernier, USA) placed 2–3 cm deep under cover substrate (Fig. 2E). The substrate humidity was nearly constant throughout the duration of the experiment.

Data were analysed with gener-alized linear mixed models. The data need some further analyses, but preliminary results support my hypotheses that moss is preferred as an oviposition substrate in the stud-ied groundhoppers and it provides a fitness advantage compared to detri-tus and sandy substrates. The eggs hatched successfully in a wide range of incubation humidity, but the dry substrate was lethal for all clutches. Next, I will test the responsiveness of the studied groundhoppers to humid-ity levels of the oviposition substrate to distinguish if the xerophilous *T. tenuicornis* is more sensitive to a choice of an oviposition substrate compared to the hygrophilous *T. subulata*. The results will help to understand the interactions between bryobiont organisms and their envi-ronment. The final output of the study will be published in an international scientific journal.

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An Attempt at Using Radio Telemetry to Understand Leaf Masquerading Behavior in *Mimetica* Pictet, 1888: Considerations for Future Projects, and Some Observations

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Camouflage strate-gies across insects are widespread and diverse, and include mimicry and crypsis. One type of camouflage in particu-lar, masquerade, is quite commonly mistaken for crypsis, and has received little attention in camouflage studies in comparison (Skelhorn et al. 2010). Crypsis is sensory deception whereby the predator organism mistakes the prey organism as a part of the background (Allen & Cooper 1985, Skelhorn & Rowe 2016), whereas masquerade is cognitive decep-tion whereby the predator organism misclassifies the prey organism as an object not of interest to the predator (Caro & Allen 2017, Skelhorn 2015). There is one problem, however, and that is the dearth of empirical infor-mation pertaining to leaf masquerade in particular. Most of the past studies that have been performed regarding masquerade have focused on twig mimicry, or anecdotally with leaf mimicry. Some examples of high-fidelity leaf mimicry can be found in polyneopteran orders, with extreme examples being phylliid leaf insects, dead leaf mantises, and true-leaf katy-dids of the subfamily Pterochrozinae. The true-leaf katydids of Central and South America are among the most striking examples of leaf masquer-ade in insects, katydids of the genus *Mimetica* Pictet, 1888 (Orthoptera: Tettigoniidae: Pterochrozinae) among them. *Mimetica* are sexually dimor-phic and appear to be polymorphic within a population and, as with other pterochrozines, likely exhibit diurnal catalepsy, and are active nocturnally (Castner and Nickle 1995). They are also difficult to encounter in high numbers in the field and are rare in insect collections. Members of *Mi-*

Figure 1. Radio telemetry tracking in the open field-understory ecotone.

metica need further study if we are to understand not only their behavior but the evolution of leaf masquerade in katydids.

My proposed project attempted to investigate, via radio-telemetry (Fig. 1), whether *Mimetica* masquerade as leaves diurnally and if different polymorphs inhabit different regions of the understory to enhance their mimesis. Radio telemetry has never been used on pterochrozines before and only once before on forest-dwelling katydids (Fornoff et al. 2012). I planned to use similar methods to understand the behavioral movements of *Mimetica* to determine if brown and green morphs inhabit significantly lower or higher understory elevations, respectively, as well as to confirm that *Mimetica* are strictly active at night. My hypothesis was that green polymorph *Mimetica* would be significantly higher in understory height (closer to green vegetation) than brown polymorph *Mimetica* (closer to fallen dead leaves).

Methods and Results

Under ideal circumstances, radio telemetry can be a valuable tool in research to obtain data like the effect of biological factors on dispersal, habitat/resource selection, and different aspects of dispersal like daily activity patterns, migration patterns, home range, and altitude above ground. For more detailed examples, consult Rink & Sinsch (2007), Negro et al. (2008), and Wikelski et al. (2010). Radio telemetry consists of three main parts: the beeper transmitter, the antenna, and the receiving unit. The transmitter is attached to the experimental organism and gives out a specific radio frequency at constant intervals. The antenna picks up and transfers the data from the transmitter to the receiving unit. When the antenna is pointed towards, or is closer, to the transmitter, the signal gets stronger and the receiving unit gives a louder "blip" sound. The telemetry equipment I used consisted of Pico-Pip Ag337 transmitter chips (0.29g) with a 10-day lifespan, a flexible Yagi 148-152 MHz antenna, and a Bio-tracker Receiver (148-156 MHz). In order to attach the transmitter chips to the katydids, I used LocTite Super Glue as an adhesive, and attached the chips to the dorsal side of the pronota so that they would inhibit movement the least. I had previously tested this

adhesive on a fifth instar *Schistocerca americana* (Drury, 1773) to see how effective it was at attaching transmitters. The experiment took place at the Texas A&M University Soltis Research Center (TAMU SRC) in Costa Rica during August 6-21, 2017, in conjunction with the Costa Rica Entomology Study Abroad class that my advisor (Dr. Hojun Song) leads. This saved on some transportation costs and provided me with field assistance in some of my endeavors. The katydids used in the experiment were to be tracked four times per day: around 5:30 A.M., at 1:00 P.M., at 5:00 P.M., and at 9:00 P.M. The initial experimental design required the live capture of ten green and ten brown *Mimetica* polymorphs, but after four nights of searching the understory for them, we had only obtained four immature individuals. Immature *Mimetica* do not have a leaf-masquerading form and were not strong enough to carry the transmitter chips.

In another attempt to collect telemetry data, I developed a back-up experiment, which required the use of ten non-leafy katydids and ten leafy katydids. The non-leafy katydids we captured for this experiment were eight *Cocconotus atrifrons* (Brunner von Wattenwyl, 1895) and five *Orophus guatemalae* (Saussure & Pictet, 1897). The sample size was constrained due to either a lack of specimens or the similar appearance of other species to *O. guatemalae*. My new hypothesis was that *O. guatemalae* movement behavior would differ significantly from *C. atrifrons*. The experiment did not go the way I had planned this time either for several reasons, but primarily because the transmitter chips were too heavy for the *Orophus* katydids and stopped their mobility, and the *Cocconotus* katydids all died the day after the transmitter chips were attached, possibly due to stress from the attachment process.

Since this experiment also did not work out as well as planned, I

conceived one last experiment to empirically test for leaf masquerade behavior in katydids. The species of katydids that we were able to collect during my time at the TAMU SRC was unpredictable, so I decided to perform another comparison of movement data using whatever species of leafy katydids were available and strong enough to carry the transmitter chips on their backs. The plan was to see if there were similarities or differences among the katydid species to examine if there were any dispersal behaviors that could be correlated to leaf masquerade. I sacrificed sample size and increased sample diversity as we only had what was available to catch in the field. One of each of the following species was used: *Copiphora rhinoceros* Pictet, 1888, *Neoconocephalus triops* (Linnaeus, 1758), *Copiphora hastata* Naskrecki, 2000, *Lophaspis hebardi* Rehn, 1947, *Lirometopum coronatum* Scudder, 1875, *Steirodon robertsorum* Emsley, 1970, and *Itarissa costaricensis* (Rehn, 1917). My new hypothesis was that all seven of the katydid species listed previously would exhibit similar or equal trends in dispersal behavior. Unfortunately, this experiment did not work out either except for different reasons this time. My sample of seven species was reduced to one for the following reasons: *S. robertsorum* managed to detach itself from the transmitter and escape, *L. hebardi* and *I. costaricensis* both died from tachinid parasitoids, *C. rhinoceros* and *N. triops* were both extremely strong fliers and flew out of range of the transmitters within the first night of being released, and, finally, on the fourth night of the experiment, *L. coronatum* fell prey to a burrowing spider as evidenced by its transmitter chip being found in a hole in the ground. The only katydid that survived all five days was *C. hastata* (see Table 1 and Fig. 2).

What to Take Away From This

As noted, there were many reasons

Figure 2. *Copiphora hastata* with transmitter attached hanging under a broad leaf in the understory.

why the three experiments outlined above did not produce expected results, so the purpose of this report is to provide some insight to any who are interested in pursuing radio telemetry in their studies. These are some considerations that should be taken into account when performing telemetric experiments. For one, understanding the abundance of the study organism is important as a rare organism could lead to insufficient sample sizes, as was the case with *Mimetica*. Having a large sample size is necessary to combat negative circumstances, like escape or predation. Understanding the cuticular structure of your study organism is also important, as when I was gluing the transmitters onto the *C. atrifrons* katydids, the chips did not adhere to the pronota the first time due to how waxy and depressed the pronotal cuticle was. The size and strength of the katydids are also paramount as you cannot track a katydid that cannot carry a transmitter chip. Having a way to

knock-out the study organism temporarily for transmitter attachment via carbon dioxide or temporary freezing is very necessary for easier attachment of the transmitters.

There were some biological observations that I would like to record here as so little is known about *Mimetica* that this may be useful to someone further down the line who wishes to study the genus or subfam-

Table 1. Tracking dates, times of day, and coordinates captured for *C. hastata*.

Day	Time	Coordinates
1	5:34 AM	10°23.003'N, 84°37.003'W
1	12:52 PM	10°23.003'N, 84°37.003'W
1	5:02 PM	10°23.003'N, 84°37.003'W
1	9:03 PM	10°23.003'N, 84°37.003'W
2	5:52 AM	10°23.005'N, 84°37.002'W
2	1:04 PM	10°23.006'N, 84°37.002'W
2	5:06 PM	10°23.008'N, 84°37.003'W
2	9:14 PM	10°23.006'N, 84°37.004'W
3	5:21 AM	10°23.008'N, 84°37.001'W
3	1:11 PM	10°23.008'N, 84°37.007'W
3	5:09 PM	10°23.006'N, 84°37.002'W
3	9:08 PM	10°23.003'N, 84°36.997'W
4	5:37 AM	10°22.998'N, 84°37.002'W
4	1:21 PM	10°23.006'N, 84°36.996'W
4	5:02 PM	10°23.005'N, 84°36.990'W
4	9:16 PM	10°23.001'N, 84°36.996'W
5	5:42 AM	10°22.986'N, 84°36.993'W
5	1:04 PM	10°22.991'N, 84°36.989'W
5	5:00 PM	10°22.988'N, 84°36.995'W
5	9:16 PM	10°23.004'N, 84°37.000'W

ily. During the first four nights of the trip, we only encountered 4 immatures, yet towards the very end of the trip, we obtained six adults and ten additional immatures. It is also worth mentioning that the majority of the *Mimetica* were encountered after a brief but strong wind storm. The same can be said for *Celidophylla albimacula* Saussure & Pictet, 1898, another pterochrozine we found during the trip. Like many katydids, these groups of Costa Rican pterochrozines are probably canopy dwellers and are inaccessible to collectors at the ground level. The *Mimetica* were found clinging onto the stems of broad-leaved understory plants and one individual was positioned in the center of a large fern leaf. Many of the adults found on the last night of the trip were found in close proximity, some being only 20 or 30 feet away from each other. As for the data collected from the third experimental attempt, there were some observations of typical camouflage behaviors exhibited by *L. coronatum* (while it was alive) and *C. hastata*. These two katydids were totally immobile diurnally, yet, perhaps unsurprisingly, became active at nightfall. The positions adopted by the two katydids consisted of clinging to the bottom of a broad leaf larger in size than the katydids themselves. When active at night, the katydids would traverse the understory by walking from branch to branch up and down the understory. They also tended to remain in the same general area from day to day, with net movement no greater than 15 feet most days.

Acknowledgments

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Orthoptera Species File Grant Reports
The Brazilian fauna of phalangopsid crickets (Grylloidea, Phalangopsidae): types from the collection of the Museu de Zoologia da Universidade de São Paulo (MZSP)

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Brazil is the largest Neotropical country and the world's most biodiverse. Regarding Orthoptera, it is expected that Brazil houses the richest fauna of our favorite insects, although several lineages are poorly known or practically unknown. This is true for crickets (Grylloidea), a taxon historically neglected in entomological studies in Brazil, the fauna of which is far from being well-known. Phalangopsidae, the most diverse Neotropical lineage of Grylloidea, only recently have been systematically studied in Brazil.

The four main Orthoptera collections in Brazil are: 1) Museu Nacional, Rio de Janeiro (MNRJ – ca. 221 type specimens according to OSF); 2) Instituto de Pesquisas da Amazônia, Manaus (INPA – ca. 27 type specimens according to OSF); 3) Escola

Figure 1. The Museu de Zoologia da Universidade de São Paulo

Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba (DEFS – ca. 267 type specimens according to OSF); and 4) Museu de Zoologia da Universidade de São Paulo, São Paulo (MZSP). Another important collection focused mainly on Ensifera is the collection of the Departamento de Zoologia da Universidade Estadual Paulista, Botucatu (BOTU), headed by Francisco de A. G. de Mello.

With the support of the Orthopterists' Society, I made photo documentation of the types of Phalangopsidae from the Museu de Zoologia da Universidade de São Paulo, São Paulo (MZSP – Fig. 1). A total of 98 type specimens (holotype, allotype, and paratypes) from 44 species were photographed and the images are being uploaded to OSF (see Table). For each specimen, approximately four images were obtained: dorsal and lateral habitus; and head and thorax, in dorsal and lateral views. The number of photographs per species was variable depending on the condition of the specimen and the presence of relevant, diagnostic characters. Thus, a total of 413 images are being uploaded to OSF. I am also uploading photographs of specimens in the field, whenever identification is possible, totalizing almost 500 images.

The MZSP houses more than 10

million animal species and is one of the largest zoological collections in Latin America. The MZSP was created from another institution called Museu Paulista, whose first natural history collection was acquired in 1890. In 1939, the Departamento de Zoologia (Zoology Department) of the Secretaria de Agricultura, Indústria e Comércio do Estado de São Paulo (Secretariat of Agriculture, Industry and Trade of São Paulo) was created to manage the increasing

zoological collections. Later, from 1940-1941, the zoological collections were transferred to a new building, the so-called Museu de Zoologia. Then, in 1969 the Museu de Zoologia was associated with the Universidade de São Paulo and received its actual name: Museu de Zoologia da Universidade de São Paulo.

The MZSP is the most important collection of Grylloidea types in Brazil, mainly due to the taxonomical studies of Francisco de A.G. de Mello in the early 1990's. Unlike other museums, the cricket collection is composed of specimens fixed in ethanol and kept in glass tubes and vials, differing from the traditional dry-pinned specimens. The preservation of crickets in ethanol started with Francisco A.G. de Mello on the 1980's (possibly influenced by his colleague Daniel Otte) and was followed by other Brazilian orthopterists, such as Carlos Sperber, Edison Zefa, Márcio Bolfarini, and myself. As a former student of Francisco, he taught me that keeping specimens in ethanol 80-85% is a good option because, despite the possible loss of coloration (as observed in green katydids), it al-
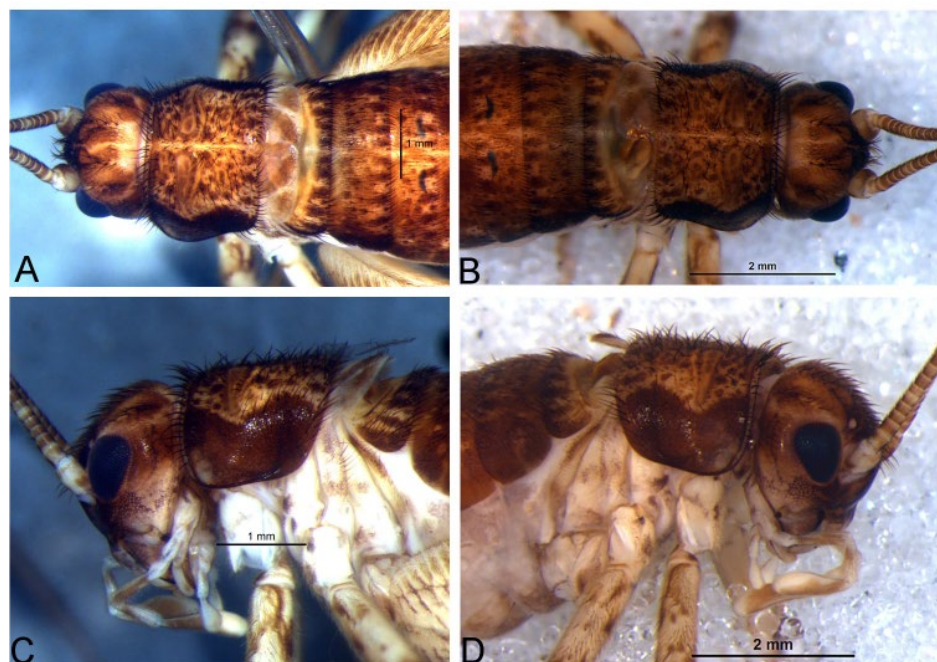

Figure 2. Comparison between different backgrounds: A, C, holotype of *Adenopygus heikoi* Bolfarini & de Mello, 2012 in a grey substrate made of modeling clay; B, D, holotype of *A. heikoi* Bolfarini & de Mello, 2012 in substrate of glass microbeads

lows the manipulation of the specimens (e.g. stretching legs, moving tegminae) and the search for details in structures and characters, since the specimens are not hardened. Moreover, keeping specimens in ethanol 85% (or superior) helps to preserve genetic material, allowing for the extraction of good quality DNA for molecular studies. On the other hand, a humid collection requires more space and is more expensive since the ethanol must be constantly checked and occasionally replaced.

Photographing specimens fixed in liquid can be challenging. The main challenge is the adjustment and adaptation of the lighting system and its interaction with the specimen and the liquid, due to the difference between the refractive indices of air and water. The fluid also makes the stability of the specimen difficult, and the color and nature of the background also influence the images.

Thus, I have done several tests with both different lighting systems and backgrounds in order to find a way to get images with good resolution, minimizing the shadows and showing morphological details. I used different backgrounds, from a uniform grey substrate made of modeling clay immersed in ethanol to a recipient filled with glass microbeads, where the specimens can be partially buried (Figs. 2, 3).

The equipment used was a Leica MZ-16 stereomicroscope attached to a DFC-420 video camera. The images were captured through the software Leica Application Suite LAS 4.0, stacked through Helicon Focus 5.3, and edited in Adobe Photoshop CS6 and GIMP (GNU Image Manipulating Program) 2.8.

Next steps

The OSF lists 108 type specimens of Orthoptera in the collection of MZSP, 56 Phalangopsidae. The only available catalog of Orthoptera types from MZSP was published by Domenico (2005), which listed only 35

Table 1. Checklist of Phalangopsidae species from the Museu de Zoologia da Universidade de São Paulo (MZSP). [* species designated but not sent to the MZSP; ** type specimens found in the collection of Alejo Mesa]

Taxon	Domenico (2005)	MZSP	OSF
Adelosgryllus rubricephalus Mesa & Zefa, 2004		X	X
Adenopygus friederickeae Bolfarini & de Mello, 2012		X	X
Adenopygus heikoi Bolfarini & de Mello, 2012		X	X
Anomaloterga mantiqueirae de Mello & Bolfarini, 2010		X	X
Aracamby balneatorius de Mello, 1992*	X		X
Aracamby mucuriensis de Mello, 1992	X	X	X
Aracamby picinguabensis de Mello, 1992*	X		X
Bambuina bambui de Mello, Horta & Bolfarini, 2013		X	X
Cacruzia bahiana de Mello, 1992*	X		X
Eidmanacris bernardii Nihei & de Mello, 2015		X	X
Eidmanacris bidentata Sperber, 1998**		X	X
Eidmanacris caipira Souza-Dias, Campos & Nihei, 2015		X	X
Eidmanacris corumbatai García-Novo, 1998**		X	X
Eidmanacris desutterae Campos, 2017		X	X
Eidmanacris eliethae Nihei & de Mello, 2015		X	X
Eidmanacris endophallica (de Mello, 1990)	X	X	X
Eidmanacris fontanettiae Campos, Nihei & de Mello, 2017		X	X
Eidmanacris gigas Campos, 2017		X	X
Eidmanacris lencionii Bolfarini, 2016			X
Eidmanacris melloi Campos, 2017		X	X
Eidmanacris minuta (de Mello, 1990)	X	X	X
Eidmanacris neomarmorata Campos, 2017		X	X
Eidmanacris papaveroi Nihei & de Mello, 2015		X	X
Eidmanacris putuhra Campos, 2017		X	X
Eidmanacris scopula Campos, 2017		X	X
Eidmanacris septentrionalis Desutter-Grandcolas, 1995*			X
Eidmanacris simoesi Nihei & de Mello, 2015		X	X
Eidmanacris suassunai Souza-Dias, Campos & Nihei, 2015		X	X
Endecous (Endecous) aguassay Mews, 2008		X	X
Endecous (Endecous) alejomesai Zefa, 2010		X	X
Endecous (Endecous) betariensis de Mello & Pellegatti-Franco, 1998	X	X	X
Endecous (Endecous) chape Souza-Dias & de Mello, 2017		X	X
Endecous (Endecous) naipi Souza-Dias, 2017		X	X
Endecous (Endecous) peruassuensis Bolfarini, 2015*			X
Endecous (Endecous) ubajarensis Zefa, 2014		X	X
Endecous (Pedroecous) apterus Bolfarini & Souza-Dias, 2014		X	X
Guabamima lopesandradei Mews & Szinwelski, 2010*			X
Guabamima lordelloi de Mello, 1993	X	X	X
Guabamima pimenteli Mews & Szinwelski, 2010*			X
Guabamima saiva de Mello, 1993	X	X	X
Guabamima zhei Mews & Szinwelski, 2010*			X
Izecksohniella aimore de Mello, 1992	X	X	X
Izecksohniella almeidai Mews & Mól, 2009		X	X
Izecksohniella puri Sperber, Rocha, Lopes-Andrade & Mesa, 2003		X	X
Joadis mesai Mews & Sperber, 2009		X	X
Laranda uai Mews, 2008			X
Lernecopsis beto de Mello, 1995	X	X	X
Marcgraviella muriciensis Souza-Dias, 2014		X	X
Marliella titai Mews & Mól, 2009		X	X
Melanotes moraesi Desutter-Grandcolas, 1993*			X
Mellopsis doucasae Mews & Sperber, 2010		X	X
Microlerneca leticia de Mello, 1995	X	X	X
Ottedana cercalis de Mello & de Andrade, 2003		X	X
Pizacris zefai (Mews & Sperber, 2010)		X	X
Sishiniheia diamantina de Mello & Souza-Dias, 2016		X	X

type specimens in the collection (13 Phalangopsidae). Today the collection must be at least twice as large than in 2005, due to the increase in taxonomical studies in Brazil over the last 10 years (which continue to increase – and this is great!), housing 45 type specimens of Phalangopsidae (October/2017).

However, despite the recent taxonomic studies in Brazil, there is incongruence in the number of type specimens of Orthoptera shown in the OSF database and actually in the collection. Recently, the MZSP incorporated the Orthoptera collection of prof. Dr. Alejo Mesa (1928-2008), acquiring a large amount of specimens (and a lot of undescribed genera and species), both dry-pinned and in ethanol, from several Orthoptera lineages and several localities (even other continents). This new collection allowed us to find types described by him, some of them considered lost. Furthermore, several species whose type specimens were designated to MZSP on the original descriptions were not sent by the authors, explaining the incongruences shown in the Table.

Thus, an updated catalogue of type specimens of Orthoptera from MZSP is being prepared in order to provide new and useful information for our community. Along with the catalogue, a photo documentation of all Orthoptera types from MZSP will be provided and uploaded to OSF.

Table 1. Cont'd.

Taxon	Domenico (2005)	MZSP	OSF
Vanzoliniella sambophila de Mello & Cezar dos Reis, 1994	X	X	X
Ubiquepuella telytokous Fernandes, 2015			X
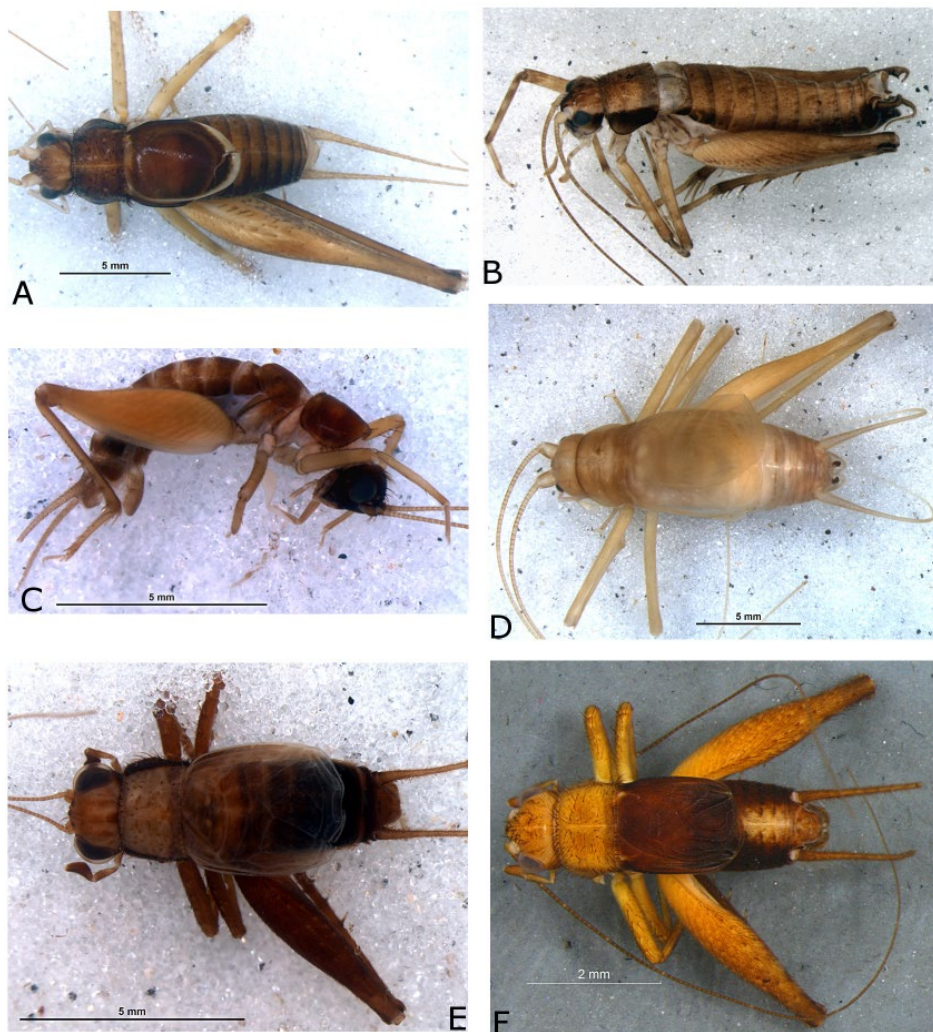
Figure 3. A, male paratype of *Guabamima saiva* de Mello, 1993; B, holotype of *Ottedana cercalis* de Mello & de Andrade, 2003; C, holotype of *Joadis mesai* Mews & Sperber, 2009; D, holotype of *Endecous betariensis* de Mello & Pellegatti-Franco, 1998; male paratype of *Microlerneca leticia* de Mello, 1995; male paratype of *Lernecopsis beto* de Mello, 1995

Dead and Alive - New images of band-winged grasshoppers (Caelifera: Acrididae: Oedipodinae) in the OSF

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The Oedipodinae, or band-winged grasshoppers, are a large subfamily of the Acrididae. With their cryptic coloration, but often brightly colored wings, they are an iconic group within the Caelifera. While some species are common and fairly widely distributed, others are rare microendemics, which are only known from the type series. Especially for many of the rare species, no images have been available so far, neither of pinned specimens, nor of specimens in the wild.

In our project we aimed to illustrate species of Oedipodinae in OSF with specific focus on the genus *Sphingonotus*. We added a total of 469 images, belonging to 149 specimens and 129 species to the OSF database. Many types were included (e.g., Fig. 1). 19 species were photographed in the field (Fig. 2-3), many likely for

Figure 1. Holotype of *Sphingonotus lavandulus* from the BMNH (London).

Figure 2-3. (2, top) *Sphingonotus pilosus* from Iran; (3, bottom) *Sphingonotus (Parasphingonotus) radioserratus* from Morocco

the first time. These images represent an important resource for future studies and help to identify unknown specimens in the future, both for private nature enthusiasts as well as for researchers.

We will keep adding additional pictures of Oedipodines from museum collections and from the field, especially from Mongolia and Iran.

Furthermore, as we are working on a phylogeny of the group we ask colleagues for material of Oedipodinae.

Digitalisation of Indian Orthoptera types deposited in British Natural History Museum, London (NHMUK) and a checklist to Orthoptera of Kerala, India

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nsects are the most species-rich taxonomic group of our planet and therefore important for global species diversity. The Indian fauna is particularly species-rich and the orders Lepidoptera, Coleoptera, and Hymenoptera are well-studied by Indian taxonomists. However, Orthoptera still remain less explored and are usually just treated as pests. For example, no grasshopper species in India has so far been considered as a biodiversity indicator. Studies on Indian Orthoptera are confined to agricultural fields

and outside Protected Areas (Usmani and Nayeem. 2012; Priya and Narendran, 2003; Gaikwad et al., 2016).

Although the Orthoptera Species File online (OSF) has revolutionized the taxonomic knowledge of Orthoptera, OSF was still lacking photos of many species and almost no photos of Indian Orthoptera were provided. The only comprehensive resources available to Indian Orthopterists were still the drawings in the Fauna of British India (Kirby, 1914 a & b). However, correct species identification is crucial in Entomology and verified species

identification is the backbone of many biological disciplines (Lehmann et al., 2017). Hence, Indian orthopterology is lacking a very important aspect of taxonomy.

Most of the type specimens of Indian Orthoptera have been deposited in European museums by some of the leading Orthoptera taxonomists of the 20th Century (Bolivar, 1900, 1902 and 1917; Bolívar, 1914 & 1930; Uvarov, 1929; Chopard, 1969; Hebard, 1929; Henry, 1937 and 1940; Kirby, 1914 a and b; Westwood, 1839). It is striking that the peak period of Indian
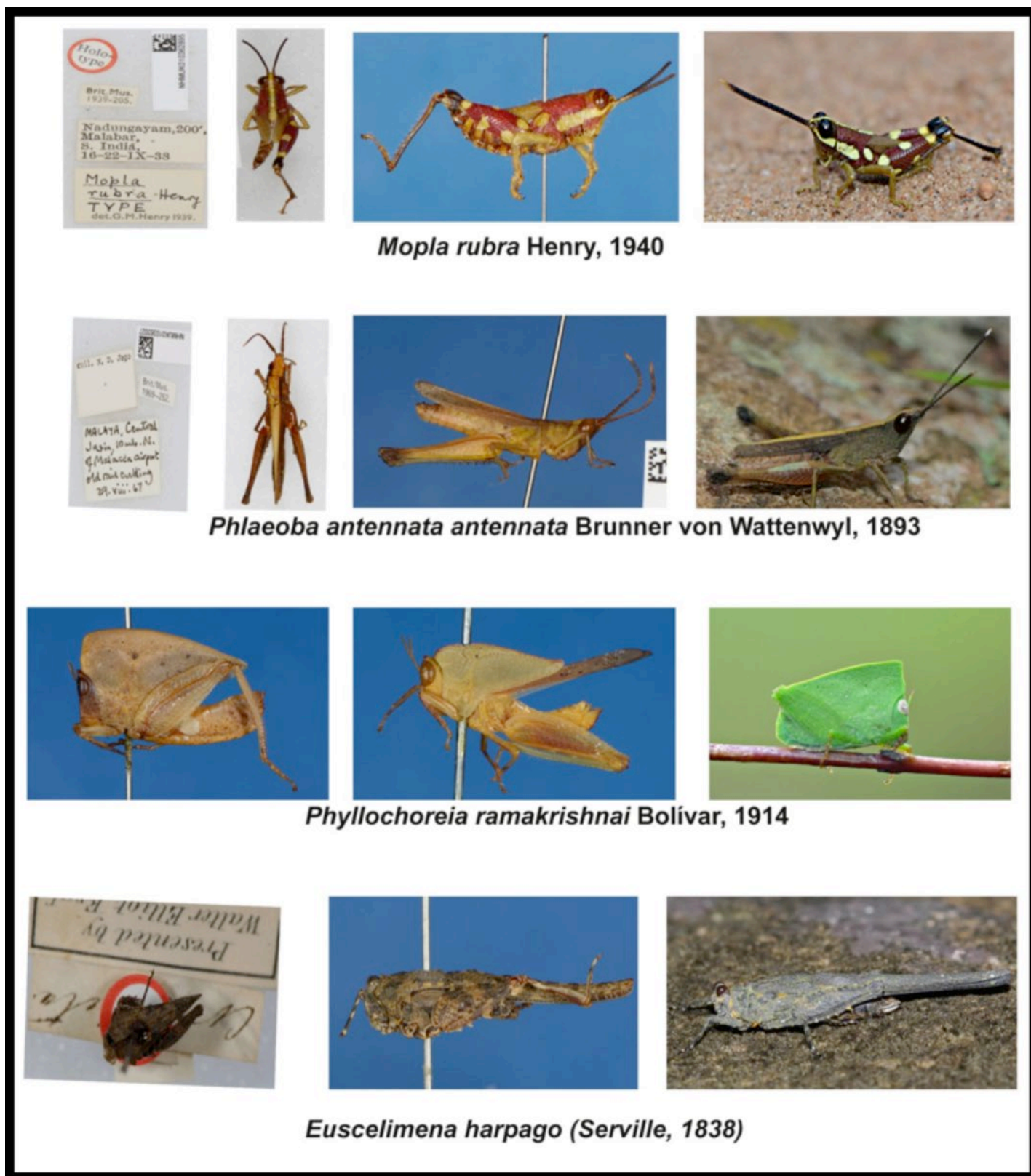
Figure 1. Images deposited in OSF.

Orthoptera research ended mid-20th Century. The only available study material for Indian Orthoptera is the annotated checklist published by Zoological Survey of India (Chandra et al., 2010). However, this checklist doesn't include any description of the morphology of the species. Therefore, it was necessary to study the type specimens in European museums and make them available to facilitate Orthoptera research in India. The British Museum of Natural History (NHM UK) is one of the major repositories of Indian Orthoptera type material as India was once a British colony. In our project, we aimed to digitise the types of Indian Orthoptera deposited

in the NHM UK and the National Zoological Collection in Kolkata (NZSI) as well as from the field to provide them to OSF.

The NHM UK holds type material of 203 Indian species and subspecies and the NZSI 14 species. Our objective was to provide photos of each species with dorsal, lateral, frontal, and ventral views. We visited NHM UK in June 2016 and spent five working days with the Indian Orthoptera type specimens. In order to provide good quality images, we used a Nikon D7000 DSLR with a Nikon 100mm macro lens and a R1C1 macro flash. The lateral view of the grasshoppers was provided with a blue background to avoid any background interference.

A total of **202** specimens of 102 Indian type species from NHM Indian Orthoptera collection, including male and female, were photographed along with their specimen records (labels) and a barcode provided by NHM UK and the total number of 1,134 images were deposited to OSF online (Fig. 1). While our target was to photograph type material of 156 species held at NHM UK, the condition of specimens and the short opening hours delayed our work speed, but we still managed to digitise at least 40 specimens per day. We found eight species not necessary to be digitised for OSF based on the existing availability of images in OSF.

Highlights: We were able to locate **seven missing type specimens** described by Chopard (1933): *Tridactylus saussurei, Gryllopsis robustus, Cophogryllus brevipes, Homaloblemmus cavifrons, Sphecogryllus armatus, Scleropterus variolosus,* and *Aspidogryllus singularis.* Several requests were made to the Director of the National Zoological Survey of India (NZSI) to get access to the museum specimens. However, there was no response and the latest mail indicates that the digitisation of the specimens is already progressing in the museum. These are proposed to be uploaded to the website.

Checklist of Orthoptera of Kerala (India)

A compiled checklist of the Orthoptera of Kerala (Southern Western Ghats - India) is prepared (Table 1) from the available published literature (Bolivar, 1900, 1902 and 1917; Bolívar. 1914 and 1930; Chandra et al., 2010; Chopard, 1969; Gaikwad et al., 2016; Hebard, 1929; Henry, 1937 and 1940; Kirby, 1914 a & b; Khan et al., 2016; Mandal et al., 2007; Nayeem et al., 2012; Prabakar and Radhakhrishnan, 2005; Priya and Narendran, 2003; Shishodia and Kazra, 1986; Shishodia et al., 2010; Srinivasan and Prabakar, 2013; Uvarov, 1929; Usmani and Nayeem, 2012; Vasanth, 1991; Westwood, 1839) and also with the Orthoptera specimens collected in 2016-2017 from the protected and non-protected areas of Kerala, India (Dhaneesh and Easa, 2017). A total of 130 species of Orthoptera from two suborders (Caelifera and Ensifera) have been reported from this part of the world. The checklist (Table 1) can be considered the first ever compiled for the Orthoptera of Kerala. As Kerala is extremely rich with its floral and faunal diversity, an extensive survey will result in a number of images of already described orthopteran species along with many species new to science. The taxonomy is updated with Orthoptera Species File online (Cigliano et al., 2017. <http://Orthoptera.SpeciesFile.org>.

Table 1. Checklist Orthoptera species of Kerala [**Coll*** represents species collected by Dhaneesh & Easa, (2017). **HR*** represents historical records compiled on the basis of published and available literature.]

Taxon	Coll*	HR*
SUBORDER **CAELIFERA**		
FAMILY **ACRIDIDAE** (MacLeay, 1821)		
Subfamily **ACRIDINAE** (Macleay, 1821)		
1. *Acrida exaltata* (Walker, 1859)	✔	✔
2. *Acrida gigantea* (Herbst, 1786)	✔	✔
3. *Bababuddinia bizonata* (Bolívar, 1917)		✔
4. *Carliola carinata* (Uvarov, 1929)	✔	
5. *Phlaeoba angustidorsis angustidorsis* (Bolívar, 1902)	✔	✔
6. *Phlaeoba antennata antennata* (Brunner von Wattenwyl, 1893)	✔	✔
7. *Phlaeoba infumata* (Brunner von Wattenwyl, 1893)	✔	✔
8. *Phlaeoba panteli* (Bolívar, 1902)	✔	✔
9. *Zygophlaeoba sinuatocollis* (Bolivar, 1902)	✔	✔
Subfamily **CATANTOPINAE** (Brunner von Wattenwyl, 1893)		
10. *Bambusacris travancora* (Henry, 1940)	✔	✔
11. *Choroedocus illustris* (Walker, 1870)	✔	✔
12. *Diabolocatantops innotabilis* (Walker, 1870)	✔	✔
13. *Naraikadua charmichaelae* (Henry, 1940)		✔
14. *Oxyrrhepes obtusa* (Haan, 1842)		✔
15. *Oxyrrhepes meyeri* (Willemse, 1936)		✔
16. *Pachyacris vinosa* (Walker, 1870)	✔	✔
17. *Palniacris maculatus* (Henry, 1940)	✔	✔
18. *Paraconophyma scabra* (Walker, 1870)		✔
19. *Siruvania dimorpha* (Henry, 1940)	✔	✔
20. *Stenocatantops splendens* (Thunberg, 1815)	✔	✔
21. *Xenocatantops henryi* (Bolívar, 1917)		✔
22. *Xenocatantops humilis* (Serville, 1838)	✔	✔
23. *Mopla guttata* (Henry, 1940)		✔
24. *Mopla rubra* (Henry, 1940)	✔	✔
Subfamily **COPTACRINAE** (Brunner von Wattenwyl, 1893)		
25. *Coptacra ensifera* (Bolívar, 1902)		✔
26. *Coptacra punctoria* (Walker, 1870)		✔
27. *Epistaurus sinetyi* (Bolívar, 1902)		✔
28. *Eucoptacra binghami* (Uvarov, 1921)		✔
Subfamily **CYRTACANTHACRIDINAE** (Kirby, 1902)		
29. *Chondracris rosea* (De Geer, 1773)		✔
30. *Cyrtacanthacris tatarica tatarica* (Linnaeus, 1758)	✔	✔
31. *Patanga succincta* (Johannson, 1763)	✔	✔
Subfamily **EYPREPOCNEMIDINAE** (Brunner von Wattenwyl, 1893)		
32. *Cataloipus indicus* (Uvarov, 1942)		✔
33. *Eyprepocnemis alacris alacris* (Serville, 1838)		✔
34. *Eyprepocnemis roseus* (Uvarov, 1942)		✔
35. *Tylotropidius varicornis* (Walker, 1870)	✔	✔
Subfamily **GOMPHOCERINAE** (Fieber, 1853)		
36. *Aulacobothrus luteipes luteipes* (Walker, 1871)		✔

Table 1. Cont'd.

Taxon	Coll*	HR*
37. *Aulacobothrus taeniatus* (Bolívar, 1902)		✔
38. *Aulacobothrus socius* (Bolívar, 1902)		✔
39. *Aulacobothrus svenhedini* (Sjöstedt, 1933)		✔
40. *Leionotacris bolivari* (Uvarov, 1921)		✔
Subfamily **HEMIACRIDINAE** Dirsh, 1956		
41. *Calamippa prasina* (Bolívar, 1902)		✔
42. *Hieroglyphus banian* (Fabricius, 1798)	✔	✔
43. *Leptacris filiformis* (Walker, 1870)	✔	✔
Subfamily **OEDIPODINAE** (Walker, 1871)		
44. *Ceracris striata* (Uvarov, 1925)		✔
45. *Dittopternis venusta* (Walker, 1870)	✔	✔
46. *Gastrimargus africanus africanus* (Saussure, 1888)		✔
47. *Gastrimargus marmoratus* (Thunberg, 1815)	✔	✔
48. *Locusta migratoria migratoria* (Linnaeus, 1758)		✔
49. *Oedaleus abruptus* (Thunberg, 1815)		✔
50. *Sphingonotus (Sphingonotus) longipennis* (Saussure, 1884)		✔
51. *Trilophidia annulata* (Thunberg, 1815)	✔	✔
Subfamily **OXYINAE** (Brunner von Wattenwyl, 1893)		
52. *Chitaura indica* (Uvarov, 1929)		✔
53. *Gesonula punctifrons* (Stål, 1861)		✔
54. *Hygracris malabaricus* (Willemse, 1962)	✔	✔
55. *Oxya hyla* (Serville, 1831)	✔	✔
56. *Oxya japonica japonica* (Thunberg, 1824)	✔	✔
57. *Oxya fuscovittata* (Marschall, 1836)	✔	✔
58. *Oxya nitidula* (Walker, 1870)		✔
Subfamily **SPATHOSTERNINAE**_Rehn, 1957		
59. *Spathosternum prasiniferum prasiniferum* (Walker, 1871)	✔	✔
Subfamily **TERATODINAE** (Brunner von Wattenwyl, 1893)		
60. *Teratodes monticollis* (Gray, 1832)	✔	✔
Subfamily **TROPIDOPOLINAE** (Jacobson, 1905)		
61. *Tristria pulvinata* (Uvarov, 1921)		✔
FAMILY **CHOROTYPIDAE** (Stål, 1873)		
Subfamily **CHOROTYPINAE** (Stal, 1873)		
62. *Phyllochoreia ramakrishnai* (Bolívar, 1914)	✔	✔
63. *Phyllochoreia unicolor* (Westwood, 1839)	✔	✔
64. *Phyllochoreia westwoodi* (Bolívar, 1930)		✔
FAMILY **MASTACIDEIDAE** (Rehn, 1948)		
Subfamily **MASTACIDEINAE** (Rehn, 1948)		
65. *Paramastacides ramachendrai* (Bolívar, 1930)	✔	✔
66. *Mastacides nilgirisicus* (Bolívar, 1914)	✔	✔
FAMILY **PYRGOMORPHIDAE** (Brunner von Wattenwyl, 1874)		
Subfamily **ORTHACRIDINAE** (Bolívar, I. 1905)		
67. *Neorthacris acuticeps acuticeps* (Bolívar, 1902)	✔	✔
68. *Neorthacris acuticeps nilgiriensis* (Uvarov, 1929)	✔	✔
69. *Neorthacris malabarensis* (Singh & Kevan, 1965)	✔	✔
Subfamily **PYRGOMORPHINAE** (Brunner von Wattenwyl, 1874)		
70. *Atractomorpha crenulata* (Fabricius, 1793)	✔	✔
71. *Aularches miliaris miliaris* (Linnaeus, 1758)	✔	✔
72. *Chrotogonus (Chrotogonus) oxypterus* (Blanchard, 1836)	✔	✔
73. *Chrotogonus (Chrotogonus) trachypterus trachypterus* (Blanchard,1836)	✔	✔
74. *Poekilocerus pictus* (Fabricius, 1775)	✔	✔
75. *Pseudomorphacris notata* (Brunner von Wattenwyl, 1893)		✔
FAMILY **TETRIGIDAE** (Rambur, 1838)		
Subfamily **CLADONOTINAE** (Bolivar, I. 1887)		
76. *Deltonotus gibbiceps* (Bolívar, 1902)	✔	✔
77. *Epitettix tamilus* (Günther, 1939)		✔
78. *Hancockella portentosa* (Kirby, 1914)		✔
79. *Tettilobus prashadi* (Günther, 1938)		✔
Subfamily **METRODORINAE** (Bolivar, I. 1887)		
80. *Miriatroides gravelyi* (Günther, 1939)		✔
Subfamily **TETRIGINAE** (Serville, 1838)		
81. *Coptotettix hancocki* (Kirby, 1910)	✔	✔
Subfamily **TRIPETALOCERINAE** (Hancock, 1907)		
82. *Tripetalocera ferruginea* (Westwood, 1834)		✔

Taxon	Coll*	HR*
Subfamily **SCELIMENINAE** (Hancock, 1907)		
83. *Bolotettix anomalus* (Hancock, 1910)		✔
84. *Criotettix Fastiditus* (Bolívar, 1917)	✔	✔
85. *Eucriotettix flavopictus* (Bolívar, 1902)	✔	✔
86. *Eucriotettix spinilobus* (Hancock, 1904)		✔
87. *Euscelimena gavialis* (Saussure, 1862)		✔
88. *Euscelimena harpago* (Serville, 1839	✔	✔
SUBORDER **ENSIFERA**		
FAMILY **GRYLLIDAE** (Laicharting, 1781)		
Subfamily **GRYLLINAE** (Laicharting, 1781)		
89. *Acheta domesticus* (Linnaeus, 1758)		✔
90. *Cophogryllus maindroni* (Chopard, 1928)		✔
91. *Gryllopsis femorata* (Chopard, 1935)		✔
92. *Itaropsis tenella* (Walker, 1869)		✔
93. *Meristoblemmus lobifrons* (Jones & Chopard, 1936)		✔
94. *Modicogryllus (Modicogryllus) pallipes* (Chopard, 1925)		✔
95. *Modicogryllus (Modicogryllus) confirmatus* (Walker, 1859)		✔
96. *Modicogryllus (Modicogryllus) signifrons* (Walker, 1869)		✔
97. *Phonarellus (Phonarellus) humeralis* (Walker, 1871)		✔
98. *Plebeiogryllus guttiventris guttiventris* (Walker, 1871)		✔
99. *Plebeiogryllus guttiventris guttiventris* (Walker, 1871)		✔
100. *Sphecogryllus armatus* (Chopard, 1933)		✔
101. *Teleogryllus (Teleogryllus) gravelyi* (Chopard, 1928)		✔
102. *Teleogryllus (Brachyteleogryllus) occipitalis occipitalis* (Serville, 1838)		✔
103. *Teleogryllus (Macroteleogryllus) mitratus* (Burmeister, 1838)		✔
104. *Velarifictorus (Velarifictorus) saussurei* (Chopard, 1969)		✔
105. *Velarifictorus (Velarifictorus) aspersus aspersus* (Walker, 1869)		✔
106. *Velarifictorus (Velarifictorus) fallax* (Chopard, 1969)		✔
107. *Velarifictorus (Velarifictorus) sahyadrensis* (Vasanth, 1991)		✔
Subfamily **LANDREVINAE** (Gorochov, 1982)		
108. *Duolandrevus nairi* (Vasanth, 1991)		✔
Subfamily **SCLEROGRYLLINAE** (Gorochov, 1985)		
109. *Sclerogryllus coriaceus* (Haan, 1844)		✔
Subfamily **PODOSCIRTINAE** (Saussure, 1878)		
110. *Indotrella maindroni* (Chopard, 1928)		✔
111. *Madasumma keralensis* (Vasanth, 1991)		✔
112. *Prozvenella saussureana* (Chopard, 1969)		✔
FAMILY **TRIGONIDIIDAE** (Saussure, 1874)		
Subfamily **NEMOBIINAE** (Saussure, 1877)		
113. *Paranemobius pictus* (Saussure, 1877)	✔	✔
114. *Paranemobius vicinus* (Chopard, 1928)	✔	✔
FAMILY **GRYLLACRIDIDAE** (Blanchard, 1845)		
Subfamily **GRYLLACRIDINAE** (Blanchard, 1845)		
115. Capnogryllacris (Capnogryllacris) nigripennis (Gerstaecker, 1860)		✔
116. Eremus basalis gravelyanus (Griffini, 1915)		✔
117. Melaneremus canillii (Griffini, 1915)		✔
118. Niphetogryllacris dravida (Karny, 1929)		✔
FAMILY **GRYLLOTALPIDAE** (Leach, 1815)		
Subfamily **GRYLLOTALPINAE** (Leach, 1815)		
119. *Gryllotalpa africana* (Palisot de Beauvois, 1805)		✔
FAMILY **MYRMECOPHILIDAE** (Saussure, 1874)		
Subfamily **MYRMECOPHILINAE** (Saussure, 1874)		
120. *Myrmecophilus albicinctus* (Chopard, 1924)		✔
FAMILY **TETTIGONIIDAE** (Krauss, 1902)		
Subfamily **CONOCEPHALINAE** (Burmeister, 1838)		
121. *Conocephalus (Anisoptera) maculatus* (Le Guillou, 1841)	✔	✔
Subfamily **MECOPODINAE** (Walker, 1871)		
122. *Mecopoda elongata elongata* (Linnaeus, 1758)	✔	✔
Subfamily **PHANEROPTERINAE** (Burmeister, 1838)		
123. *Elimaea bidentata* (Brunner von Wattenwyl, 1878)		✔
124. *Execholyrus allector* (Henry, 1940)		✔
Subfamily **CONOCEPHALINAE** (Burmeister, 1838)		
125. *Gonatacanthus pulcher* (Bolívar, 1900)		✔

Pictorial Field Guide for Indian Orthoptera

   By using the type specimen images and OSF online data, we are proposing a pictorial field guide for Indian Orthoptera. We strongly believe that the book will contribute a lot to Orthoptera research in the region. The field guide aims at students and field biologists who are interested in Orthoptera research and we expect that Orthoptera may become a new priority group of Indian naturalists. Since India is experiencing poor internet connectivity along its countryside, most of the researchers and field biologists are not able to access the OSF online website in the field. This marks the importance of a pictorial field guide (under the lead authorship of Dhaneesh Bhaskar). A model page has been prepared for the species Mopla rubra Henry, 1940 (Fig. 2).

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Table 1. Cont'd.

Taxon	Coll*	HR*
Subfamily **PHYLLOPHORINAE** (Stål, 1874)		
126. *Strongyloderus serraticollis* (Westwood, 1834)		✔
Subfamily **PSEUDOPHYLLINAE** (Burmeister, 1838)		
127. *Tegra viridivitta* (Walker, 1870)		✔
FAMILY **PHALANGOPSIDAE** (Blanchard, 1845)		
Subfamily **PHALANGOPSINAE** (Blanchard, 1845)		
128. *Arachnomimus* (*Arachnomimus*) *maindroni* (Chopard, 1969)		✔
Subfamily **PARAGRYLLINAE** (Desutter-Grandcolas, 1987)		
129. *Paragryllodes* (*Paragryllodes*) *gravelyi* (Chopard, 1928)		✔
FAMILY **RHAPHIDOPHORIDAE** (Walker, 1869)		
Subfamily **RHAPHIDOPHORINAE** (Walker, 1869)		
130. *Rhaphidophora indica* (Gorochov, 2013)		✔

Figure 2. *Mopla rubra* model species page prepared for Pictorial field guide (Pg 23 and 24).

pp., 1 pl.

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Review of the recent chapter on locust phase polyphenism by Cullen et al. (2017)

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This publication is only a chapter in *Advances in Insect Physiology*, but it is sufficiently comprehensive and should be regarded as a recent review on the subject. Eight years ago, Pener and Simpson (2009) presented the last comprehensive review on locust phase polyphenism. Meanwhile, many locust-related studies were published, including a review by Wang and Kang (2014) on molecular mechanisms of locust phase changes. Considering the rapid advances in locust phase research, the recent review, which was based on two symposia held at the XXVth International

Congress of Entomology (Orlando, Florida), is most welcome.

The chapter by Cullen et al. (2017) has 20 authors and it comprises 118 printed pages. The construction of the chapter by many authors has the advantage that each major section is in itself a review on a specific subject and can be read independently from other sections. The chapter covers almost all subjects on locusts as its title says: "....the mechanisms and consequences of locust phase polyphenism". According to this attitude, locust plagues are consequences of phase change from the solitarious to the gregarious phase.

The chapter opens with an introduction that comprises the scope of the review, nomenclature with a worldwide list of locust species, and an account of recent locust outbreaks. It is followed by a section on evolution and diversity of swarming grasshoppers, emphasizing a gradient of traits between sedentary species and true locusts, as well as the polyphenism of locusts.

The next section (section 3) deals with phase-related behavior and its methods of measurement and quantification. It is generally accepted that locusts in the gregarious phase are more active and attracted each other, whereas in the solitarious phase they are less active and are repelled from fellow locusts. However, there are situations in which these concepts may not be correct, or their interpretation is difficult. Moreover, in some studies, change of phase-related behavior has not affected activity level (Guo et al. 2011, as mentioned in section 4). Methods of studying and measuring gregarious (or solitarious) behavior are presented in *Schistocerca gregaria*, by automated video tracking in *Chortoicetes terminifera*, and separately in *Locusta migratoria*. The section ends with suggestions for future studies.

The following section is on the proximal stimuli inducing phase change as investigated in nymphs.

Not many recent studies were reported on *S. gregaria*. According to the data reviewed by Pener & Simpson (2009), combined visual and olfactory stimuli and especially mechanosensory stimulation of a defined area of the hind femora induce gregarious behavior in this species. In *C. terminifera* specific tactile stimulation of the antennae induces gregarious behavior. Employment of olfactometer and genomic studies on phase change indicated the importance of olfactory stimuli in *L. migratoria* (see Guo et al. 2011). In my opinion, although olfactory stimuli may be important, they are not the sole factor in phase change in *L. migratoria*. I recall Ellis' (1959) study showing that single nymphs of *L. migratoria* kept with a crowd of non-gregarious grasshopper species and even with a crowd of woodlice (Isopoda) aggregated when first placed together. No doubt seems to be that tactile mechanosensory stimuli are also involved.

The fifth section is devoted to biogenic amines and their role in locust phase change. In my opinion, this section is unnecessarily excessive. The discussion of the phylogeny and classification of the receptors of biogenic amines does not contribute much to locust workers; it would have been sufficient to deal with the role of biogenic amines and their receptors in locusts, and their complex effects on locust phase change. The literature is very rich in relations of locust phases and phase changes to serotonin, dopamine, octopamine, and tyramine. Content of these substances is measured in the thoracic ganglia and in the brain and their change and role in relation to experimentally induced behavioral transition of phase. For example, serotonin is involved in behavioral gregarization of *S. gregaria*, but it may be also involved in processes of solitarization. Serotonin content of the thoracic ganglia increases in phase transformation to either direction. In *L. migratoria* some evidence indicates that serotonin is linked to both behav-

ioral solitarization and gregarization, possibly by downstream effects of different receptors. The chapter ends with conclusions emphasizing reports on "....different individual biogenic amine and receptor combinations on both gregarization and solitarization within the same species" (Cullen et al. 2017, p.210). However, despite the fact that large parts of the puzzle are available, no coherent picture emerges.

Section six is entitled "Genomics, transcriptomics and epigenetics". In the first subsection the history of published studies relevant to sequence information is briefly outlined, culminating in the article by Wang et al. (2014) with a reference genome of 17,307 predicted genes of *L. migratoria* with several functional categories. Wang et al. (2014) found that the draft genome sequence is 6.5 Gb and for the time being it is the largest animal genome sequenced. Next, transcriptomic differences between the phases are discussed with the conclusion that in L migratoria the largest difference, 594 differently expressed genes, is found in fourth instar nymphs. The difference is even higher during phase transition. Mobile elements in the genome of *L. migratoria* are presented and discussed as a reason for the large

genome size; these elements may play a role in locust phases. The genome of *S. gregaria* has not yet been sequenced, but its size is estimated to be around 8.55 Gb. DNA methylation in locusts is compared with that of other insects and it is different between solitarious and gregarious *L. migratoria* and *S. gregaria*. This phase-dependent difference, however does not seem to reflect directly on a locust's ability to exhibit phases.

The seventh section deals with phase-related neurophysiology. The chapter well covers all relevant aspects of the subject, starting from phase-dependent differences in the functioning of the metathoracic slow extensor tibiae (SETi) motor neuron. These phase-dependent differences of the functioning of SETi are related to differences in walking behavior between solitarious and gregarious locusts. Further differences are found in the brain which is 30% larger and has different proportions in gregarious than in solitarious *S. gregaria*. This difference may be related to the very different lifestyles of the different phases. Learning abilities are also phase-dependent. Behavior of solitarious and gregarious locusts is described within the frame of a subsection, "Phase-related differences in daily rhythms of activity". Gregarious *L. migratoria* and *S. gregaria* are active at day-time, whereas solitarious conspecifics are usually active at night. The latter often make individual migratory flights after dusk. This subsection also deals with phase-dependent differences in hatching and emergence of the hatchlings. Finally, neurophysiology related to the diel patterns of activity and the circadian clock genes in *S. gregaria* are delineated.

Collective behavior in the laboratory and in the field (i.e., behavior of bands of hoppers and swarms of adults), constitutes the eighth section. Obviously, only gregarious locusts exhibit collective behavior. The section is devoted mainly to marching bands of hoppers with little attention to swarming adults. Two subjects of locust marching bands are detailed: firstly, the behavior of the individual interacting with the collective motion of the band and vice versa; movements of the whole band in the field constitute the second subject. Laboratory work on the first subject yielded detailed data, including modelling of locust collective movements. The second subject is somewhat less investigated, although the different formations of locust bands are known. In some instances the formation is species-specific (narrow and dense stretching streams in *Locustana pardalina* or broad frontal crescent formation in *C. terminifera*), but in some other species the formation is variable. When marching is discontinued the hoppers remain aggregated. Larger bands may be followed by air craft or by drones. The section ends with conclusions, emphasizing the need for more field data.

The ninth section outlines environmental stimuli affecting phase change; actually, the section is limited to phase change toward gregarization. Two major factors seem to exert effect: resource distribution (clumped or fragmented) and resource availability (poor or rich), presumably including nutritional state. In clumped resources locusts are attracted to the clumps for feeding, which results in enhanced interaction, leading to gregarization. The contrasting situation was reported in a large-scale landscape study for *S. gregaria*, indicating, rather, that fragmented over clumped vegetation may lead to outbreaks. It seems that optimal diet promotes migratory tendencies in locusts. This is in contrast to older views that poor resources enhance migration.

"Ecology and landscape-level processes" is the title of the tenth section. It contains three subsections: Remote sensing, climate change, and a locust ecology case study. The history of remote sensing by satellites is outlined. Satellite imagery, employed routinely for *S. gregaria* and *C. terminifera*, is useful for observing changes in vegetation, rainfall areas, and temporary locust habitats, but usually is useless to directly detect locust bands or swarms. The potential habitats should be checked by high resolution methods, such as vehicles or drones (see section 8). The portion on climate change deals first with attempts to correlate historical climate cycles with locust plagues, mostly in China, and then it discusses the effects of the present local warming. Northern expansion of the distribution area of *Dociostaurus maroccanus* and *Calliptamus italicus* was reported. Also, *D. maroccanus* has moved to higher altitudes. Warming causes shortening of the duration of egg and nymphal development and this may lead, in some species, to an extra annual generation. The last subsection is on a "Locust Ecology Case Study: The Central American Locust, *Schistocerca piceifrons*".

The eleventh section is devoted to human-locust interactions. Locust plagues, as reported in old Chinese literature and described in the Old Testament, often caused disaster in human history and they are threatening agriculture even today. The problem is still acute, especially in developing countries, and it may affect economy. The damage is the greatest at the level of the farm, but individual farmers cannot fight a locust plague; coordinated responses are needed. Human activities sometime increase the probability of locust outbreaks; for example, deforestation may lead to an increase of breeding areas. Figure 2 shows the systems of human-locust interactions that should be taken in account for sustainable locust management. The section ends with the sentence "....temporal and spatial scales, in addition to the bio-physical and social contexts, need to be defined and integrated to find effective, economically efficient and sustainable solutions to locust plagues" and relevant literature.

The last section presents the "Concluding Remarks" summarizing the achievements in locust phase research in the last decade and outlines new experimental approaches to better understanding of the molecular basis of locust phase change. It also points out the importance of comparative analysis of different locust and "near locust" species of acridids. Locust phase research is extended to collective motion studies, to effects of environmental factors, and to neuronal and behavioral plasticity. The section is closed by stressing the importance of human-locust relations and developing solutions to the challenge of locust plagues.

In spite of the comprehensive approach, some subjects are neglected. The word "pheromone" is mentioned only once. The review of Hassanali et al. (2005) is not cited and neither is the article on the solitarizing effect of phenylacetonitrile on nymphs of *S. gregaria* (Bashir & Hassanali, 2010) (phenylacetonitrile is the major component of the volatiles of *S. gregaria* adults). The substance is not toxic to some non-locust insects (Badr et al. 2015). As for *Locusta migratoria*, the study of Guo et al. (2011) is discussed in relation to the role of olfactory stimuli on phase change, but the article by Shi et al. (2011) on fecal volatiles that elicit aggregation in this species is ignored. Also, the

study by Wei et al. (2017) on phase-dependent volatiles in *L. migratoria* is not mentioned despite the fact that it was already available online in 2016. Nevertheless, I warmly and strongly recommend the chapter to locust workers, as well as to people working in adjacent fields.

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A hitchhiking migratory locust from Queensland Australia

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n late May of 2017 (the Australian autumn), I returned from a 10-day outback trip down the Darling River Run from Bourke to Wentworth in Western New South Wales, camping in various national parks and farm stays with my partner and friends. The country was as dry as chips and had not received any significant rain since September 2016 (following a wet winter) and I saw no grasshoppers or few insects at all for that matter.

When we returned to our home, south of Canberra, we put our camper trailer in the garage with the canvas erected to dry out. A week later (May 31st) my partner checked the interior

The actual specimen

before we folded the canvas away and found a large grasshopper on the pillow of the bed at the front of the camper trailer that has a hard top. I immediately recognised it as a young, post-teneral, brown morph of the female migratory locust, *Locusta migratoria migratorioides*, still flexible and only recently dead. As far as I am aware, the last time this species was reported this far south was during the locust plague in central Queensland in 1976 (Farrow 1979) when locusts arrived at Whitecliffs (another place in Western New South Wales) and the Australian Capital Territory.

This specimen must have been brought in our trailer from the Darling trip, but could not have bred locally in western NSW, so where did it come from and how did it get into our camper? The nights were cold (minimums: 5-12°C), although there was a northerly airflow for the latter five days of the trip, preceding a weak cold front that brought some light rain between Wednesday and Thursday May 17-18.

Like most locusts and many grasshoppers, the migratory locust undertakes extensive downwind night flights at an altitude of 250-500m after fledging that may take it many hundreds of kilometers. Take-off occurs after sunset when surface air temperatures are still warm. These locusts are also attracted to light at the end of these flights (Farrow 1977). So, I examined the surface synoptic charts for the period we were away and the most likely weather systems favouring a migration of this locust were on May 16th and 17th, when we camped at Kinchega NP and Pooncarie localities, respectively.

The interesting thing about Pooncarie was that the caravan park had a bright street lamp just above our site, but there were no lights at Kinchega where we bush-camped. Surface temperatures were quite cold during the night at Pooncarie, but the northerly airflow above the inversion would have been much warmer. However, we were shut up in our trailer by 9 pm and it is difficult to work out how the locust got inside the trailer after a long night flight when it should have arrived late in the night. It may have entered when we were packing up the next morning. There are some small external lights on our camper and the only other insects attracted to them that night were a few local ghost moths emerging after the light rain. It is also surprising we did not see the locust in the camper trailer the next day since it would have been alive at this stage, but there are some crevices where it could have hidden.

The alignment of the isobars, shown above, suggest that the locust would have flown in a south-easterly direc-
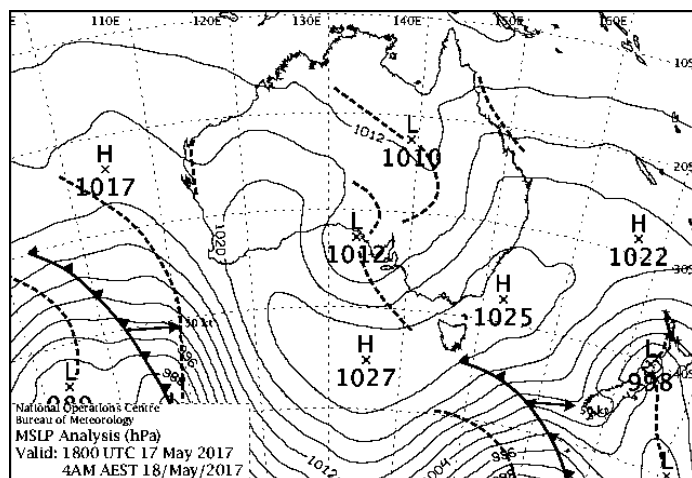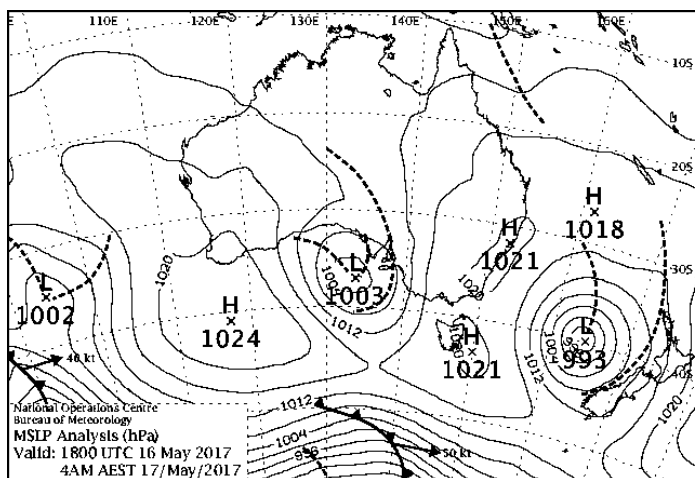
Weather systems at Kinchega NP and Pooncarie localities on May 16th (left) and 17th (right)

tion from south-central Queensland, possibly from the Central Highlands (Carnarvon area), where there was abundant grassy vegetation in which migratory locusts could have bred during the preceding summer. This region is thought to be the main breeding area of this locust in Australia (Farrow 1979). It is unlikely to have been the only migratory locust flying that night, but no others have been reported. I do not have the dusk air temperatures for the suggested departure area available, but the 3pm temperature at nearby Roma was well above average at 26.8C indicating a warm evening ahead, suitable for locust take-off and flight.

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Collecting in Southern Mexico: Oaxaca and Guerrero states

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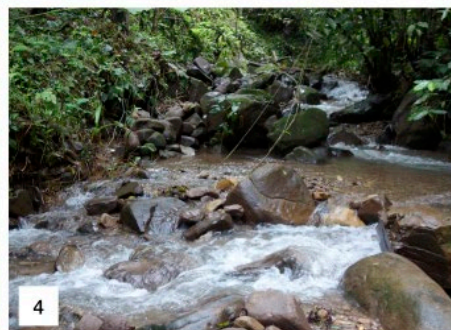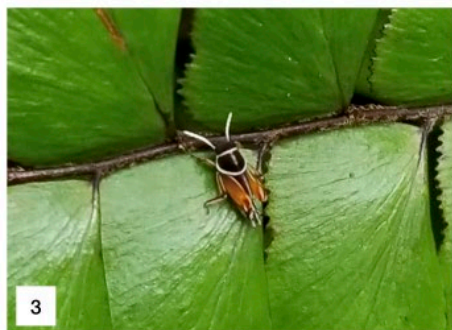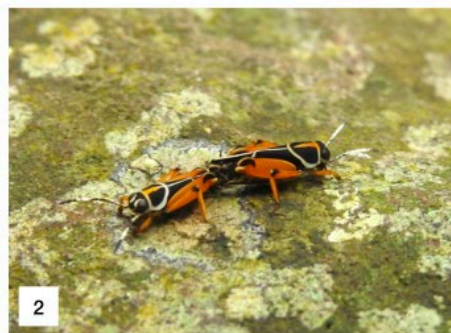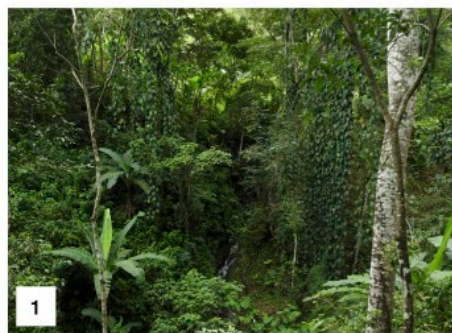***pselliopus@yahoo.com.mx**

The Orthoptera fauna of Mexico is diverse, with currently more than 1,000 valid species reported. One area of particular interest is Southern Mexico, due to the presence of a complex orthopterofauna, comprising Nearctic and Neotropical species, as well as several groups that have evolved in situ. This, together with the multiple mountain ranges of different ages and elevations harboring a mosaic of contrasting environments, makes it a unique and highly diverse area. For instance, the state of Oaxaca, which comprises less than 5% of Mexican territory, harbors 20% of the Mexican orthopterofauna. In this context, we conducted an expedition last October to certain areas in the states of Oaxaca and Guerrero. In this article, we present photographic records of some of our most interesting findings.

Ripipterygidae

In the Papaloapan region of Oaxaca mainly surrounded by rainforest (around 390 masl), we were amazed by the tiny (only 4-10 mm!) species *Ripipteryx tricolor* (Figs. 1-3). This species prefers very humid habitats and it is often found next to sandy shores of pools, streams, and small ponds (Fig. 4). They have some intriguing modifications to this type of habitat, such as plates on the hind tarsi that help them move on the water, modified front legs for digging, and harder and shorter front wings compared to the hind ones. They tend to form aggregations, and were indeed very abundant. They are hard to catch due to their size and fast reaction speed when disturbed. We increased our chances of catching them on the rocks by moistening the inner walls of our vials with ethanol, a useful

Figures 1-4. Species and habitats of Ripipterygidae observed in Oaxaca.

Figures 5-8. Species and habitats of Xyronotinae observed in Oaxaca.

Figures 9-12. Species and habitats of Proctolabinae observed in Oaxaca and Guerrero.

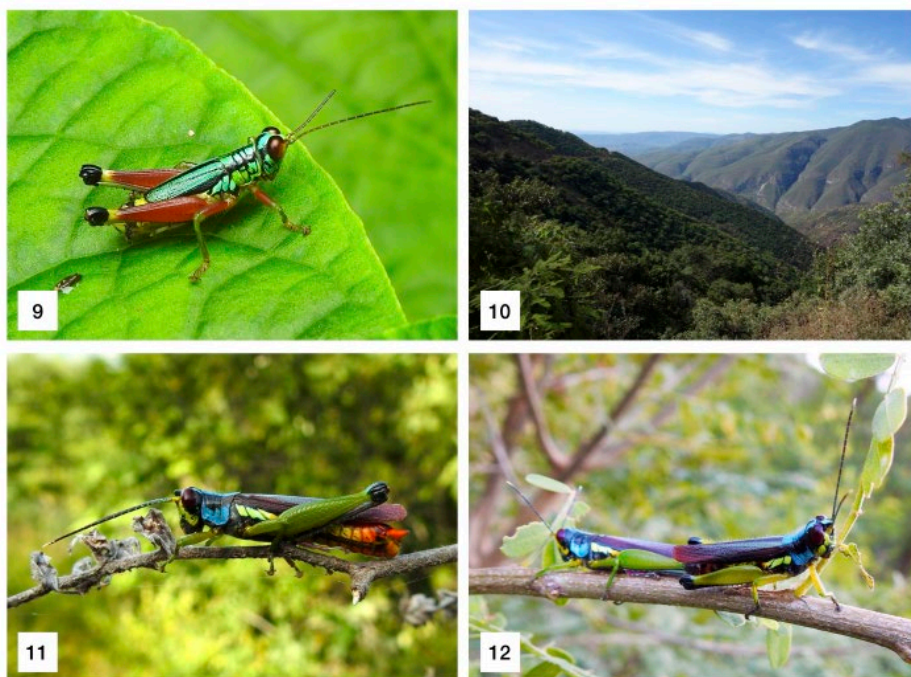(Dirsh & Mason, 1979). In previous expeditions, we were unsuccessful in finding them, even when visiting the type localities. This time we stopped very close to the localities provided by Dirsh & Mason (1979). After some hours of day collecting Bert was able to find an adult. Fortunately, we spent the night in a lodging next to the forest and decided to check again during the night. It was cold and raining, so our expectations were low. To our surprise, they were there! Males, females, and nymphs, just sitting in the leaf litter. Despite the fact that they possess bizarre cerci and are easily to identify as members of the family Xyronotidae, we had to review the internal genitalia to determine which of the two species we collected. Salomón extracted the genitalia; following the illustrations provided by Dirsh and Mason (1979), we identified the specimens as *Xyronotus cohni* (Figs. 6-8). We collected a good series in a small area (no more than 100 m^2) for morphological and molecular studies. It appears that the population is healthy and this information will be used in the upcoming IUCN Red List evaluation for this species. It was good news to hear from the local people that many efforts have been done to preserve these humid forests (Figs. 5 & 7). The communities from the region understand very well how valuable the habitat is and they are organized to patrol the area.

Proctolabinae (Acrididae)

In the rainforest of the Papaloapan region of Oaxaca, we saw a green metallic proctolabine that belongs to the species *Tela bolivari* (Fig. 9). Further, in tropical deciduous forest of the Balsas basin river, in Papalutla, Guerrero (around 1,600 masl) (Fig. 10) we found *Proctolabus mexicanus* (Figs. 11-12). This genus has a peculiar distribution from Sinaloa in Northwestern Mexico to Chiapas in Southern Mexico, but only on the Pacific side. As you can appreciate in the photographs, their colors are spectacular.

tip from Sam Heads. When the tiny grasshoppers jump, they are immediately stuck on the moistened walls. Using this technique we were able to collect a good series of males, females and nymphs.

Xyronotidae

This mysterious family is endemic to humid forests of Mexico from the states of Puebla, Veracruz, Oaxaca, and Chiapas. There are only two genera and four species. This group is very old and the current evidence suggest that their closest relative is the Trigonopterygidae from the Far East. In the cloud forest of the Sierra Norte region of Oaxaca (1,600 masl; Fig. 5), we searched for the enigmatic genus *Xyronotus* (Figs. 6-8), of which two species are reported in this area: *Xyronotus cohni* and *X. hubbelli*

They were very abundant, with up to ten individuals in a single shrub.

Romaleidae

Martina has experience in collecting romaleids in South America. However, this was her first time to collect them in Mexico and we encountered several species. The common *Taeniopoda auricornis* (Fig. 13) can be found in disturbed areas next to houses and crop land. Along Oaxaca's mountain ranges they were very abundant and easy to grab them by hand. We also came across another species of *Taeniopoda* in Guerrero's mountain ranges even though we were able to collect only very few specimens (Fig. 14). Another species that we commonly found was *Xyleus discoideus mexicanus* (Fig. 15). Its genus is comprised of 16 species of which 15 are distributed exclusively in South America. The only species (with two subspecies) of which the range extends further North is *Xyleus discoideus rosulentus* in Central America and *X. d. mexicanus* in Mexico. Like *Taeniopoda*, this romaleid is also sluggish, but it lacks its impressive colors. It is usually found on the ground and it is easy to identify by its particular shape of the pronotum. FInally, another romaleid encountered on a few occasions was the colorful *Chromacris colorata* (Fig. 16). It is characterized by the coloration of its antennae: the basal half is yellow, while the more apical half is black.

Other Orthoptera

During our expedition, we identified several other species of Caelifera, including members of the genera *Abracris*, *Aidemona*, *Melanoplus*, *Schistocerca* (Fig. 17), and *Sphenarium* (Fig. 18). Within Ensifera we found three species of *Stilpnochlora* (*S. azteca, S. quadrata* and *S. thoracica*), *Dichopetala mexicana* (Fig. 19), *Scudderia mexicana* (Fig. 20), *Philophyllia guttulata*, *Gongrocnemis* sp. (Fig. 21), *Orophus tesellatus*, *Insara* spp., *Phlugis chrysopa*, *Neo-*

Figures 13-16. Species of Romaleidae observed in Oaxaca and Guerrero.

Figures 17-18. *Schistocerca nitens* and *Sphenarium histrio* observed in Oaxaca.
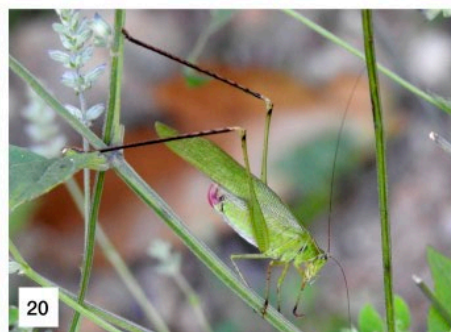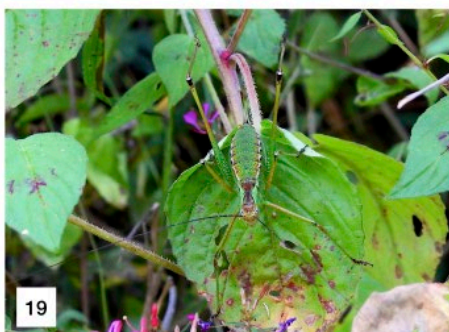
Figures 19-22. Some species of Ensifera observed in Oaxaca and Guerrero.

conocephalus triops, and *Copiphora azteca* (Fig. 22), among others. Many of our records will help to increase the knowledge of distribution ranges and morphological variation of the identified species.

Southern Mexico has been explored for the last ten years and we are still finding new genera and species in almost every expedition. This trip was no exception and several new species of Acridoidea are in the process of being described.

Acknowledgments
We want to thank Orthoptera Species File Grant, Hojun Song, and Raúl Cueva del Castillo for funding for the expedition (Fig. 23-26). We also thank Víctor Ramírez Delgado and Miriam Illescas Aparicio for their help during the expedition, and to the people and authorities of San Mateo Yetla (Oaxaca), Santiago Camotlán (Oaxaca), Iliatenco (Guer-

Figures 23-26. Fieldwork and expedition team.

rero), and Papalutla (Guerrero) towns for permits. Photographers: Figs. 7, 13, 14, 16, 17, 22 & 23 by BF; Figs. 3, 5, 6, 8, 10, 15, 24 & 26 by MEP; Fig. 4 by RMP; Figs. 1, 2, 9, 11, 12, 18, 19, 20, 21 & 25 by SSU.

Orthopteroid Symposium Recap from the 2017 ESA Conference

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For the fourth year in a row, there was an orthopteroid symposium at the annual Entomological Society of America (ESA) conference (this time, in Denver, CO), that I co-organized with Tyler J. Raszick, a Ph.D. Candidate in Greg Sword's lab at Texas A&M University. The 3.5-hour symposium was entitled "Orthopteroids: Innovative Organisms to Ignite and Inspire Scientific Research and Communication" and adequately reflected

the theme of the conference and the composition of the program, which included presentations on many of the 10 extant orders of orthopteroids:

Blattodea (+Isoptera), Dermaptera, Embiidina, Grylloblattodea, Mantodea, Mantophasmatodea, Orthoptera, Phasmatodea, Plecoptera, and Zorap-

Figure 1. Symposium organizers and speakers (left to right): back row: Dustin C. Krompetz, Alexandre V. Latchininsky, Mark Janowiecki, Bert Foquet, Oscar Salomon Sanabria-Urban, and Derek A. Woller; front row: Tyler J. Raszick, Hojun Song, Janice S. Edgerly, Marion Le Gall, Akira Wong Sato, Martina E. Pocco, and Shiala Naranjo.

Figure 2. The after-symposium celebration at Rock Bottom Restaurant and Brewery in downtown Denver, CO. Good times!

tera. Tyler kicked off the event with a brief introduction to orthopteroids followed by 12 other speakers (Fig. 1), which included an undergraduate, graduate students, postdocs, and seasoned researchers, with most traveling from within the U.S., but also from Japan, Argentina, and Mexico.

As always, I thought the presentations were all fascinating and entertaining, and I think the audience would agree since it was around 50 strong at any given time, a very good turn-out. For your enjoyment, a brief abstract and figure (for most) have been provided below by each speaker (in order of presentation). Following the final keynote presentation by Hojun Song, almost everyone reconvened at the first-ever meeting of the Arizona State University's Global Locust Initiative led by Arianne Cease and Ariel Rivers (see their recap article elsewhere in this edition). Most of us then headed out to a wonderful dinner at a local place called Rock Bottom Restaurant and Brewery where good times were enjoyed by all (Fig. 2)! Tyler and I would like to graciously thank the Society's officers for supporting the travel of Society member Oscar Salomon Sanabria-Urban from Mexico to give his neat presentation on his work with the genus *Sphenarium* (Orthoptera: Pyrgomorphidae). Likewise, the ESA administration must also be thanked profusely for supporting the travel of Akira Wong Sato who came all the way from Japan to share his work on plecopterans with us. Also, like last

year, we made use of the wonderful orthopteroid banners that the Society had constructed in 2017 (Fig. 1) and which are available for use by any members who wish to request them from Hojun in whose lab they currently reside.

An evolutionary retrospective of the Melanoplus Puer Group (Orthoptera: Acrididae: Melanoplinae)

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The 27 flightless grasshopper species of the Puer Group (Orthoptera: Acrididae: Melanoplinae: Melanoplus) found in the southeastern U.S.A. comprise a biological system of fascinating complexity that was heavily influenced by sea level fluctuations during the Pliocene and Pleistocene, especially during the latter. These past sea level shifts resulted in an oceanic island system that can now be classified as a landlocked archipelago (also known as ridges), one that still reflects the patterns of its ancestral roots in terms of speciation and dispersal. To better understand patterns of speciation in this group, we used a number of synergistic methods: molecular-based phylogenetic reconstruction, divergence time estimation, correlative microscopy and 3D model reconstruction of copulation, and shape analysis of male genitalia in an evolutionary time-based phylogenetic framework.

This archipelago system is extraordinarily young (25 million years old) compared to the rest of the southeastern states (up to a billion years old) and the Puer Group was estimated
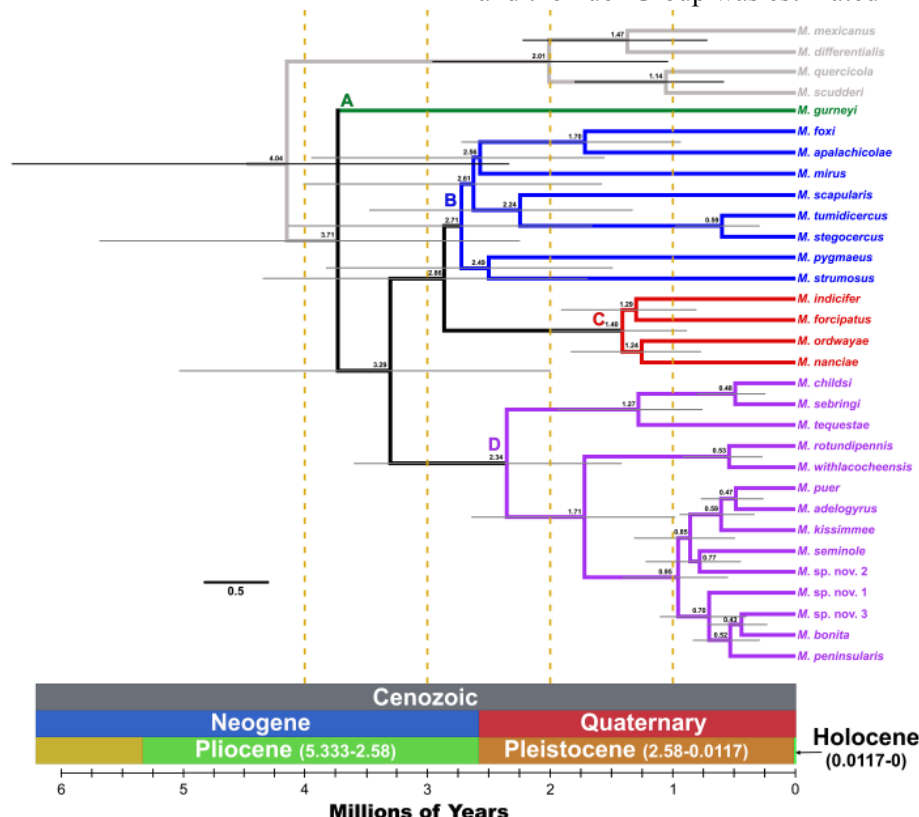

Figure 3. Bayesian analysis of estimated divergence time of the 27 Puer Group species (and four outgroups – in gray) run using BEAST2 and calibrated at three nodes using estimates of ridge ages. Letters and colors correspond to the four major lineages recovered.

to only be 3.71 million years old (Fig. 3). As predicted, our evidence indicates that the biogeographical and speciation history of this system was shaped dominantly by allopatry, most likely resulting from sea level changes, in the past and, more recently, sexual selection, especially for the species in peninsular Florida. Our quantitative evidence also added strong support for the concept, especially in light of evolutionary time, that sexual selection is able to drive genital evolution divergently and rapidly. Our investigation of the function of genital components (some new to science) during copulation was combined with our shape analyses of five of those genital components to reveal that sexual selection's evolutionary tempo on these components is accelerating and/or decelerating. The relative speed was found to be dependent upon the component and its associated function(s). We also discovered that one of the youngest Puer Group clades has speciated at a rate high enough to possibly be the highest yet for insects.

The obvious complexity of this biological system requires additional investigation at finer scales in order to further dissect the intriguing patterns and processes of evolution herein revealed to be at work. Further analyses of the Puer Group, both quantitative and descriptive, are encouraged, especially because the threat of destruction and fragmentation of the group's xeric habitats (especially scrub) looms large. Speciation is still largely a biological black box, but its inner workings will continue to be slowly revealed with illuminating studies like this one.

Linking land use and the nutritional ecology of locusts: The case of the Senegalese locust (*Oedaleus senegalensis*)

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Before the 1970s the Senegalese locust, *Oedaleus senegalensis*, was not reported to cause economic damage. Today it is considered the main pest of the African Sahel. Previous research indicates that *O. senegalensis* locusts are more abundant in fallow fields, but the mechanisms underlying this pattern are not known. We tested the hypothesis that land use can promote locust outbreaks by creating nutritionally optimal

Figure 4. Locust performance on five artificial diets in no-choice experiment. The diets used range from very carbohydrate-biased (e.g., p7:c35, 7% protein and 35% carbohydrates), to very protein-biased (p35:c7), and are isocaloric (42% macronutrients). Panel (A) shows mean development time throughout the last nymphal stadium; panel (B) shows wet mass gain throughout the last nymphal stadium; panel (C) shows Specific Growth Rate (SGR); panel (D) shows Performance (SGR x % success molting). The color gradient varies from light (highest median) to dark (lowest median). The plot shows the kernel probability density of the data at different values. Different letters indicate statistically significant differences between the five diet treatments (as determined by ANCOVA, using start mass as a covariate, and post hoc comparisons).
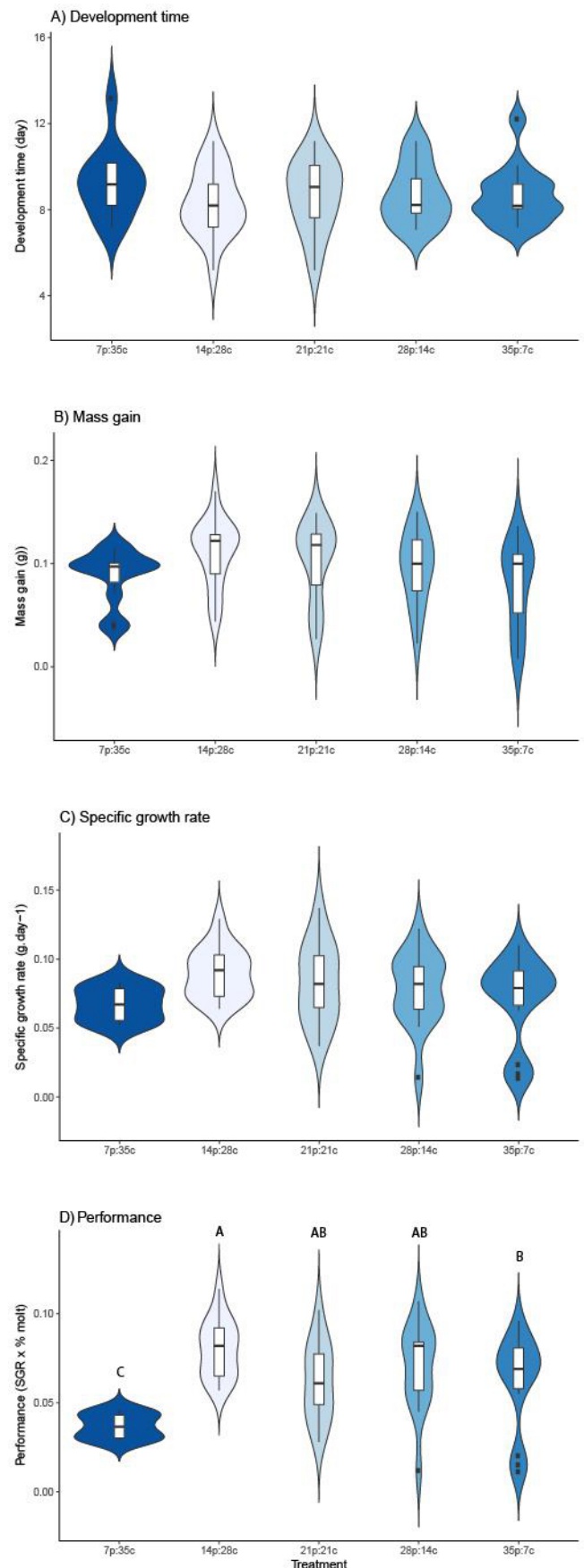
niches. In this study, we 1) quantified the nutritional landscape available to *O. senegalensis* across different crop types (millet and groundnut), fallow, and grazing fields; 2) measured how nutrients affect locust foraging behavior and performance using artificial diets; and 3) mapped the distribution of locusts found across 10 Senegalese farms to our nutritional landscape and correlated it to the locust performance data. Our results show *O. senegalensis* prefers and performs best on carbohydrate-biased diets (14% protein and 28% carbohydrates) and fallow fields contain more plants that are carbohydrate-biased. We discuss our results in light of general sustainable management strategies for locust species.

Revealing the molecular architecture of locust phase polyphenism using RNAi on the Central American locust (*Schistocerca piceifrons*) and non-swarming relatives

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Locusts are grasshoppers that form migrating swarms and show density-dependent phase polyphenism, referring to the existence of a solitarious and a gregarious phase. Solitarious locusts occur under low densities. They are rather inactive, avoid each other, and nymphs are inconspicuously colored. When densities increase, locusts go through remarkable changes: they become very active and are attracted to each other. Furthermore, nymphal coloration changes to yellow/orange with black spots. The morphological, physiological, and neurobiological characteristics of this polyphenism have been well-studied, but the molecular basis is largely unknown.

We focus on a clade of closely related species, containing one locust (*Schistocerca piceifrons*) and three non-swarming grasshoppers with varying degrees of density-dependent phase polyphenism (from clear to negligible: *Schistocerca americana*, *Schistocerca serialis cubense* and *Schistocerca nitens*). We tested the effect of knockdown of well-chosen genes on density-dependent phase polyphenism. First, differential gene expression between both phases is investigated, after which the effect of target genes will be tested using knockdown by RNAi. RNA of five isolated-reared and crowded-reared individuals of each species was extracted and sequenced. Using edgeR and DEseq2, we discovered differentially expressed genes between both rearing conditions for every species. There is a clear congruency between differentially expressed genes found in our study and in similar studies on other locust species, confirming the validity of our data. Furthermore, the aforementioned spectrum of polyphenism is also represented on a molecular basis.

Using the produced data, ten target genes are selected based on (1) the likelihood of playing a role in density-dependent phase polyphenism and (2) having high expression levels in crowded-reared locusts. We hypothesize that reducing the expression of these genes will result in a more solitarious state in crowded-reared locusts. Three genes (pacifastin-5, yellow-b and Juvenile Hormone (JH)-receptor) were already tested in another locust species, *S. gregaria*, during an internship at the KULeuven, Belgium. As *S. gregaria* and *S. piceifrons* belong to the same genus, results for both species are probably
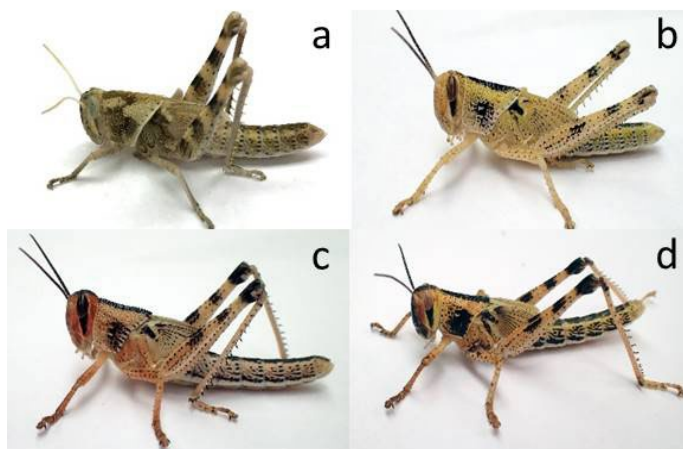

Figure 5. A spectrum of density-dependent phase polyphenism, from absent to complete: (a) *Schistocerca nitens*, a regular grasshopper. (b) *S. serialis cubense* (c) *S. americana* (d) *S. piceifrons*, a true locust. All images depict crowded-reared locusts.

similar. Pacifastin-5 and yellow-b possibly have regulatory functions and are differentially expressed in both species. The JH-receptor was chosen due to large numbers of differentially expressed genes interacting with JH.

Each group of 20-40 locusts was injected twice with double-stranded RNA (dsRNA) targeting either the target gene or GFP (control). The behavior of last instar-nymphs was recorded for 10 minutes in a rectangular arena with a stimulus chamber containing 20-30 locusts on one side while the other side is empty. Locusts injected with dsRNA targeting pacifastin-5 or yellow-b did not differ significantly from the control group. Injecting dsRNA targeting the JH-receptor induced more gregarious behavior in contrast to our hypothesis. Possibly, this is due to a negative feedback-loop activated by knockdown of this receptor.

In conclusion, (1) the spectrum of density-dependent phase polyphenism in our species is also represented at a molecular level. (2) Pacifastin-5 and Yellow-b are differentially expressed in both *S. piceifrons* and *S. gregaria*, but knockdown appears to have no behavioral effect in *S.gregaria*. (3) Juvenile hormone might play a role in locust density-dependent phase polyphenism.

Differences and similarities between Dictyoptera mitochondrial genomes

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Alignment-free clustering methods and machine learning were used to investigate the relationships of mitochondrial genomes of praying mantises (Mantodea) and cockroaches (Blattodea). Most multiple sequence alignment (MSA) methods require complicated computation and uphold evolutionary assumptions that can lead to controversial results. Alignment-free clustering methods can outweigh the disadvantages of MSA. Methods like kmer and natural vector have shown promising results for using whole genomes to build evolutionary trees in viruses and bacteria. These methods require less RAM, which can decrease analysis time from days to minutes. However, these methods are best used in ensemble since they can neglect position of nucleotides and create uncertainty. A total of 55 Dictyoptera mitogenomes were retrieved from GenBank. Trees built using complete linkage clustering with natural vector and kmer-6 with different combinations methods yielded expected results about the relationships between species to species and family to family. In Mantodea (n=16), Mantidae was well-established, while in Blattodea (n=36), the termites were the most established group. In Mantodea, Liturgusidae (consisting of *Humbertiella nada*, *Theopompa* sp., and *Leptomantella albella*) was well-distinguished from Mantidae. *Rhombodera* spp. show to be more closely related to *Mantis religiosa* and *Tenodera* spp. than to *Statilia* spp. As expected from numerous past studies, the genus *Cryptocercus* was well established in the termite cluster. However, trees using neighboring kmer failed to reach stability

in the presence of basal groups. These methods are normally immune to different evolutionary histories, but low sample size may have depressed its usefulness.

Machine learning was used to test if base composition heterogeneity may have been the culprit behind the noise generated when basal groups were added. Random forest is a pattern recognition tool that builds multiple decision trees to grow a decision-forest that creates one unbiased ensemble decision-tree. The classifier was able to learn to distinguish between groups using only C+G content. In the future, random forest could be applied to especially messy groups or cryptic species. Further research is needed to test the efficiency and applications of this method in whole genome sequences.

Diversification patterns in Neotropical grasshoppers: The case of the genus *Sphenarium* (Orthoptera: Pyrgomorphidea)

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The Neotropical region harbors the greatest biodiversity on earth, which is mainly represented by insects. Within this region, the Mexican territory represents an interesting place for studying insect diversification because of its high insect diversity and because this area contains several groups of different biogeographic origins that intermingle and have undergone further evolutionary divergence. The complex geological and climatic history, as well as the environmental heterogeneity, of Mexico can explain its biodiversity. However, so far studying and testing the impact of historic events and environmental

heterogeneity in the diversification of Neotropical Mexican insects has received little attention, especially orthopteroid species, some of which have biological, cultural, and economical importance. In this context, the grasshoppers of the genus *Sphenarium* Charpentier, 1842 represent a good model to study diversification of Neotropical grasshoppers because of their biological characteristics. In this project, we investigated the diversification patterns in the genus *Sphenarium*. Specifically, we explored the relative impact of historic events and evolutionary forces in the diversification of the genus.

Because the taxonomy of *Sphenarium* was incompletely resolved we first re-evaluated the diversity of the group analyzing the variation of morphological and genetic characters in a wide geographic sampling of the genus. Using morphological and genetic evidence together we recognized 17 species of *Sphenarium*, of which 8 represented new taxa. In addition, we identified several instances of putative incipient speciation processes within species with the widest geographic distributions. Our Bayesian phylogenetic reconstructions revealed a strong phylogeographic structure of the monophyletic groups identified in the genus, suggesting that vicariance played an important role in the diversification of its genetic lineages. Moreover, our divergence time estimations indicated that the earliest divergence events in the genus correlated spatially and temporally with the latest formation episodes of the Mexican Volcanic Belt (between 7.5 and 3 Ma). However, most of the diversification of its diversification occurred mainly during the Pleistocene glacial and interglacial cycles between 2.6 and 0.01 Ma.

All these lines of evidence indicate that the geologic and climatic history of Mexico had a considerable impact on the lineage diversification of *Sphenarium*. Interestingly, we identified three broad patterns of differentia-
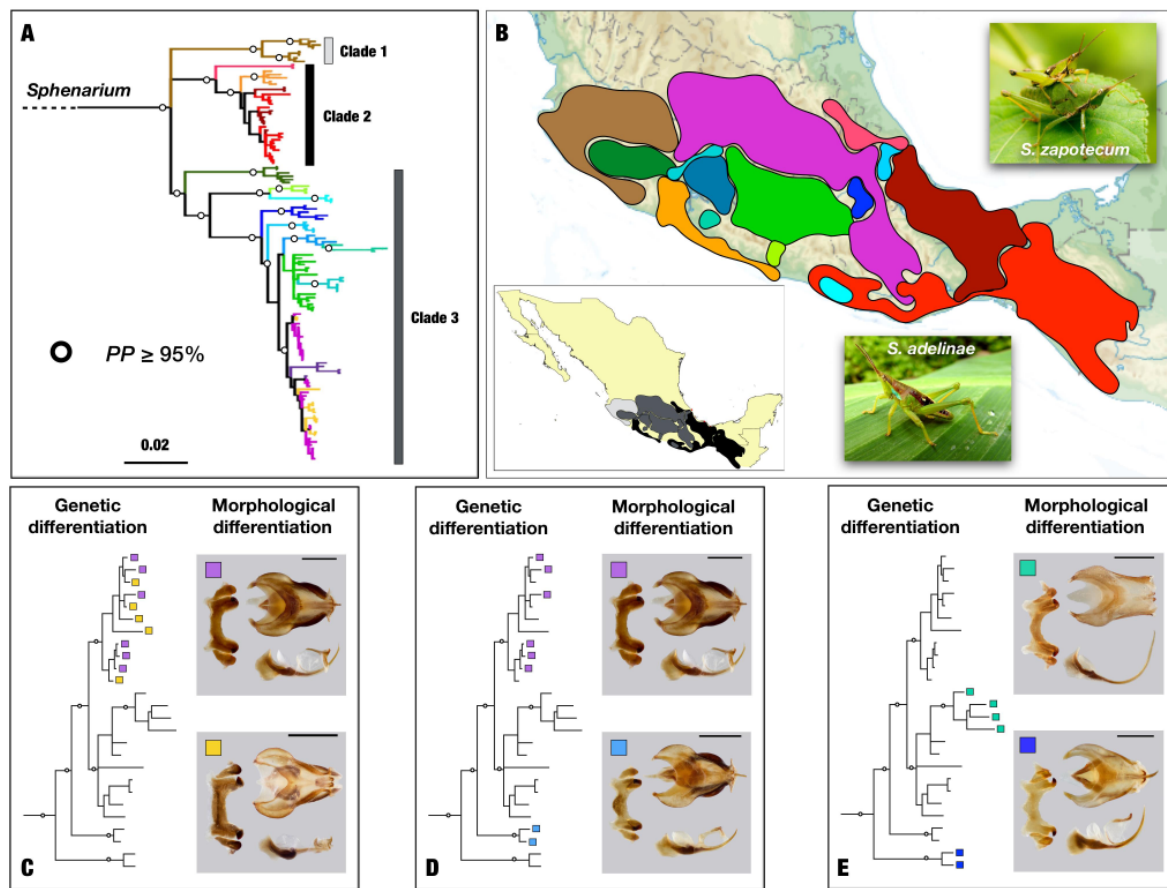
Figure 6. Summary figure of some of the results of our project: A) Concatenated Bayesian phylogeny of *Sphenarium* based on nucleotide sequences of five loci (CO1, CO2, 12S, ITS2, and H3) from 129 ingroup terminals. B) Geographic distribution of major clades, and internal monophyletic and paraphyletic groups of *Sphenarium* and images of living individuals of two of the new species identified. C-E) Patterns of genetic and morphological (male genitalia) differentiation observed within *Sphenarium* species.

tion that probably reflect a complex interplay between evolutionary forces in the diversification of the group. On the other hand, a comparative phylogenetic analysis to study the relationship between climatic variation and body size revealed a significant body size cline, in which larger *Sphenarium* species are associated with warmer winters and smaller species are associated with colder winters. This correlative evidence suggests the possibility that natural selection could have also enhanced the diversification of the group through local adaptation on life history traits to climatic variation in these grasshoppers. The genus *Sphenarium* provides the opportunity to study in more detail the process and mechanism involved in speciation and this can improve our understanding of the diversification of Neotropical grasshoppers and insects.

A novel Plecoptera–angiosperm interaction: Flower visits, direct pollen feeding, and pollination by a stonefly species

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Stoneflies (Plecoptera), likely the most basal neopteran insects, are mostly known for their long-lived aquatic nymphs, widely studied because of their importance as water quality indicators. Whereas, the short-lived terrestrial adults have been rarely studied in the field, and their behavior, biology, and ecology are poorly understood. Moreover, associations between adult stoneflies and terrestrial plants appear to be rare. Previous studies have reported facultative flower visits of adult stoneflies

feeding on dew and even on soft tissues of angiosperm plants. Yet the role of stoneflies in pollination remains unclear.

We studied the pollination system of *Corylopsis gotoana* (Hamamelidaceae) in a deciduous forest in Shiga Prefecture. In preliminary observations, we found that flowers of *C. gotoana* were mostly visited diurnally by bombyliid flies, Asian honeybee workers, bumblebees, solitary bees, and, unexpectedly, by one stonefly species, *Strophopteryx nohirae* (Taeniopterygidae: Plecoptera) (Fig. 7). Further observations showed that the stonefly regularly visited the small *C. gotoana* population during its flowering period, but were not the main flower visitors, and that the male and female stonefly had different behaviors. The male was more active, usually observed walking in branches and inflorescences, likely searching for mate partners. Whereas the female was less active and was generally found resting or feeding in inflorescences. Additionally, the female visited *C. gotoana* flowers more frequently than the male. Mating was occasionally observed in branches and inflorescences of *C. gotoana*.

Pollen attached to the male and female stoneflies belonged almost solely to *C. gotoana* flowers. And even though both the male and female stoneflies were observed to feed on pollen directly from the flowers,

Figure 7. *Strophopteryx nohirae* stonefly visiting a flower on the plant *Corylopsis gotoana*.

pollen attachment was higher in the female, particularly in the antennae, head, mouthparts, and thorax. To assess the pollination efficiency of the stonefly, we introduced stonefly samples with *C. gotoana* pollen dusted in their bodies to *C. gotoana* inflorescences of other trees that were previously bagged and emasculated to prevent pollination. Results of this introduction experiment showed that the stonefly contributes to pollination, but had a low success ratio. A further feeding experiment showed that adult feeding is necessary for the female stonefly to extend its life span.

To conclude, this study illustrated the flower visits and direct pollen feeding by the stonefly *S. nohirae*, but, more importantly, it is the first study to demonstrate that stoneflies can really pollinate flowers. The observations and results of the experiments suggest that the stonefly, particularly the female, is a potential pollinator of *C. gotoana*. The adoption of the stonefly as a pollinator is considered an option to secure pollination in the earliest spring in colder years, because the climatic regime is often different between terrestrial and aquatic habitats. Additionally, the female stonefly feeding in the adult stage might be of importance for egg

production, as documented for confamiliar species. Interactions between stoneflies and angiosperms might be more common than thought and particularly in the family Taeniopterygidae, which has several records of interactions with angiosperms, besides the one presented in this study.

Silk spinning motifs of the Embioptera: Insights from musicology

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Embiopterans spin by stepping in choreographed routines with their front feet while releasing silk fibers with each spinstep. Recent research in our lab demonstrated that spinstep routines

display phylogenetic signal while, at the same time, some routines reflect lifestyle. For example, those that live on tree bark exposed to the elements are more likely to execute spinsteps over their dorsum and to their sides, creating more extensive silk sheets in the process compared to burrowing embiopterans. That research was based on simple transition matrices, such as the probability of going one from spinstep to another. The spinning motifs, however, are extremely complex and long because there are 28 possible footfall positions. We filmed dozens of individuals from 26 species and 9 families over an hourlong session for each female; most individuals displayed thousands of spinsteps. Because many individuals are creating complex domiciles, they also show transitions over time during a spinning bout from framework construction to spinsteps that reinforce the emerging structure.

All in all, the routines are more
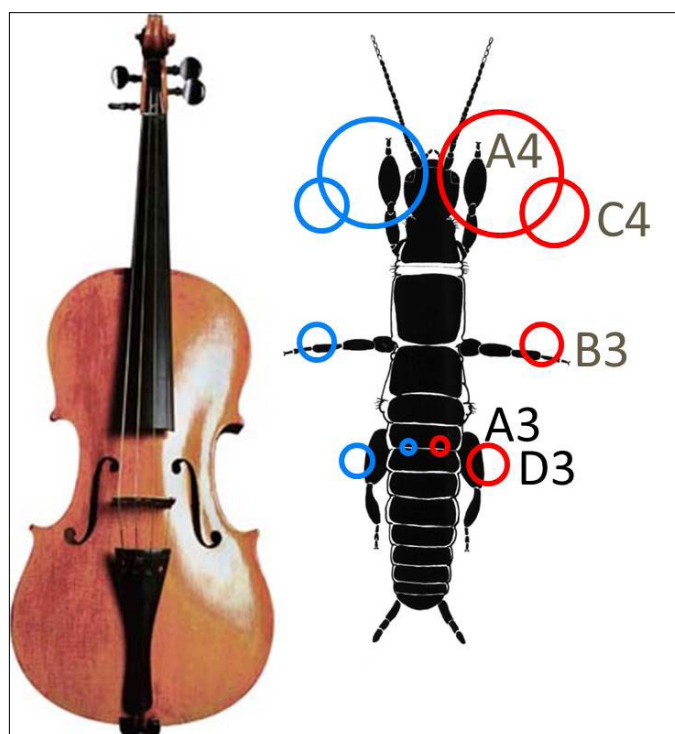
Figure 8. An embiid spins by stepping with her front feet, releasing silk with each footfall. Circles represent the stereotypical step positions; diameter of each circle reflects proportion of steps in each position. Lettering shows the octave (as a number) and musical note attributed to each position. Musical scores using these notes (and more to include all 28 spin-steps) generated for violin yielded lovely music. Compositions reveal aspects of spinning to the listener that are otherwise hard to interpret or detect.

complex than any behaviors we have examined before, and indeed, we were not able to find any methodology from the behavior literature that would help define spinstep motifs of such long lengths, let alone compare individuals to determine if there are species signatures. Thus, we turned to the field of musicology after realizing that the form our data takes is much more like music than other types of information. Musicologists have recently been working with computer scientists as they seek to uncover patterns and sequences that define compositions; there is a large body of work. We therefore decided to tackle our research questions by applying string sequence analysis from the field of musicology.

Our preliminary results show promise. Cluster diagrams revealed that female spinners in some species have strong similarity in their spinning routines, even for those that execute thousands of spinsteps. Other individuals seem to be more spontaneous, such as some oligoto-mid species, which interestingly are also the same species that have been introduced throughout the world; their ability to adapt to new habitats might align with greater spontaneity in behavior. In addition to our search for phylogenetic signal, we also transformed spinning routines into music by coding spinsteps as musical notes and producing graphs (using R Studio) that resemble musical scores tuned for the violin (Fig. 8). Listening to these scores played on a violin reveals the repeated and complex motifs in a beautiful way. One can hear patterns that resemble songs and verses, or movements in a symphony, where elements of the song stay intact but improvisation and/or modulations provide variety, and the different motifs repeat, disappear, and then reappear. "Spinning music" sounds like a lovely musical composition. Future work will include greater emphasis on musical composition as a way to illustrate the complex spinning behav-iors of embiopterans. In addition, we continue to explore whether spinning motifs hold evidence of phylogenetic relatedness for females that otherwise look very much alike no matter the taxonomic affiliation.

Locust and grasshopper management worldwide: A challenge that inspires

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Locusts and grasshoppers (Orthoptera: Acridoidea) are an essential component of normally functioning grassland ecosystems worldwide. They stimulate plant growth, participate in nutrient cycling, and represent an important part of food chain. Abiotic (weather), biotic (natural enemies), and anthropogenic (agricultural practices) factors generally keep acridid populations in check. However, from time to time they escape controls and their populations explode to catastrophic proportions. During outbreaks, which in the case of the locusts can reach transcontinental dimensions, acridids enter into severe competition for food with livestock and wildlife and become extremely important economic pests. Locust and grasshopper outbreaks occur on every continent except Antarctica and affect 10% of the world population. These pests are very mobile, highly polyphagous, and extremely voracious. Chemical control remains the main means of locust and grasshopper control. During the Desert locust (*Schistocerca gregaria*) upsurge of 2003-2005, over 30 million acres were treated with 3.5 million gallons of broad-spectrum insecticides in 26 countries, with the total cost of the campaign exceeding half a billion U.S. dollars.

The challenges of controlling these unique pests have inspired many scientists worldwide. C.V. Riley led the U.S. Entomological Commission to study and control the devastating Rocky Mountain locust *Melanoplus spretus* in the 1870s-1880s. Norman Criddle developed an efficient recipe for grasshopper baiting in Canada in the late 19th – early 20th centuries, which was subsequently used for decades in North America. Sir Boris

Figure 9. Ultra-Low Volume (ULV) spraying against the Moroccan locust, *Dociostaurus maroccanus*, in a semi-desert in Uzbekistan.

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Uvarov elucidated the mystery of locust phases in the 1920s, established the famous London Anti-Locust Research Centre and pioneered international cooperation in locust management in the mid-20th century. In the former Soviet Union, for the first time in the world, agricultural aviation was introduced into locust control in the 1920s. Later, in the 1950s, a new technology called Ultra-Low Volume spraying was developed for locust control in desert areas of Africa. ULV does not need water and remains the main technology to spray locusts in arid zones (Fig 9).

The enormous scale of locust and grasshopper infestations is a huge challenge for monitoring their populations. It inspired researchers to develop applications of geospatial technologies, such as satellite imagery and GIS, to locust ecology. Now these technologies are an integral part of locust forecasting in Africa and Australia; however, in other parts of the world this approach is still lacking. Drones appear a promising tool for locust and grasshopper monitoring and this technology is being currently actively developed in different geographic areas.

Another important challenge of locust control is the massive use of pesticides. As mentioned before, during outbreaks millions of acres are covered with broad-spectrum neurotoxins worldwide. An alternative, which is gaining speed, is the use of natural controls, such as microbial pathogens, to provoke locust and grasshopper epidemics. Such an approach is much more selective and less environmentally hazardous. There are several entomopathogenic fungi which serve as active ingredients for locust and grasshopper biopesticides. Another alternative is to use lower-toxicity pesticides, such as Insect Growth Regulators applied in intermittent swaths; this method became the preferred way to control grasshoppers on U.S. rangelands. Locusts and grasshoppers continue to

present challenges, and inspire pest managers, in the 21st century.

Survey of rangeland using remote sensing tools to assess forage saved

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Rangeland grasshoppers and Mormon crickets are a perennial threat to North American rangelands. Left unchecked, native rangeland damaged by outbreak populations can be overwhelmed by invasive plant species, which can infest productive range with less desirable plants. The cornerstone of management efforts is field survey to determine the grasshopper species present on the rangeland, population density, and forage availability.

Efforts to create a force multiplier for field survey methods are of increasing interest to rangeland managers. Remote sensing was utilized to assist rangeland managers by analyzing the topography of rangeland through aerial black and white photography during the 1930s. The next major advance was the onset of satellite remote sensing, which offered a method for assessing rangeland on a broad scale through an increased sensor field of view in comparison

to the existing aviation assets of the day. The introduction of Unmanned Aircraft Systems (UAS) and the miniaturization of electronics, producing lightweight sensors and flight control equipment, has created a new potential for remote sensing to affect rangeland survey through increased resolution and flexible use. We exist in the age of cheap, commercially available aerial platforms in tandem with an increasing diversity of lightweight sensors.

Using multispectral analysis of rangeland, we hypothesized that rangeland grasshopper and Mormon cricket populations may be estimated and delimited by classifying pixels within an NDRE vegetation index as plant or soil area and comparing these classifications temporally. We tested this hypothesis using eight 40-acre plots of rangeland near Encino, NM during the summer of 2017. Multispectral images were gathered over each plot on the 24th of June and again on the 25th of September using a MicaSense Red Edge Multispectral sensor. Four of the eight plots were treated with Dimilin to remove the grasshopper population and provide a comparison to a low population area. Each pixel within the imaged areas
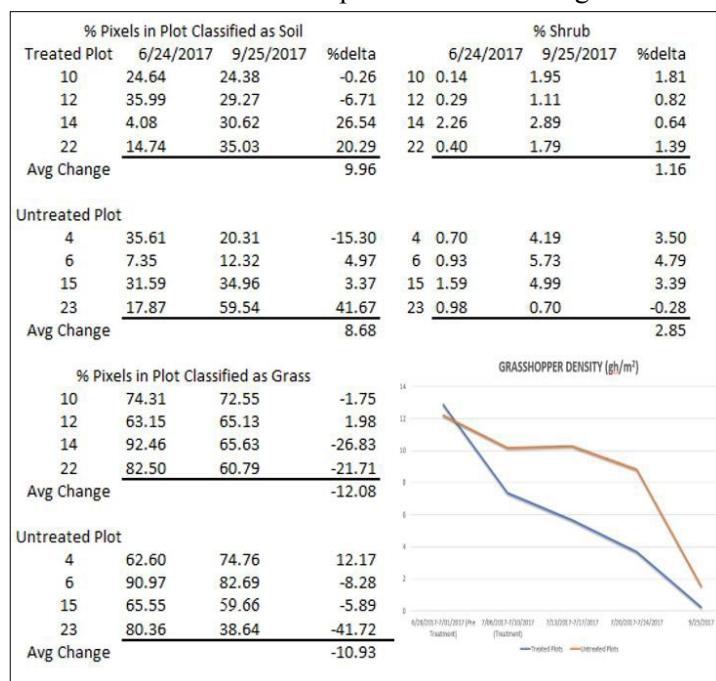

% Pixels in Plot Classified as Soil				% Shrub			
Treated Plot	6/24/2017	9/25/2017	%delta		6/24/2017	9/25/2017	%delta
10	24.64	24.38	-0.26	10	0.14	1.95	1.81
12	35.99	29.27	-6.71	12	0.29	1.11	0.82
14	4.08	30.62	26.54	14	2.26	2.89	0.64
22	14.74	35.03	20.29	22	0.40	1.79	1.39
Avg Change			9.96				1.16
Untreated Plot							
4	35.61	20.31	-15.30	4	0.70	4.19	3.50
6	7.35	12.32	4.97	6	0.93	5.73	4.79
15	31.59	34.96	3.37	15	1.59	4.99	3.39
23	17.87	59.54	41.67	23	0.98	0.70	-0.28
Avg Change			8.68				2.85

% Pixels in Plot Classified as Grass			
10	74.31	72.55	-1.75
12	63.15	65.13	1.98
14	92.46	65.63	-26.83
22	82.50	60.79	-21.71
Avg Change			-12.08
Untreated Plot			
4	62.60	74.76	12.17
6	90.97	82.69	-8.28
15	65.55	59.66	-5.89
23	80.36	38.64	-41.72
Avg Change			-10.93

GRASSHOPPER DENSITY (gh/m²)

Figure 10. Percentage of pixels classified as soil, grass, or shrub.

was classified as soil, grass, or shrub (Fig. 10). The results from this experiment are still being analyzed.

Future exploration of the hypothesis involves the direct measurement of forage height and fractional cover to estimate the available biomass of the rangeland. We plan to next compare data sets using a LiDAR sensor during nymph development and attempt to ascertain forage loss from feeding. The measurement of forage loss, temporally, may allow for the estimation of the density of the grasshopper populations. Spatial measurements of available forage, using the direct measurement of forage height and fractional cover, may allow for an expedited method to delimit high density, hot spot, grasshopper populations without the need for a temporal analysis.

Territoriality in *Reticulitermes*: Insights from field and lab studies

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Territoriality, the occupation and defense of an area, is common across animals. In social insects, like termites, this territoriality can vary from nests, food items, and foraging trails, to entire foraging areas. This project examines territoriality in subterranean termites, *Reticulitermes* spp., by investigating how termites detect other nearby termite colonies, how they then recognize their own colony, and, finally, their reaction to opposing termite colonies. To tease apart these processes, a field site was established at the Sam Houston State University Center for Biological Field Studies in Huntsville, Texas. Two 28 m x 28 m grids were created with pine stakes placed 2 m apart. Samples from these monitors were collected monthly and genetically identified to species. Each group of actively foraging termites was then genotyped with microsatellite markers to determine colony identity. In the first 16 months (September 2016 to December 2017), termite activity appeared to be correlated with soil temperature (Fig. 11).

Termites from this field site will be collected and brought back into the laboratory for behavioral studies. These will consist of petri plate aggression assays, the standard but less realistic setup in which termites of each colony are differentiated by feeding on dyed filter paper and introduced into a petri plate for a set amount of time. Planar assays, where an area of media is sandwiched between two sheets of Plexiglas allowing termites to tunnel in a 2 dimensional space, will be used as a more field relevant test of aggression. In these assays, various cues can be isolated and tested. For example, the vibrational signature of a colony will be recorded from a single colony in a planar arena and then played back to a different colony in a planar arena. This will test the importance of vibrational cues to colony detection. Additionally, the role of gut microbes will be assessed in these arenas. The microbes will be knocked out with antibiotics and then reintroduced from a different colony through trophallaxis or proctodeal feeding. These termites with newly introduced microbial fauna can be paired in arenas with control individuals from their original colony, as well as members of the colony the new microbial profile was introduced from, to compare the aggressive responses between groups.

A better grasp of these processes is important to a more complete understanding of termite biology. Also, if understood, these cues could be engineered into a mechanism of controlling pest termite species by causing either civil wars within colonies or battles between colonies by manipulating cues of recognition and avoidance.

Insights into the evolutionary history of the Neotropical Romaleinae (Acridoidea, Orthoptera)

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The subfamiliy Romaleinae (Romaleidae), with more than 250 valid species in 69 genera, occurs in the Americas, mainly in the Neotropical Region. Its distributional range covers a wide variety of habitats, extending from Argentina with diminishing diversity to the south of the Nearctic region. One of the hypotheses on the diversification of the group suggests
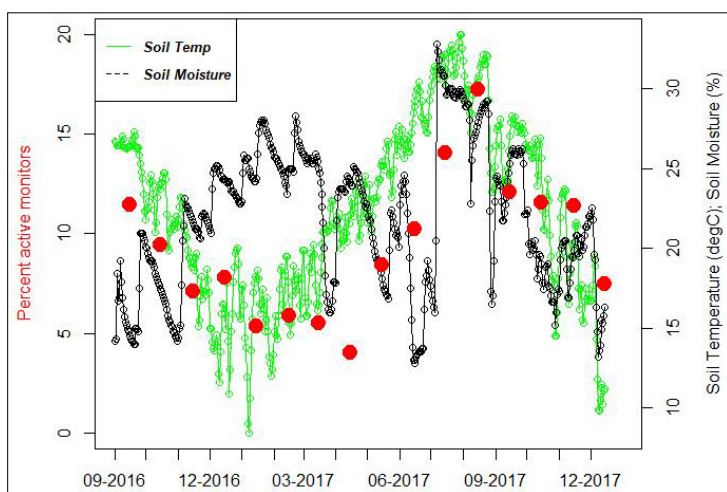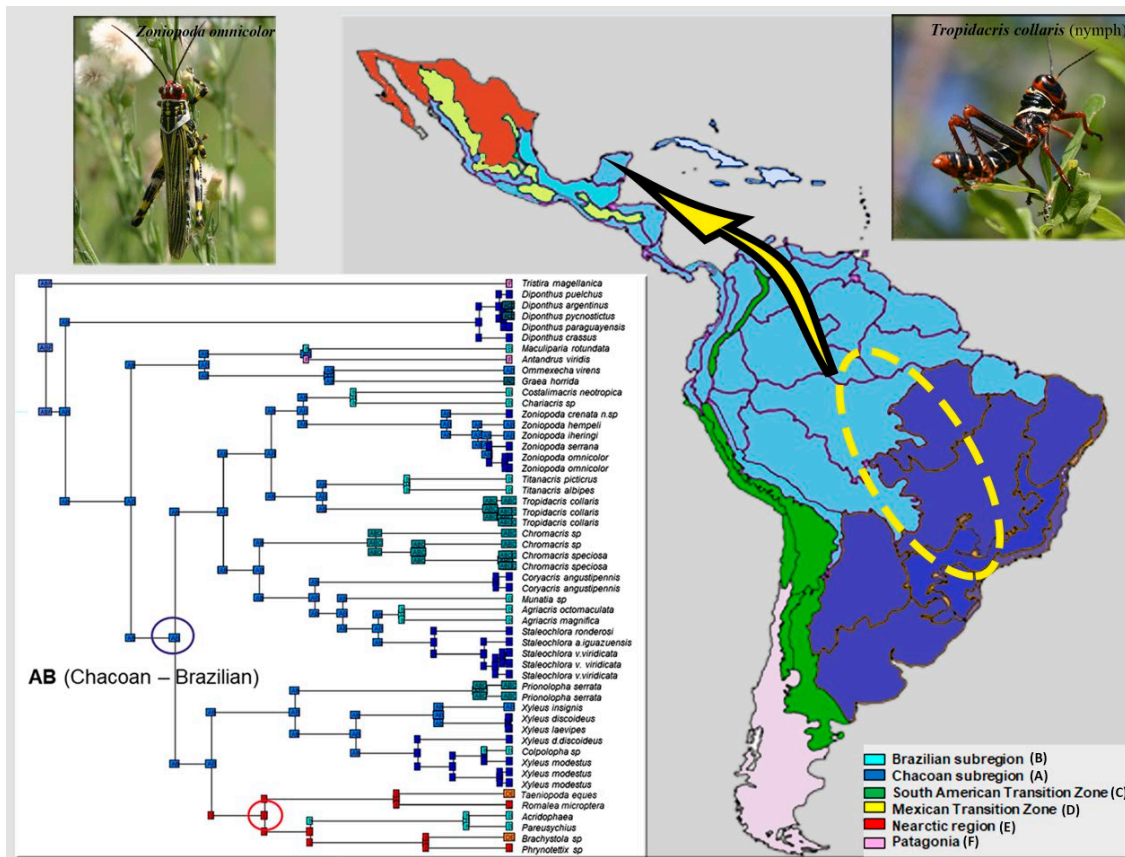

Figure 11. Termite activity (red dots), measured by the percent of stations with active termite foraging for the first 16 months. Additionally, soil temperature (green) and moisture (black) are plotted for the same timespan (source: nrcs.usda.gov).

Figure 12. Areas of the Neotropical region (Morrone, 2014) used for the biogeographic analysis, and estimation of the ancestral area and colonization direction for the Romaleini sensu lato (BioGeoBEARS, BAYAREALIKE + J).

pers. However, this is a preliminary study and we have uncertainty regarding some relationships, e.g., the position of the Hisychiini within the Romaleini clade. Further studies, including a wider taxon and character sampling, will be conducted in order to obtain a more robust phylogenetic hypothesis for the Romaleinae and to test the biogeographic hypothesis for the whole subfamily.

The future of orthopteran systematics

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a tropical South American origin, and considers that the colonization of the temperate zones of South America might have occurred earlier than the extension to the temperate zones of North America (Carbonell, 1986). Here we test this hypothesis for the tribe Romaleini *sensu lato* based on a phylogeny established on morphological and molecular evidences. The total evidence data set included 35 species (47 specimens) representing 19 genera of Romaleini sensu lato and six outgroup species (6 specimens) of Romaleinae (Phaeopariini, Hisychiini), Ommexechidae and Tristiridae. The morphological set was constituted by 92 characters from external morphology and male genitalia, and the molecular set included fragments of COI, COII and H3 markers. We performed a Bayesian Analysis (BEAST v1.8.3), and the tree obtained was analyzed using the R package BioGeoBEARS (Matzke, 2013) to estimate the ancestral geographic range of the group.

We defined six areas following the regionalization of the Neotropical region by Morrone (2014).

The results of the phylogenetic analysis (Fig. 12) recovered with low support all the genera of Romaleini sensu lato considered in this study except for the genus *Antandrus* (endemic to Chile) and the South American genus *Diponthus*. Furthermore, the representatives of Hisychiini were included in this major clade, grouped with the North American members of the Romaleini. The BAYAREALIKE + J resulted as the most probable model in BioGeoBEARS, inferring that the ancestral area for the clade of Romaleini, including the members of Hisychiini, was set in the Chacoan and Brazilian subregions (Fig. 12), and the major diversification of the group might have occurred in this area too.

Our results suggest a colonization route from South America to North America for this group of grasshop-

Orthoptera is the largest polyneopteran order with more than 27,800 valid species, consisting of two monophyletic suborders, Ensifera and Caelifera. In recent years, a number of molecular phylogenetic studies focusing on various orthopteran groups have been published, which have collectively advanced our understanding of the biology and evolution of this fascinating group of insects. Some of these findings have provided novel insights into understanding the higher-level relationships as well as the evolution of major orthopteran lineages, including Tettigoniidae, Gryllidae, and Acrididae. It has also become evident that there are several clades that would require additional studies in order to fully understand their phylogenetic relationships and there are many challenges in achieving full resolution.

Although most phylogenetic studies of Orthoptera are still largely lim-

ited to Sanger data or mitochondrial genomic data generated using next-generation sequencing, I reported current progress made in collaboration with the 1KITE consortium and our approach to combine transcriptome and mitochondrial genome data to infer the phylogeny of Orthoptera (Fig. 13). While we have made great strides in molecular phylogenetics, we are also rapidly losing our taxonomic expertise. I discussed historical reasons why we have entered the era of taxonomic impediments and highlighted some interesting groups, such as Eumastacoidea, Gryllacrididae, and Rhaphidophoridae, which are in urgent need of a new generation of taxonomic experts.
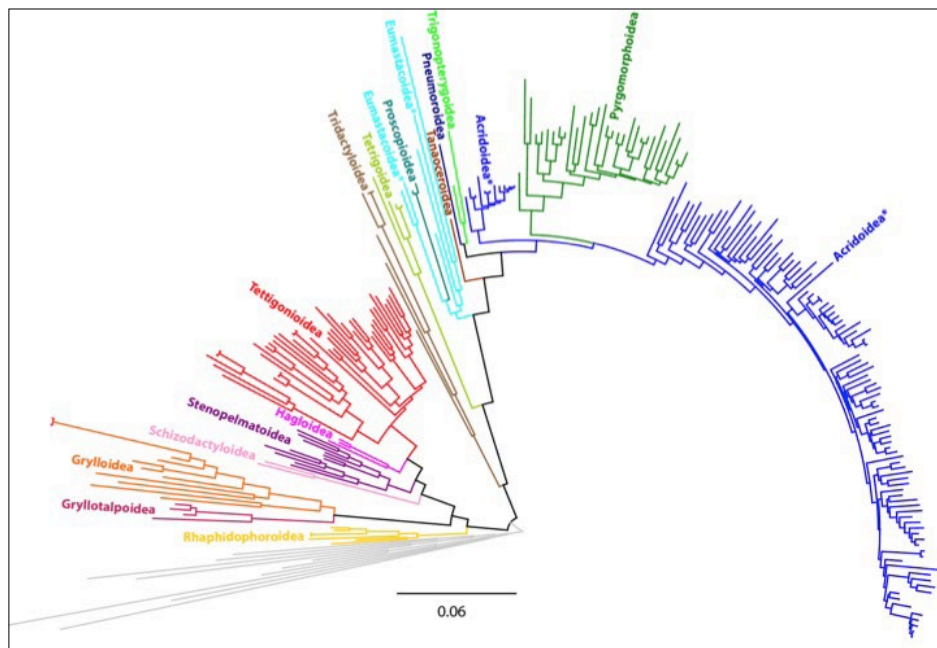

Figure 13. A combined phylogeny of Orthoptera based on transcriptome and mitochondrial data.

The 2nd Eurasian Orthopterological Symposium
(Novosibirsk, Russia, August, 2-3, 2017)

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The 2nd Eurasian Orthopterological Symposium was organized as a satellite meeting during the 15th Congress of Russian Entomological Society (Novosibirsk, 2017, July 31–August 7) and the Symposium was held in August 2–3. The Symposium was hosted by Novosibirsk State University and the Institute of Systematics and Ecology of Animals. Orthopterists from different parts of Russia – from Moscow to Vladivostok – could meet during the Symposium. The Program of the Congress included special time for formal and informal meetings of the orthopterists. They were also involved in activity of other sessions of the Congress. During the Symposium and informal meetings the orthopterists could discuss

Bryodema gebleri gebleri (Fischer de Waldheim), female, in the mountain semi-desert of the central part of Tuva (South Siberia) (Photo credit: M. G. Sergeev)

some actual problems of orthopteran systematics, geography, and ecology, and develop some ideas concerning cooperation between different groups of researchers. Some prospects to prepare and publish a comprehensive book about Orthopteroidea of Tuva (South Siberia) have been specially discussed. Additionally, the attendees discussed some issues of applied acridology: new approaches to population management, some opportunities to use remote sensing technologies and new types of biological acridicides. After the Congress, all attending orthopterists were asked to prepare English versions of their abstracts for publication in *Metaleptea*, which can be found below

Mixed sound-vibrational communication in Orthoptera

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Sometimes it is almost impossible to draw a clear boundary between sound and vibrational signals in bioacoustics, since sound signals themselves cause oscillations in solid media. Besides, a singing insect can secondarily induce vibrations in substrate without direct contact. Until now, in most cases sound and vibrational signals of insects have been studied separately. Moreover, the vibrational communication of Orthoptera remains practically unexplored. Recently for the acridid insects, which produce sounds by rubbing their hind legs against forewings, the curves of motion algorithm of hind legs have been registered additionally and then compared with the amplitude-time modulation of the sound oscillogram. In the case the movements of the hind legs are not accompanied by an audible sound from stridulations, they are interpreted as demonstrational. Our studies have shown that it is not

always the case. The author is the first to apply the method of synchronous recording of sounds and vibrosignals produced by male orthopterans on two separate channels of a digital recorder. Rather complete picture of mixed sound-vibrational intersexual communication has been obtained for some representatives of katydids (Tettigoniidae), crickets (Gryllidae), and grasshoppers (Acrididae: Gomphocerinae and Oedipodinae). It was found that males of all species studied use specific sound and vibrational signals during courtship. Besides, their calling sound signals lack the similar vibrational component. For instance, rhythmic abrupt jerking of the entire body, which induce high-amplitude vibrational pulses, is observed in grasshoppers and crickets during stridulation performed by a male next to the female. At the same time, a soundless tremulation of hind limbs, which induce well-registered vibrations in the substrate, is noticed in a similar situation prior to stridulation in some grasshoppers living among vegetation and leaf litter (Acrididae: Gomphocerinae). In contrast, geophilous species (Acrididae: Oedipodinae) had almost completely switched to a vibrational communication channel (strikes against substrate, tremulations), using sound much more rare than other orthopteran species studied.

Recently we have discovered specific mixed sound-vibrational communication in the small rice grasshopper *Pseudoxya diminuta* (Walker) (Acrididae: Oxyinae). Both sexes of this species have developed tympanal organs for hearing. Receptive females produce rather loud sound signals by spines of hind tibiae scratching against forewings and thereby attract males. Besides, other females are probably warned of occupancy of the territory (this is part of the function of calling signals). Vibrosignals are not noticed for females, and also no sound signals are known for males. Unlike females, males produce only vibrational signals at close distances

in two different ways, alternating them during the emission of one phrase. At the beginning of phrase the contraction of thorax muscles transmits as a well-defined vibrosignal via middle limbs into the substrate. It is followed by a tremulation (large-amplitude trembling) of hind limbs in a horizontal plane, perpendicular to the body axis, also inducing specific vibrations. It is possible that such role of communication has been developed in this species due to fierce competition for communication channels in the multispecies communities of singing insects of South-East Asia. The analysis of all data allows us to conclude that the occurrence of the special vibrational channel in intersexual sound communication among representatives of different groups of the orthopteran insects can be an additional way of interspecific isolation, and also play an important role in keeping a female next to the courting male.

Translocation model of the sex chromosomes evolution in the Pamphagidae grasshoppers

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In Pamphagidae we described an unusual event for the grasshoppers' karyotype evolution: translocation of an autosome to the X-chromosome. This chromosome rearrangement resulted in formation of a new mechanism of the sex determination:

neo-XY♂/XX♀. We searched for diversity of structural variants of the sex chromosomes in previously un-investigated 40 species belonging to Pamphagidae from South and North Africa, Asia Minor, Transcaucasia and Central Asia. We showed that all studied species of the tribe Nocaro-deini (Pamphaginae) and most species from the genera *Asiotmethis* Uvarov and *Glyphotmethis* Bey-Bienkoi (Th-rinchinae) have the neo-XY♂/XX♀ sex chromosome system in contrast to other Pamphagidae, which have common for the orthopteran insects the X0♂/XX♀ sex determination. The evolutionary trends towards the min-iaturization and heterochromatization of the Y chromosome and different stages of this process in the subfami-lies Thrinchinae and Pamphaginae indicate the independent origin of the neo-Y chromosome in these subfami-lies (Jetybayev et al., 2017).

Original microdissected DNA probes from different regions of the neo-Y and the neo-X chromosomes of the species of the tribe Nocaro-deini, the genera *Asiotmethis* and *Glyphotmethis* (Thrinchinae) were generated. Heterologous chromosome painting in *Asiotmethis* and *Glypho-tmethis* species with the *Asiotmethis heptapotamicus* (Zubovsky). DNA probes revealed significant homol-ogy of repeated DNA sequences in the neo-Y chromosomes in different species of these genera. This result underscores the weak divergence of the molecular composition of the Y chromosome within this group of species. Heterologous chromosome painting in the Nocarodeini species with the *Nocaracris cyanipes* (Fischer de Waldheim), *Nocaracris rubripes* (Fischer de Waldheim), *Nocaracris tardus* Ünal et al., and *Paranocarodes tolunayi* Ramme DNA probes also revealed the homology of repeated DNA sequences in the Y chromo-some in some species groups, but not between all studied species of these groups. Furthermore, the intensity of the painting signal between species

may be used as an additional phyloge-netic signal in the tribe Nocarodeini. The painting revealed no homolo-gous repeats in the sex chromosomes between the subfamilies Thrinchinae and Pamphaginae. We suggest that heterochromatinization of the neo-Y chromosome involves amplification of random rapidly evolving DNA repeats in different lineages of species.

Altitudinal distribution of Or-thoptera in the North Urals

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In the North Urals, 21 species of Orthoptera have been found, namely 1 species of Gryllidae, 4 of Tettigo-niidae, and 16 species of Acridoidea. Field studies were organized in the Pechora-Ilych Nature Reserve in the Komi Republic (the north-eastern part of European Russia) from 2005 until 2012. Two grasshoppers spe-cies, namely *Chorthippus apricarius* (Linnaeus) and *Chorthippus paral-lelus* (Zettestedt), were found for the first time in the North Urals. The long-term investigations allow to reveal some evident pattern of the orthopteran altitudinal distribution. Almost all species both of katydids and grasshoppers are associated with local plains where they populate meadow openings, swamps and clear-ings. The only *Podismopsis poppiusi* (Miram) occurs in the altitudinal belts of the alpine meadows and moun-tain tundras. Its abundance may be relatively high, up to 3–5 per square meter. This pattern may be explained by some adaptations of the species especially associated with egg-laying process. The shape of its egg-pods is

irregular depend on substrate. Egg-mass is enveloped by finely meshed, shining, brown froth and with frothy layers in between eggs. The egg-pod wall is either absent (for the egg-pods on leaves), or of plant remains and soil particles cemented by froth (in leaf litter), or of weakly cemented soil particles (in soil layer). Egg-pods are either on leaves, or in leaf axils, or in leaf litter, or in soil layer. Egg-pods dispose either up to 0.5–0.7 mm above soil-surface (in two first cases) or 5–7 mm below it (in last case). Such type of disposition is suitable for heating and early development. This is especially important for the mountain tundras. Three species of the genus *Tetrix* Latreille occur in the piedmont and mountain areas. Their egg-laying peculiarities allow them also to live in the local mountains. Besides, some specimens of *Melanop-lus frigidus* (Boheman) was observed in the lower part of the mountain tundra belt. Thus, structures and dis-positions of egg-pods are the limiting factors for altitudinal shifts of orthop-teran species in the region.

Katydids and crickets (Orthop-tera, Ensifera) in the forest-steppes of right-bank Priob'e (South Siberia)

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The landscapes on the right-bank of the Ob Rivers are a mosaic of different relief forms: some parts of West Siberian Plain, piedmont hills of Salair Range, Salair Range per se, intermountain Kuznetsk Basin. They are in the region with a humid conti-nental climate. The areas are charac-terized by complicated combination of both, natural (steppes, meadows, forests) and transformed (agricultural

fields, pasturelands, urban landscapes, land changed by coal mining, etc.) habitats. It provides conditions for the dwelling of various Ensifera (Orthoptera). The report is based on both original data collected in 1998–2008 and some published data (Tarbinsky, 1925; Berezhkov, 1946; Skalon N., 1997; Skalon O., 2008). The author is sincerely appreciated to Dr M. G. Sergeev for opportunities to use his materials from 1979, 1981, 1983. In the forest-stepped landscapes of this region, there are 17 species of Ensifera belonging to two superfamilies: Tettigonioidea (Tettigoniidae only) and Grylloidea (Gryllidae and Gryllotalpidae). The level of the Ensifera diversity is relatively low in comparison with the fauna of the left-bank (the so-called Baraba forest-steppe) due to drastic decrease in the steppe species. The fauna of the right-bank area is similar to the corresponding faunas of adjacent mountain regions (Altay and Sayans) with which it shares 11 common species (Storozhenko, 2004). The most humid habitats (flood-plain grassy meadows, swamp grassy meadows, meadows in depressions) are inhabited by *Roeseliana roeselii* (Hagenbach). In flood-plain osierbeds, tall grass meadows, wastelands and forest belts, *Tettigonia cantans* (Fuessly) is often found. Open and more warm habitats, formed out of forbs with an admixture of meadow grasses, attract *Poecilimon intermedius* (Fieber), *Bicolorana bicolor* (Philippi). In steppe meadows, *Gampsocleis sedakovii* (Fischer de Waldheim), *Decticus verrucivorus* (Linnaeus), *Phaneroptera falcata* Poda joins them. In the meadow and sagebrush steppes, *Montana montana* (Kollar) occurs too. Two species of crickets, namely *Dianemobius fascipes* (F. Walker) and *Melanogryllus desertus* (Pallas), are distrubuted over well-warmed rocky slopes, beaches and heaps of gravel as well as along the roads. The synanthropic *Acheta domesticus* (Linnaeus) is widely spread, populating cellars

and the first floors of houses as well as heating mains. We have not found yet *Tettigonia caudata* (Charpentier), *Montana eversmanni* (Kittari), *Metrioptera brachyptera* (Linnaeus), and *Modicogryllus frontalis* (Fieber), previously noted in the Kuznetsk Basin (Berezhkov, 1946; Skalon N., 1997; Skalon O., 2008). The zoogeographical analysis revealed that the Ensifera fauna of the region consists of the species belonging to the quite different faunistic complexes associated with (1) the steppes of West Asia (37 %), (2) the nemoral landscapes of the West Palearctic (14 %), (3) the semi-deserts of West Asia (37 %), (4) the forests of the East Palearctic (7 %), the forest-steppes of the West Palearctic (7 %), the steppes of Central Asia (7 %), the Paleosubtropical areas (7 %), the deserts of West Asia (7 %).

Key words: Ensifera, katydid, cricket, South Siberia, distribution, biodiversity

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Orthopteran assemblages in the steppe landscapes of Central Yakutia

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The distinct feature of the landscapes of Central Yakutia is the presence of steppe vegetation among the larch taiga. Such habitats are confined by treeless south-exposed slopes of river valleys, upper terraces, and the periphery of the so-called alas depressions. The study was conducted in 1997–2011 covering different regions of Central Yakutia (the Amga River valley, the Lena–Amga interfluve, the Lena River valley, and the south-western part of the Lena–Vilyuy interfluve). In total, 17 orthopteran species have been recorded, most of them belong to the family Acrididae, two species are of the family Tettigoniidae, and the only species is of Tetrigidae. The core of steppe assemblages was

formed by 8 species: *Gampsocleis sedakovii* (Fischer von Waldheim), *Montana montana* (Kollar), *Omocestus haemorrhoidalis* (Charpentier), *Glyptobothrus maritimus jacutus* Storozhenko, *Gomphocerus sibiricus* (Linnaeus), *Aeropedellus variegatus variegatus* (Fischer von Waldheim), *Celes skalozubovi* Adelung, and *Bryodemella tuberculata* (Fabricius). *Chorthippus fallax* (Zubovsky) and *Euthystira brachyptera* (Ocskay) were less common. *Chorthippus albomarginatus* (De Geer) inhabited the meadow steppes and abandoned fields. On the Lena-Amga interfluve, with its well known and widely distributed the thermokarst depressions (or alases), *Montana eversmanni* (Kittary) and *Arcyptera albogeniculata* (Ikonnikov) have been recorded (in the Tyungyulyu vicinities). The local orthopteran assemblages usually consists from 3 to 9 species. The richest assemblages (7–9 species) were in the forb-grass steppes on the southern slopes of the Lena River valley and in the meadow steppes on the river terraces. The poorest assemblages (1–2 species) were recorded in the petrophytic steppes on the slopes of the Amga River valley.

All studied assemblages are characterized by the low and moderate biodiversity levels. The Shannon diversity index did not exceed 1.98. The Pielou evenness index varied between 0.42 to 0.94. The abundance levels were from the low to moderate ones (24–232 per hour). The qualitative and quantitative compositions of assemblages are determined by composition of plant associations, human activity, and climatic fluctuations. The most xeric variants of steppes on slopes were characterized by absolute dominance of *Glyptobothrus maritimus jacutus* (scoring V according to the scale of relative abundance by Pesenko (1982)). *Chorthippus albomarginatus* and *Omocestus haemorrhoidalis* were very abundant in the meadow steppes on river terraces. In the Amga River valley, an unique

assemblage with predomination of *Stenobothrus lineatus* (Panzer) was revealed on the slope covered by the petrophytic Festuca–Pulsatilla–Orostachys steppe. This species is usually found in the forb vegetation along the larch forest openings. Two major types of the steppe orthopteran assemblages can be distinguished in Central Yakutia based on species composition, structure, and landscape–biotopic preferences: (1) Assemblages of the relic steppes with dominance of Glypthobotrus maritimus jacutus and (2) assemblages of the forb steppes and ruderal vegetation.

The study was conducted within the frame of the Basic Project AAAA-A17-117020110058-4.

Meiosis in the Speckled cockroach *Nauphoeta cinerea* (Olivier) (Blaberidae): Close to either the Migratory locust or Common fruit fly?

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Meiosis provides the formation of cells with a reduced number of chromosomes. Reduction is provided by two cell divisions after one round of replication. In the prophase of the first division, the homologous chromosomes are pairing, recombination occurs between non-sister chromatids. These events connect the homologues into bivalents and allow them to divide in the first anaphase. The synapsis is accompanied by the synaptonemal complex formation. For the recombination multiple double-strand breaks (DSB) are required, which are labeled with the phosphorylated form of histone H2AX (γ-H2AX). Then, there is a search for homology and repair with recombinase Rad51. Only a part of these DSB leads to crossover exchange. Now the two most common variants of these events sequence are known, which are described for different taxa (Viera et al., 2004; Zickler, Kleckner, 2016). Both of which are found in insects. In the first variant, DSB, homology search and recombination precede the synapsis (*Mus musculus* Linnaeus, Saccharomyces cerevisiae Meyen ex E. C. Hansen, and locust. Another variant was found in the roundworms and fruit flies, organisms whose homologues are synapted constantly, so the synapsis precedes recombination.

The cockroach *N. cinerea* has $2N\male = 36 + X0$ (Desai, 1970). In this species, the large and medium metacentric chromosomes with huge C-heterochromatin blocks that occupy almost the entire one of chromosome arms were found (Kornienko et al., 2009). During the leptotenes and zygotenes these heterochromatin blocks do not involve in the synapse and are located in the region of the nucleus opposite to the "bouquet" of synaptic regions. We investigated the dynamics of synapsis and recombination in the Speckled cockroach by immunolocalization of key meiotic proteins (Anderson et al., 1999; Viera et al., 2004) on the preparations of spreading spermatocytes (Peters et al., 1997). To visualize the axes of chromosomes and the formation of synaptonemal complexes, antibodies to the protein of the cohesin complex SMC3 were used. To visualize DSB, antibodies to γ-H2AX and Rad51 proteins were used. A study of SMC3 distribution in the meiotic prophase showed that in *N. cinerea*, as in the Migratory locust, this protein was detected mainly in the axial elements of chromosomes. It was found that γ-H2A signals were detected before the chromosome synapsis and remained until the end of the pachytene and later. At the stage of the late pachytene the number of signals decreased, their number and position on the chromosome often corresponded to the usual position of chiasmata in the species. The same pattern was for Rad51. In general, the sequence of events revealed in the prophase of meiosis in the cockroach was close to that described in *Locusta migratoria* (Orthoptera: Acrididae). However, the pattern of signal distribution at different stages in *N. cinerea* demonstrated some peculiarities. The γ-H2A signal on the X chromosome, unlike the Migratory locust, was not detected.

Faunistic barriers and zoogeographical regionalization of the central part of the Volga-Kama region based on the data on Orthoptera and butterflies (Lepidoptera, Rhopalocera)

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The Volga-Kama region covers a vast territory in the basin of the Middle Volga River and its tributaries, being bounded by the Ural Mountains in the east. With regards to the territorial division, the central part of the region is the Republic of Tatarstan (RT) (Popov, 1960). We have performed complex studies of orthopterans and rhopalocerans in last decades. The results of the studies allowed us to compile the full lists of species belonging to these insect groups and to obtain data on their spatial distribution within the territory under consideration (Karmazina, Shulaev, 2015; Petrov et al., 2017). To date, we registered 72 orthopteran species from 48 genera and 6 families and 161

butterfly species from 66 genera and 6 families.

Based on the data on the distribution of insects in the region and on the analysis of faunistic similarities between different physiographic provinces of RT, the following nine zoogeographical borders were identified: (1) Upper Volga border (low-efficiency border, runs along the Volga River up to the mouth of the Kama River); (2) Vyatka border (medium-efficiency border, runs along the Vyatka River and divides the Cis-Kama area into the western and eastern parts); (3) Upper Volga–Kama border (low-efficiency border); (4) Vyatka–Kama border (medium-efficiency border, runs along the Vyatka and Kama Rivers); (5) Kama border (medium-efficiency border, runs along the Kama River from the borders of Tatarstan to the mouth of the Kama River); (6) Upper Kama border (medium-efficiency border); (7) Lower Volga border (low-efficiency border, runs along the Volga River from the mouth of the Kama River up to the RT boundary); (8) Lower Volga–Kama border (low-efficiency border, runs along the Kama River and the Volga River up to the mouth of the Kama River); (9) Bugulma–Belebey border (this medium-efficiency border coincides with the boundary of the Bugulma–Belebey Upland).

According to the above zoogeographic borders, we suggest a scheme of zoogeographical regionalization of the studied territory, which includes the following five provinces: I. Western Cis-Kama forest Province (with the pine, pine-deciduous, deciduous, and mixed forests). II. Eastern Cis-Kama Province of forests and bogs (with the dark coniferous and nemoral forests). III. Cis-Volga Province of forests and forest-steppes (with the deciduous and pine-deciduous forests and the forest-steppe with the steppe landscapes). IV. Trans-Kama Province of forests and forest-steppes (with the deciduous and pine-deciduous forests and the forest-steppe with the steppe landscapes). V. Bugulma-Belebey forest-steppe Province (with the meadow steppes and deciduous steppe-grass forests). Therefore, we have described the zoogeographical regionalization scheme of the territory based on the peculiarities of its insect fauna for the first time.

Key words: Orthoptera, Rhopalocera, butterflies, regionalization, faunistic barrier, Volga, Kama, Tatarstan

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Distribution and abundance of the Moroccan locust (*Dociostaurus maroccanus* (Thunberg)) in South-West Tajikistan

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Grasshoppers are one of the most abundant and important ecological groups in natural and transformed ecosystems of Tajikistan. Their local fauna may be characterized as highly diverse. It includes at least three locust species. Some acridids, especially locusts, may be important pests. However, only the Moroccan locust was and is the very serious pest in the Republic. In spring and in the beginning of summer this species is commonly very abundant over local dry grasslands. Its outbreaks are determined by habitat altitudes, other peculiarities of ecosystems, and weather conditions. In the South-West Tajikistan, hoppers usually hatch in the end of March. Their development continues until the end of April. Egg-pods are laid in relatively hard soils covered by heterogenous grass vegetation on grassland hills and plains. In April of 2014 and 2015 several plots with high abundance of the Moroccan locust have been revealed in the Vakhsh, Bokhtar and Khuroson Districts. The egg-pods have been laid in the typical soils. Young hoppers' abundance has varied between 30 and 432 per hour. In the beginning of June, 2015, the Moroc-can locust outbreak has occurred on the right bank of the Panj River (Hamadoni District). This outbreak has been associated with plain habitats covered by dry vegetations. The density has been between 2 and 15 adults per square meter. Numerous pairings have also been observed. The similar situation has been revealed on the right bank of the Panj River, but in the Qumsangir District on the piedmont plain of Terekli-Tau. The density has been between 5 and 47 adults per square meter. The small outbreak with densities between 2 and 25 adults per square meter has been described in the Khuroson District. Numerous adults of the Moroccan locust have been also observed in the Jilikul District. The density has been about 1–5 per square meter.

Key words: Moroccan locust, *Dociostaurus maroccanus*, South-West Tajikistan, outbreak

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The Italian locust — *Calliptamus italicus* (Linnaeus) (Orthoptera): A quarter of a century after

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The Italian locust is a common and the most important pest in the steppes and semi-deserts of Eurasia, from the Ukraine to the southern part of West Siberia. Many of its outbreaks were described from these areas and from the neighboring mountains, and also from the Mediterranean region. The situation became especially serious in the end of the last century. For example, in 2000 more than 16,600,000 ha were infested and more than 10,000,000 ha were treated by different insecticides (Latchininsky et al. 2002). Waves of the Italian locust

outbreaks have resulted in significant changes in both, our knowledge of its ecology and approaches to its population management. The unprecedented series of the Italian locust outbreaks in 1992–2002 was determined by both, climatic fluctuations and significant changes in political, economic and social life in the former USSR. Numerous bands and swarms of the species were observed almost every summer, however, their spatial distribution changed significantly.

An analysis of published and unpublished data on the Italian locust population dynamics collected during last two decades shows the strategy and tactics to manage its populations should be changed considerably. (1) Crucial habitats and periods that are important for the Italian locust population dynamics should be determined. The new strategy should be based on a set of diverse tactic approaches associated with some peculiarities of specific territories, habitats, time lapses, and economic situations. (2) Agricultural practices per se have to be changed significantly, e.g., in many regions, overgrazing should be minimized. (3) Information technologies, especially associated with remote sensing, GIS and big data storage and analysis, should become the main basis for monitoring and forecasting. (4) New solutions are also important for field assessments of the Italian locust populations. Real time observations by using UAV may be very promising. (5) New types of acridicides, both chemical and biological, should be tested. These formulations should be both very effective and ecologically acceptable(e.g., selective). (6) New approaches must be developed to manage locust populations on the landscape scale and to treat agricultural fields and rangelands. (7) International bodies should be developed to manage populations of grasshoppers as a whole and of the Italian locust in particular, especially in the trans-boundary areas of upsurges.

In any case, the acridids are one of the most significant parts of the steppe and semi-desert ecosystems. Stebaev (1968, 1972), Kambulin and Bugaev (1980), Gandar (1982), Hewitt and Onsager (1982) showed the evident role of grasshoppers in ecosystem energy/matter fluxes. These insects consume significant part of aboveground vegetation, increase rates of its transmission in food chains and change spatial characters of fluxes in local ecosystems (Stebaev 1968, 1972). Belovsky (2000) also finds that grasshoppers can enhance plant production over years. Some locusts during outbreaks can change energy and matter fluxes in ecosystems, e.g., by accelerating and escalating nutrient turnover (Boshoff 1988). In the West Siberian forest-steppes, during outbreaks grasshoppers can consume up to 90 % of grasses (Kurkin & Stebaev 1959;Kurkin 1976) and in many cases, they damage not only leaves but also growing points of grasses. As a result, vegetation cover changes significantly because competition patterns change between plants. This means we should preserve ecological and taxonomical diversities of grasshoppers to save grasslands. It is necessary to optimize relationships between these insects and humans on the basis of peaceful coexistence.

Key words: Italian locust, *Calliptamus italicus*, steppe, semi-desert, population, dynamics, outbreak

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Susceptibility of locusts and grasshoppers (Orthoptera: Acrididae) to the fungus *Beauveria bassiana s. l.* as dependent upon host ecology

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This is well known that parasite-host interactions are influenced by abiotic and biotic environmental conditions. In this respect susceptibility to *Beauveria bassiana* was assayed in several insect species from the family Acrididae (both swarming and non-swarming) remarkably different in their ecological preferences and consequently habitats.

Fungal virulence was assayed using 11 acrid taxa: *Locusta migratoria migratoria* L. (natural populations from the Astrakhan and Alma-Ata regions), *L. m. migratorioides* Reiche et Fairmaire и *Schistocerca gregaria* Forsk. (lab cultures from the Moscow Zoo collection), *Calliptamus italicus* L., *Dociostaurus maroccanus* Thunb., *Calliptamus barbarus* Costa, *Dociostaurini* species complex, *Oedaleus decorus* Germ., *Chorthippus parallelus* Zett. (natural populations from Southern Kazakhstan), *Mioscirtus wagneri* Ev. and *Mecostethus parapleurus parapleurus* Hagen. (Astrakhan region).

As many as 2–6 strains of *B. bassiana s.l.* per an insect species were used. Conidial suspension (1 · 107 conidia per ml) was used to treat 3–4th instar nymphs by brief (5 sec) immersion. All fungal strains assayed showed high virulence to the locusts and grasshoppers. After 13–15 days post infection (d.p.i.) nearly all the treated locusts (with the only exception of control) perished from mycosis. The mortality dynamics, however, significantly differed depending upon a host species and its habitat. The highest death rate was characteristic of *C. barbarus*, *Oe. decorus* and *M. wagneri* (85–100 % mortality at 7 d.p.i.; LT50 — 3.5–4.5 days). The same level of mortality was observed for three locust species (the Desert, Moroccan, and Italian locusts) at 9 d.p.i. (LT50 — 4,8–5,6 days). The best survival was demonstrated by the Migratory locust and M. parapleurus showing 55 to 90 % mortality by this time (LT50 — 6,8–7,5 days). Thus,

the xerophilous species display higher susceptibility to mycosis as compared to the hygrophilous ones. In our opinion, the cause for this variation is the difference in ecological preferences of these species, as three of them, namely *L. migratoria*, *Ch. parallelus* and *M. parapleurus*, prefer moist habitats (the reed beds at water bodies, moist meadows), while the others inhabit arid landscapes (from the forest-steppes to the deserts). In moist biotopes, the condition are optimal for fungal development and the probability of contact between the parasite and the host is higher, which may drive the insect to better adaptation to fungal infections. On the contrary, under arid conditions insects meet fungal pathogens infrequently and do not, therefore, develop mechanisms for such adaptation.

Key words: locust, grasshopper, fungus, parasite, *Beauveria bassiana*, mortality, habitat

On the fauna and ecology of Orthoptera in the arid zones of Uzbekistan

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The insect fauna of Uzbekistan has not so far been studied properly. The order Orthoptera is among the few taxa that have been investigated quite well. There are a lot of publications by numerous authors concerning the fauna and ecology of Orthoptera (Uvarov, 1927; Bey-Bienko, Mistshenko, 1951; Stolyarov, 1966; Bekuzin, 1968; Alimjanov, Ergashev, 1972; Davletshina et al., 1979; Pravdin, 1978; Pravdin, Mistshenko, 1980; Shamuratov, Kopaneva, 1980; Erga-

shev, 1982; Latchininsky et al., 2002; Gapparov, 2014). Between 2009 and 2012 we have published a series of faunistic analyses of Orthoptera in the southern part of the Aral Sea area (Medetov, 2012; Nurjanov et al., 2012). We have also studies the fauna and ecology of Orthoptera in the arid zones of Uzbekistan. Until now we have found more than 124 orthopteran species in the arid zones. Thus, according to the preliminary research, the total number of Orthoptera species in the arid zones is 142, which belong to 68 genera, 10 families and 2 suborders. We found a grasshopper species (*Eremippus costatus* Serg. Tarbinsky) new for the Central Asian fauna. The following Orthoptera species and subspecies were recorded in the arid zones of Uzbekistan for the first time: *Glyphonothus alactaga* Miram, *Phaneroptera falcata* (Poda), *Ceraeocercus fuscipennis* Uvarov, *Turanogryllus lateralis* (Fieber), *Melanotmethis fuscipennis* (Redtenbacher), *Asiotmethis heptapotamicus* (Zubovsky), *Pezotmethis ferghanensis* (Uvarov), *Pezotmethis nigrescens* (Pylnov), *Tropidopola turanica iliensis* Bey-Bienko, *Conophyma semenovi semenovi* Zubovsky, *Conophyma sokolowi decorum* Mistshenko, *Heteracris pterosticha* (Fischer de Waldheim), *Mecostethus parapleurus turanicus* Serg. Tarbinsky, *Oedaleus decorus* (Germar), *Pyrgodera armata* Fischer de Waldheim, *Stenobothrus kirgizorum* Ikonnikov and *Chorthippus (Glyptobothrus) biguttulus biguttulus* (Linnaeus).

Species abundance and their ecologic grouping were characterized by the method developed by F. N. Pravdin (1978). The species with low abundance (1–3 per hour) comprised 39.4 %, rarely occurring species (3–20 per hour) — 42.9 %, frequently occurring species (21–100 per hour) — 14.0 % and mass species forming aggregations — 3.5 %. The densities of Orthoptera in Kyzylkum Desert (0.04–0.1 per square meter) and Usty-urt Plateau (0.1–0.9 per square meter)

were relatively low, while those in the natural reserves (1.2–2.9 per square meter) and in agricultural landscapes (0.2–27 per square meter) were quite high. The orthopteran fauna of the arid zones of Uzbekistan consists of herpetobionts (4.2 %), facultative chortobionts (19.01 %), psammobionts (6.3 %), chortobionts (2.1 %), tamnobionts (9.1 %), microtamnobionts (7.0 %), chortobionts associated with grasses and sedges (2.8 %), specialized phytophiles (3.5 %), eremobionts (18.3 %), fissurobionts (10.1 %), geobionts (1.2 %), chortobionts associated with grasses (4.2 %), flying migrants (1.2 %), geophiles living under vegetation cover (2.8 %), herbivorous chortobionts (2.1 %), bothrobionts (0.7 %), petrobionts (4.2 %).

Key words: Orthoptera, Uzbekistan, arid zone, biological diversity, abundance, life form

Peculiarities of long-term population dynamics of grasshoppers (Acridoidea) and blister beetles (Meloidae) in the Kulunda Steppe (South Siberia)

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Blister beetles and grasshoppers are typical forms of the semi-arid landscape biota, damaging cultivated crops when appeared en masse. These insects' lifecycles are intimately connected by the fact of the blister beetles larvae penetrating and developing in the acridid egg-pods, consuming the egg-mass and, thus, dramatically reducing the host abundance. The objective of the present research is to compare the long-term dynamics of blister beetles and grasshoppers populations and their relationships in the central part of the Kulunda Steppe located in the southeastern part of

West Siberian Plain between the Ob and Irtysh Rivers. The territory of the study was chosen for the multiple damaging outbreaks of locusts and grasshoppers. The long-term dynamics of populations of both taxa was studied on two model plots: (1) near the Ust-Volchiha Village (2000–2009 and 2015) and (2) near Bolshoe Yarovoe Lake (1979, 1992, 2000–2008 and 2015).

There were four peaks of acridid abundance in the dry steppes near the Ust-Volchiha Village: in 2000, 2003, 2009, and 2015 (especially significant with general abundance more than 7000 specimens per hour and average density about 20 per square meter). In 2000 *Dociostaurus brevicollis* and *Oedaleus decorus* were main dominants. The Italian locust (*Calliptamus italicus*) was also common. In other cases, the group of most abundant species includes relatively small grasshoppers, namely *Omocestus petraeus*, *Glyptobothrus biguttulus*, *G. mollis* (in 2015 — also *Dociostaurus brevicollis* and *Calliptamus italicus*). The abundance of the blister beetles (mainly *Mylabris sibirica*) was maximal in 2001 (306 adults per hour) and relatively high in 2000. Since the larvae of *Mylabris sibirica* predominantly develop in the egg-pods of abundant *Dociostaurus brevicollis*, the increased population of *Mylabris sibirica* in 2001 could be associated with the abundant colonization of the egg-pods of the grasshopper the year earlier. The females of the common dominants in 2003, 2009, 2015 (*Glyptobothrus biguttulus, G. mollis, Omocestus petraeus*) produce the small egg-pods unsuitable for the development of the majority of blister beetles.

There were three periods with high acridid abundances in the dry steppes near Bolshoe Yarovoe Lake: in 1979, 2000–2001, and 2005–2007. In 1979 *Myrmeleotettix pallidus*, *Glyptobothrus biguttulus, G. mollis* and *Euchorthippus pulvinatus* were very abundant. In 2000 and 2001 the density of the Italian locust was very high. *Glyptobothrus biguttulus* and *Euchorthippus pulvinatus* were main dominants in 2005–2007. The level of the blister beetles' abundance was very low in 1979, 1992, and 2000 (after . They were almost absent in other years. This means some correlations between the long-term dynamics of the meloid and acridid populations may exist, but with some time-lag.

Transformation of orthopteran assemblages in the rangelands of extra-tropical Eurasia

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The steppes (including the so-called forest-steppes and semi-deserts) are perfect for many ungulates, rodents and grasshoppers. It was generally supposed that these animals were extremely abundant in the Eurasian steppes several millennia ago. The ungulates might (and may) consume the most part of above ground biomass and they can destroy plant litter and tussocks by their hooves. However, almost all area of the steppes has been settled by different ethnic groups of nomads with their numerous herds at least 2–3 millennia ago (Markov, 1976). As a result, almost all wild ungulates (horses, aurochs, bison, saiga, and some other antilopes) have been entirely or significantly eliminated until the 19th century (Kirikov, 1983). These species have been substituted by domestic animals, mainly sheep, cattle, horses and camels. In any case,

removal of ungulates from the steppe ecosystems results in their degradation (Gribova et al., 1980). Besides that, the huge areas of the steppes have also been ploughed: in the western parts — several centuries ago, in the eastern ones — mainly in the 19–20th centuries.

Grasshoppers and katydids are extremely significant groups in natural and disturbed ecosystems of the Eurasian steppes. These insects are abundant and colonize almost all natural and anthropogenic habitats (rangelands, agricultural fields, lawns etc.). In the steppes, grasshoppers are often the primary aboveground herbivores, consuming over 10 % of the available forage each summer (Stebaev, 1968). Among the local grasshopper there are many potential pests, e.g., the Italian locust (*Calliptamus italicus* (Linnaeus)) and the Siberian grasshopper (*Gomphocerus sibiricus* (Linnaeus)). Therefore, we may classify many orthopteran insects as keystone forms. However, this order includes many rare species too. As a rule, their ranges are relatively small, and their abundance may be low. Grazing may affect both pests and rare forms. The specific, near-polar steppes of North-Eastern Yakutia are mainly inhabited by the widely distributed steppe grasshopper (Berman, Mordkovich, 1979). The similar situation is in the dry parts of central Yakutia, in which *Chorthippus albomarginatus* (De Geer), s.l., *Gomphocerus sibiricus*, *Glyptobothrus maritimus* (Mistshenko), and *Omocestus haemorrhoidalis* (Charpentier) are the most common species over all meadow and steppe-like habitats, including the overgrazed ones. In the nemoral regions, the level of orthopteran abundance over local grazed habitats is relatively high. They are settled by widely distributed species and forms mainly associated with local river valleys. In the forest-steppes of south Siberia, human activity may be estimated as comparatively significant, but the level of grazing

is low. *Chorthippus fallax* (Zub.), *Myrmeleotettix palpalis* (Zubovsky), and *Gomphocerus sibiricus* usually prefer the local overgrazed plots. In the steppes of Kazakhstan and West Siberia, slightly grazing habitats are settled by abundant and diverse communities, however, the structure of assemblages does not change significantly. Rangelands with moderate grazing are characterized by diverse and abundant assemblages of Orthoptera. In the natural and disturbed ecosystems of the semi-deserts of Kazakhstan, we have observed the orthopteran assemblages with high level of diversity and abundance. Almost all local species are widely distributed through all grasslands, including overgrazed. Such species spread through pastures without problems, and their abundance may be very high. In the semi-deserts of South Siberia and Mongolia, the dominance of the local endemics, especially from the tribe Bryodemini, is the characteristic of assemblage composition. This situation may be observed in both, natural and disturbed ecosystems, including overgrazed. In the temperate and subtropical deserts, grazing usually results in increasing abundance and decreasing diversity. Thus, peculiarities of orthopteran assemblages and their transformations in the rangelands of extra-tropical Eurasia are determined by both, the regional geographic and ecological conditions and grazing specificity.

Orthopteroidea of Tuva: Diversity and general distribution patterns

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Tuva is the mountain region in the central part of Asia, politically it corresponds the Tyva Republic of the Russian Federation. There is a highly diverse set of ecosystems. There are many plant and animal species of different geographic, ecological and phylogenetic relations, e.g., associated with the Boreal, Gobian, Turanian and Manchurian parts of the Palaeractic. Its fauna also includes several endemic or subendemic taxa. The terrestrial and amphibiotic orthopteroid insects are very abundant and diverse in this region. Consequently Orthopteroidea is the almost ideal model group to reveal general patterns of biological diversity transformations in the region. Some studies of Orthopteroidea in Tuva started in the beginning of the 20th century and have been continued until now. However, the main part of the original data has not been analyzed before now and some taxa should be revised. Besides that, more or less relatively comprehensive publications concerning the main groups of Tuvan Orthopteroidea are absent. Therefore, published and applicable unpublished data concerning diversity, geographic and ecological distribution of these insects, and their roles in the local natural and disturbed ecosystems should be analyzed. The general patterns of orthopteroid assemblage structures and transformations and possible range shifts should be revealed relative to global, regional and local changes.

On the first stage of our project the list of all Tuvan Orthopteroidea has been composed for the first time. It includes the species known from the adjacent areas of South Siberia and Mongolia too. There are the members of several orders of the orthopteroid insects: Dictyoptera (only cockroaches — 2 known synanthropes, 2 possible species); Plecoptera, or stoneflies (73 species — 59 known taxa, 11 possible forms, 3 species should be checked); Notoptera (*Grylloblattella sayanensis* Storozhenko); Dermaptera, or earwigs (*Anechura bipunctata* (Fabricius) — known and *Labidura riparia* (Pallas) — possible); Orthoptera (119 species, including 90 known species, 26 possible forms, 4 species should be checked). There are no endemic of Tuva per se. The group of the endemics of the Altay-Sayn Mts. includes *Grylloblattella sayanensis* (Notoptera), *Zubovskya mongolica* Storozhenko, *Podismopsis altaica* Zubovsky, *Stenobothrus newskii* Zubovsky (Orthoptera). The species mainly associated with the boreal and subboreal parts of the Palaearctic populate the northern part of Tuva. Its arid territories are usually settled by the insects associated with the desert and semi-desert faunas of Mongolia and China. Several Turanian forms (e.g., *Eremippus* simplex (Eversmann)) penetrate into the arid intermountain basins of the region. Besides, the local fauna includes some species mainly associated with the Far East (*Prumna primnoa* Fischer de Waldheim, *Ognevia longipennis* (Shiraki), *Schmidtiacris schmidti* (Ikonnikov) etc.)

Mating strategies in acoustically communicating grasshopper species (Orthoptera, Acrididae, Gomphocerinae)

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Acoustic communication plays an important role in reproductive isolation in grasshoppers of the subfamily Gomphocerinae. A solitary male produces calling song to search and attract a female at distance. The receptive female responds to the male, either by an acoustic response or by a phonotaxis. At the same time males of different species use different strategies to search mates. We hypothesized that the species producing short calling songs demonstrate a higher degree of locomotion and lower acoustic activity than the species with long calling signals. Mating strategies have been studied in two areas: Moscow (Bitsevsky Park) and the Volgograd Region (Volga–Akhtuba floodplain, surroundings of Volzhsky). We used a method of individual observations. Before the beginning of each observation, the male was marked by color paints on its pronotum. We documented duration and frequency of singing, contacts with other individuals, and locomotion activity for 20–80 min. Observations were made in sunny weather (T ≈ 35 oC) from 12:00 to 16:00 on average. Six species of the genus *Chorthippus* were investigated. In the Bitsevsky Park, we studied *Ch. apricarius* (N = 6), *Ch. biguttulus* (N = 3), *Ch. albomarginatus* (N = 7) and *Ch. paralellus* (N = 4). In the city of Volzhsky, we studied *Ch. maritimus* (N = 5) and *Ch. loratus* (N = 7). During an analysis of the results, the following parameters were measured: a ratio of calling signaling duration to duration of observation (relative calling duration), a rate of calling signaling, a ratio of total distance a male moved to duration of observation (relative distance), and the number of the movements (jump or walk) per unit time (relative locomotion activity). Comparison of the relative calling duration showed significant differences between the species. The relative calling duration was the highest in *Ch. apricarius* (on average 21.9 %) and the lowest — in *Ch. loratus* and *Ch. albomarginatus* (2 % and 1.6% respectively). The comparison of the rate of the calling signaling showed some non-significant difference between the species. It was the largest in *Ch. parallelus* and *Ch. biguttulus* (on average 6.7 and 2.8 calling songs per minute respectively), whereas in other species this parameter varied from 0.5 to 1.9. The analysis of the relative locomotion activity showed significant differences between the species. The highest values of this parameter were found in *Ch. parallelus* and *Ch. apricarius* (on average 0.9 and 0.7 locomotion acts per minute respectively). The relative distance showed non-significant differences between the species. The highest distance was revealed for *Ch. maritimus* (16 m on average), the lowest — for *Ch. loratus* (1.5 m). Significant positive correlations were found between the relative duration and the rate of the calling signaling, between the relative locomotion activity and the relative distance of locomotion, and, surprisingly, between the relative duration of calling signaling and the relative locomotion activity. We have not found any significant correlations between the relative calling duration and the relative distance.

Key words: grasshopper, mating activity, acoustic communication, locomotion

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Orthoptera of the Pacific regions of Russia and adjacent countries

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Nowadays the fauna of Orthoptera of the Russian Far East, North-East China, Korea and Japan is sufficiently investigated. Totally 451 species (or 483 nominal taxa of species and subspecies rank) in 152 genera, 33 subfamilies and 16 families of this order are known from the region. Present communication aims to clarify the general trends of Orthoptera biodiversity in the island and continental sectors of the northern part of East Asia. The Orthoptera of the Pacific part of North Asia are generally characterized by dominance of Archipalaearctic (Manchurian–Japanese) species, representing 65 % of whole fauna; the East-Palaearctic, Oriental-Palaearctic and Transpalaearctic are less numerous (17, 10 and 6 % respectively). The sum of the Holarctic and widely distributed in the tropics and subtropics species is less than 2 %. The trend of increasing of the species diversity of Orthoptera from north to south is obvious in the continental sector of the northern part of East Asia. The fauna of Chukchi Peninsula consists of 5 species, Kamchatka — 10, Magadan region — 16, and Lower Amur region — 54 species. Totally 81 species are known from the Middle Amur region, and 111 species recorded from Primorye in Russia. The sum of species in North-East China (provinces Heilongjiang and Jilin) is 187. The fauna of Korean Peninsula consists of 164 species, of which 118 species are known northwards and 136 species are recorded southwards 37o N. Comparing with the Lower Amur region the number of species increased in the Middle Amur region in 1.5 times, in Primorye — in 1.9 times, in Korean Peninsula — in 2.9 times, and in North-East China — in 3.3 times. Orthoptera are absent in the north part of Kuril Archipelago, while 28 species are recorded from Southern Kuril (Iturup, Kunashir, Shikotan). The fauna of Sakhalin Island consists of 36 species, Hokkaido Island — 89,

Shikoku Island — 169, Kyushu Island — 134 species. The largest Japanese island Kyushu is characterized by most diverse fauna (218 species). The fauna of small island located between Korea and Japan is less diverse (Jeju — 89 species, Tsushima — 51 species). Comparing with Sakhalin the number of species increased in large Japanese islands as follow: Hokkaido — in 2.5 times, Kyushu — in 3.7, Shikoku — in 4.7, and Kyushu — in 6 times. Thus, the trend of increasing of species diversity of Orthoptera in the island sector of the Pacific part of North Asia is more obvious than in the continental one.

The matrix of species distribution in the different continental regions and large islands was analyzed using the program PAST (version 1.57). Four types of fauna in the Pacific part of North Asia are discriminated, namely (1) the Okhotsk fauna of the forest-tundra and boreal coniferous forests (Chukchi Peninsula, Kamchatka, Magadan and Lower Amur regions, North Sakhalin, i.e. regions around Okhotsk Sea); (2) the Manchurian fauna of the continental coniferous and broad-leaved forests (Middle Amur region and Primorye in Russia, North-East China, and the northern part of Korean Peninsula); (3) the Sakhalin–Hokkaido fauna of the coniferous and deciduous forests (South Sakhalin, Hokkaido, and South Kuril); (4) the Korean–Japanese fauna of the broad-leaved and evergreen coniferous forests (the central and southern parts of Korean Peninsula, Jeju, Tsushima, Honshu, Shikoku, Kyushu islands).

Molecular phylogeny of the Acrididae grasshoppers

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For a long time, taxonomy, phylogenetic relationships and understanding of the evolution of the family Acrididae were based mainly on the comparative analysis of key morphological structures of recent and fossil species. However, on the subfamily level and lower, problems of convergence and parallelism become significant for these insects, making it challenging to establish phylogenetic relationships between subfamilies, tribes and genera. One of the most effective methods to estimate phylogenetic relationships is the analysis of various DNA markers. In present work, we conducted the molecular phylogenetic analysis of the complete mitochondrial sequences, concatenated sequences of three mitochondrial genes (COI, COII, CytB) and nuclear sequences (ITS2) of more than 220 species of the acrid grasshoppers from 15 subfamilies. The data on nucleotide sequences for these insects were obtained experimentally and from NCBI database. The sequences obtained experimentally were submitted to the NCBI database and are freely accessible. Some phylogenetic trees for different combinations of these markers were obtained using the maximize likelihood and Bayesian methods. The complete sequences of the mitochondrial genomes currently set for 59 species belonging to 11 subfamilies.

The phylogenetic tree constructed based on these sequences consist of four major groups. First group included three subfamilies: Gomphocerinae, Oedipodinae, and Acridinae. Second group included representatives of four subfamilies: Calliptaminae, Catantopinae, Cyrthacantacridinae and Eyprepocnemidinae. Third and fourth groups are monophyletic and consist of one subfamily each: Melanoplinae and Oxyinae, respectively. The phylogenetic tree constructed on these sequences served as the basis for the further analysis. The phylogenetic trees based on COI, COII, CytB and ITS2 sequences confirm and complement the results obtained from the analysis of the complete mitochondrial sequences. As the result of the work done, we revealed all studied species could be divided into two main phylogenetic groups: (1) Gomphocerinae, Oedipodinae, and Acridinae, and (2) Calliptaminae, Catantopinae, Cyrthacantacridinae, Conophyminae, Eyprepocnemidinae, Melanoplinae, Pezotettiginae and Hemiacridinae. Subfamily Oxyinae formed a separate branch from both groups, as well as the subfamilies Proctolabinae, Spathosterninae and Coptacrinae (presented by only one species each). Five subfamilies (Acridinae, Oedipodinae, Gomphocerinae, Oxyinae and Catantopinae) were found to be polyphyletic in the present study. We also revealed that the positions of branches containing species from the polyphyletic subfamilies are interrelated with their geographical distribution, showing that morphological differences are most likely to be the result of convergence and parallelism.

The diversity and some ecological aspects of the orthopteran fauna in Pakistan

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Pakistan is an agricultural country. A variety of crops is cultivated. The majority of people are living in the

villages and the main source of their living is agriculture. About 70 % of the population is engaged in agriculture both directly and indirectly. Agriculture is a source of revenues for the federal and provincial governments. Local bodies also get revenue from the agriculture sector. The present report deals with the major and minor pests from the order Orthoptera. Some representatives of three superfamilies of Ensifera, namely Schizodactyloidea , Tettigonioidea and Grylloidea, and 5 superfamilies of Caelifera, namely Acridoidea, Pyrgomorphoidea, Tetrigoidea, Eumastacoidea and Tridactyloidea, were found. The fauna includes about 157 species from 21 subfamilies of Caelifera and 63 species of Ensifera belonging to 11 subfamilies. Specimens collected from the different ecological zones of Pakistan for the last forty years are at Sind Entomological Museum (SEM), University of Sindh, Pakistan. The taxonomic keys for various taxa were also constructed for their future identification. Some brief descriptions of each suprageneric category of Orthoptera were prepared. Distribution patterns with ecological notes were also documented. Furthermore, the detailed list of host plants from Pakistan was also composed for the first time. These findings supplied some important basis and data for Integrated Pest Management (IPM), orthopteran biodiversity conservation and grassland restoration in Pakistan.

Evaluation activity of pathogenic Aspergillus against the acridid grasshoppers in Pakistan

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The species of the genus *Aspergillus* are registered world-wide for the grasshoppers and locusts control. This practice is currently under consideration as potential alternative to chemical insecticides for the pest control in Pakistan. Grasshoppers and locusts are major agricultural pests damaging varieties of crops (e.g., rice, sugarcane, wheat, maize, and fodder crops). Several chemical insecticides are commonly used to control acridid populations, but these chemical compounds are often strongly associated with environmental and health issues. In order to reduce these problems, an attempt was made to introduce a pathogenic fungi to control acridid populations. About 2,000 specimens from six subfamilies of Acrididae were collected from different ecological zones of Sindh and were treated with three species of the genus *Aspergillus*, namely *A. flavus, A. fumigatus* and *A. niger*. The isolation percentage of entomopathogenic fungi and their association with acridid pest species was also noticed. Food consumption and faecal production by the insects treated with different formulation of the *Aspergillus* species were analyzed under laboratory conditions. It was noted that the cumulative percent of faecal material from the insects treated by various pathogenic fungi differed significantly from the control. Other three treatments resulted in some significant impact on food consumption and feeding behavior. After two days insects gradually reduced its feeding activity, because fungi development stopped its usual activities. This means that exploration and screening must be conducted to provide additional pathogens for evaluation as potential biological control agents against grasshoppers and locusts.

Notes on the fauna of grasshoppers (Orthoptera, Acrididae) of Taman Peninsula

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The unique nature of Taman Peninsula has been attracted biologists for decades. Its geographical position and hilly relief with numerous ravines contributed to the formation of a specific fauna of insects in general, and grasshoppers in particular. The purpose of this study is to refine the taxonomic structure and morpho-ecological analysis of the grasshoppers (Acrididae) of Taman Peninsula. The major data were collected in 2015-2017 by generally accepted methods. Twenty seven species of grasshoppers are known for the territory of the Peninsula, from which 2 species are known from the published sources. *Ramburiella turcomana* (Fischer von Waldheim, 1846) and *Stenobothrus miramae* Dirsh, 1931 are recorded from Taman Peninsula for the first time and *Acrotylus longipes* (Charpentier, 1845) is new for the fauna of the Caucasus. In Taman the last species is found on sandy parts of the coast of Kerch Strait and Black Sea. Its global range includes the southwestern Ukraine (from Odessa to the Danube River), Asia Minor, South Iran, Pakistan, South Europe, and North Africa. *A. longipes* was previously known from South Crimea. This grasshopper feeds on monocotyledons, mainly on various Cyperaceae and Poaceae. In each local population, the individuals with the yellow and orange hind wings are found in equal proportions. Egg laying and the egg-pods of *A. longipes* are described. The egg laying includes stages when the female immerses the posterior half of the body up to the thorax (including tegmina) in sand. The female rakes the sand with its hind legs to the

abdomen, and then clenches them and rakes the sand with long middle legs. The analysis of the life forms of the grasshoppers of Taman Peninsula showed that the grass-feeding chortobionts (40 %) and facultative chortobionts (26 %) are commmon. There are a few open geophiles (4 species, 15 %), microtamnonobionts (7 %), herbivorous chortobionts (4 %), sedge-grass chortobionts (4 %), and geophiles living under vegetation cover (4 %). There are no endemic grasshoppers since geologically this peninsula is a relatively young. In the beginning of the Neogene it underwent a long continental stage, then was partially flooded with only separate islands of Paleogenic origin towering over [Novosad, 1992]. *Ramburiella turcomana*, *Stenobothrus miramae* and *Acrotylus longipesa* are distributed insularly. Their local populations are in Crimea, from where they could migrate to Taman. *Chorthippus loratus* and *Chorthippus biguttulus* are the most abundant species. They are found everywhere over the Peninsula. Some peculiarities of species distribution over local habitats were also revealed. 13 species (48 % of the total number) were found in the sandy habitats of the sea coasts and braids. The saline meadows along the edges of estuaries and seashores were inhabited by 5 species (18.5 %). *Platypygius crassus* occured only in the halophytic habitats. In the areas with the psammophytic steppe, we found 9 species (33.3 %). In the preserved steppe areas of the forb-grass vegetation on the hills and slopes of the ravines, 13 species (48 %) occured, most of them were also found in other habitats. In agricultural landscapes, we observed 9 widely distributed species (33.3 %).

Key words: Acrididae, grasshopper, North Caucasus, biological diversity, life form, distribution, egg-pod

Acoustic signals and morphology of the two subspecies of Stenobothrus eurasius Zubovsky (Orthoptera, Acrididae, Gomphocerinae): Evidence of belonging to different species

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On the territory of the Ukraine, Russia, Kazakhstan and Kyrgyzstan, two subspecies of *Stenobothrus eurasius* are recognized: *eurasius eurasius* (Zubovsky, 1898) and *eurasius hyalosuperficies* (Vorontsovskii, 1928). *S. eurasius eurasius* Zub. is suggested to inhabit the southern regions of Siberia reaching Transbaikal (Dauria) to the east, Kazakhstan and the mountains of Kyrgyzstan; S. eurasius hyalosuperficies Vor. is suggested to occur in the southern regions of the Ukraine and European Russia. We have recorded and analyzed calling and courtship songs of the specimens from the Ukraine, Russia and Kazakhstan. Not only the sound but also the movements of the hind legs during stridulation were recorded with a unique opto-electronic device. The specimens from one locality of Saratov, from the Orenburg Region (the type locality of *S. eurasius hyalosuperficies*) and Kazakhstan (some type localities of *S. e. eurasius*) generated sound by two different mechanisms: hind-leg stridulation, which is typical for gomphocerines, and wing clapping, which was previously described only for the *S. rubicundulus*-group (Elsner, Wasser, 1995). The calling song was only produced by wing clapping, which was performed on the ground. The courtship song started with the low-amplitude leg movements, which generated single or double soft pulses (element I). An element II was produced by the high-amplitude leg strokes, which accompanied by conspicuous movements of antennae. In a developed courtship, groups of 4–7 soft pulses generated

by legs alternated with a loud sound generated by wing beats (element III). The specimens from the Ukraine and another locality of Saratov generated sound by only hind-leg stridulation. During calling, the males produced a single phrase consisting of complex syllables. The first half of each syllable was produced by faster vibrations during the leg up-stroke, whereas the second half of each syllable – by slower vibrations during the leg down-stroke. As a result, each syllable included pulses of different rate and duration. The courtship song started with groups of 3–5 soft pulses, which were gradually transformed into a sound, resembled the calling song syllables. In the developed courtship, the vibrating up-stroke of a syllable was replaced by an abrupt, high-amplitude up-movement of the hind legs. We suggested a difference in morphology of the hind wings between subspecies to be a main morphological character, which allows us to distinguish the subspecies. Medial field of the hind wing is broader in specimens singing by wing beats than in specimens singing only by stridulation. Also, fore margins and costal field of the hind wings are more sclerotized and cubital veins are more fused in specimens that produced wing clapping than in specimens singing only by stridulation. Presumably, a degree of sclerotization of the hind wing depends on the mechanism of sound production (Elsner, Wasser, 1995). On the basis of the strong differences in songs and some differences in morphology, we propose to classify the two subspecies, eurasius eurasius and eurasius hyalosuperficies, as different species. However, it is still unclear how to name these two species. First, the type specimens of Vorontsovskii were lost, and second, it is likely that there are both species among the type specimens of Zubovsky.

Key words: grasshopper, acoustic, sound production, courtship, taxonomy

Stoneflies (Plecoptera) of the Us River Basin in the West Sayan Mts.

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Stoneflies are one of the least studied groups of amphibiotic insects. Almost all species of these insects are rheophilic. Their highest species diversity is in mountain rivers often being difficult to access. This is why local faunas and assemblages of stoneflies are not known for many mountain river basins. There are only three sources of data about plecopteran diversity and distribution in the mountain streams of the Altai–Sayan Mts. [Koveshnikov, 2009; Zaika; 2012; Baturina, 2015]. However, the streams of the southern macroslope of the West Sayan Mts. have not been studied yet. The southern macroslope of these mountains, facing the Tuvan Intremountain Basin, is characterized by the phenomenon of reverse anticyclones. This results in the relatively arid and continental climate with the annual precipitation around 400 mm, long and cold winters. Besides, weathers are usually determined by the Asian anticyclone. The Us River is one of the major rivers of this territory. It is the right tributary of the Yenisei River. The Us River begins in the West Sayan Mts. and flows southwestward across the Us Depression. It breaks in April or the beginning of May and freezes in November. We studied diversity and ecology of stoneflies in the middle part of the Us River and in its tributary, namely the Buyba River. Both streams are in the typical rhithral zone. 23 species of stoneflies have been found in 2013–2016: *Alascaperla longidentata* (Raušer, 1968), *Arcynopteryx dichroa* (McLachlan, 1872), *A. amurensis* Zhiltzova et Levanidova, 1978 (this species was previously know from the Far East), *A. polaris* Klapálek,

1912, *Alloperla deminuta* Zapekina-Dulkeit, 1970, *A. rostellata* (Klapálek, 1923), *Amphinemura borealis* (Morton, 1894), *Capnia ahngeri* Koponen, 1949, *C. pygmaea* (Zetterstedt, 1840)?, *Diura nanseni* (Kempny, 1900), *Isoperla asiatica* Raušer, 1968, *I. altaica* Šámal, 1939, *I. eximia* Zapekina-Dulkeit, 1975, *I. lunigera* (Klapálek, 1923), *Megarcys ochracea* (Klapálek, 1912), *Nemoura arctica* Esben-Petersen, 1910, *N. nigrodentata* Zhiltzova, 1980?, *Paraleuctra zapekinae* Zhiltzova, 1974, *Pictetiella asiatica* Zwick et Levanidova, 1971, *Stavsolus manchuricus* Teslenko, 1999, *Skwala compacta* (McLachlan, 1872), *Suwallia teleckojensis* (Šámal, 1939), *Taenionema japonicum* (Okamoto, 1922). The stonefly *Megarcys ochracea* (one of the largest species of the Perlodidae family) and *Suwallia teleckojensis* (Chloroperlidae) were the most widespread. Reproduction of the first species occurs from the last decade of June until the second decade of July. The young larvae may be found in the first decade of July. Reproduction of *Suwallia telecko-*

jensis occurs in the second decade of August. We also compared the species diversity of the Us River Basin with other regions of the Altay-Sayan Mts. The level of the Sørensen–Czekanowski similarity index was almost equal for all pairs: with Mountain Altay — 0.56, with North Altay — 0.58, with the Upper Yenisei — 0.59. This means that the stonefly fauna of the Us River Basing is more or less typical for the mountain system.

Key words: stonefly, Plecoptera, West Sayan, mountain stream, biological diversity, rhithral

Italian locust (*Calliptamus italicus* (Linnaeus)), female, in the north steppe of West Siberia (Photo credit: M. G. Sergeev)

Treasurer's Report

By **PAMELA MIHM**
Treasurer
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he Statement of Assets as of December 31, 2017 and the 2017 Summary of Cash Receipts and Expenditures are shown below. The Orthoptera Species File continues to be the largest cash activity. This is funded by an allocation of endowment income from the University of Illinois. The second largest use of cash was publishing the *Journal of Orthoptera Research (JOR)*. During 2017, the Society contracted with Pensoft, an industry leader in open access publishing, to achieve better visibility and a more attractive format for the *JOR*. This requires more funds for *JOR*. The Society supported two new projects in 2017—Orthoptera Symposium grants and AAIS meeting support. The financial position of the Society has been greatly enhanced by the generous bequest from Dr. Theodore Cohn and from generous contributions over the years from other members. If you have any questions, please contact me at p.mihm@regency-multifamily.com.

Orthopterists' Society
Statement of Cash Receipts and Expenditures
(1/1/17 through 12/31/17)

Cash Receipts

Dues	$3,855.00
Publications	3,320.00
Page charges	573.00
Community Foundation endowment	11,572.27
Royalty and revenue sharing	17,437.95
Book reimbursements	474.74
Donations	110.00
Transfer cash from Vanguard & Wells Fargo	20,700.00
Proceeds from sale of investments	27,794.00
Contribution for OSF-David Eades	5,000.00
University of Illinois allocation	135,000.00
Total Cash Receipts	$225,836.96

Cash Expenditures

Publisher JOR	$11,355.68
JOR assistance	21,000.00
Research grants (Ted Cohn)	16,095.00
Executive director remuneration	1,500.00
Ed. Metaleptea remuneration	1,500.00
Webmaster remuneration	300.00
JOR editor remuneration	3,000.00
Maintenance of Orthoptera Species File	80,000.00
Grants-Orthoptera Species File	53,267.99
Professional fees	6,450.00
(income tax preparation and audit)	
Accounting reimbursement	12,000.00
AAIS meeting support	1,000.00
Publication of "Orthopterans of Oaxaca"	5,000.00
Orthoptera Symposium grant	2,000.00
Young Professional Award	2,500.00
Storage unit rent	910.00
Other	2,137.33
Total Cash Expenditures	$220,016.00

Excess of Cash Receipts

over Cash Expenditures	$(5,820.96)
Beginning Cash Balance	4,410.13
Ending Cash Balance	**$10,231.09**

Orthopterists' Society
Statement of Assets
(As of December 31, 2017)

Cash

Paypal cash balance	$166.67
Midland States Bank	10,064.42
	$10,231.09

Investments at market value

Vanguard:	
Grants (Note 1)	$423,792.64
Operating (Note 2)	809,145.84
	1,232,938.48
Wells Fargo:	
AAAI (Note 3)	13,016.79
Endowment (Note 4)	30,113.39
Operating (Note 2)	251,795.68
Grants (Note 1)	78,458.57
	373,384.43
Total assets	**$1,616,554.00**

Note 1: This fund is restricted and can only be used for research grants.
Note 2: This fund is nonrestricted.
Note 3: This fund can only be used for the Uvarov Award made at each int'l meeting.
Note 4: The income in this account is available for Society expenses; can extract capital but must have a plan for repaying it within 3 years.

Editorial

By HOJUN SONG
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Another great year has started! Judging from the activities reported from the Ted Cohn grantees and the OSF grant awardees, our society has many young members paving the way for a bright future.

Every fall, I get many emails from prospective students asking to join my lab. Often, I have to turn them down because I do not have funds to support them, but now I am at the point where I do need to recruit more students to push my research programs forward. An interesting trend that I have observed over the years is that most prospective students who are interested in orthopteran taxonomy happen to be international students. While I would love to have more international students in my lab, it is becoming financially more difficult to support them without a major research grant. Of the domestic students who have contacted me, I have not yet found anyone who's a die-hard orthopterist. Often, these students have interests in beetles or some other insects and are willing to switch to Orthoptera, but not originally interested in grasshoppers or katydids. Sometimes this switch is successful, and sometimes it is not. Is this a real trend or something that I am imagining based on my limited interaction with the new generation of potential students?

I don't have a good answer for this question yet. I have a sense that it might have to do with the fact that there are not many orthopterists in the U.S. training students who want to pursue higher degrees. It might also be that many international students are more in touch with nature because they are curious about the insects they see, but they don't have access to taxonomic experts who can train them.

Despite the trend that I see in my own program, I am relieved to read all the reports and the meeting abstracts written by our younger members (most of whom I have not yet had a chance to meet). This means that there are young orthopterists who are being trained right now somewhere in the world. As long as this is true, the future of orthopteran taxonomy remains promising.

This issue is a particularly massive one because of two meeting abstracts. I am continually excited to learn about all of the fantastic research being done on Orthoptera. Remember that *Metaleptea* completely relies on the member contributions, so please send me your stories to share with other members.

I would like to thank all those who have contributed to this issue as well as our Associate Editor, Derek A. Woller, for his continued assistance in the editorial process. Please congratulate him on successfully defending his dissertation and graduating in December of 2017!

To publish in *Metaleptea*, please send your contribution to hsong@tamu.edu with a subject line starting with [Metaleptea]. As for the format, a MS Word document is preferred and images should be in JPEG or TIFF format with a resolution of at least 144 DPI. The next issue of *Metaleptea* will be published in May of 2018, so please send me content promptly. I look forward to hearing from you soon!