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METALEPTEA

THE NEWSLETTER OF THE ORTHOPTERISTS' SOCIETY

President's Message

By **DAVID HUNTER**
President
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Dear Fellow Orthopterists!

As I am writing this from Canberra, the sky is filled with dense smoke from the catastrophic fires we have had in Australia this fire season. Continuing drought and weeks of unusually high temperatures have led to widespread fires covering millions of hectares: as of the first week in January, 6.3 million ha have burnt which is just under half the area of England! A catastrophic situation indeed!

Our society continues our support for research through OSF grants and Ted Cohn Research grants for which we encourage students and Post doctorate members to apply for ahead of the March 31 deadline. Details on our **Orthopterists' Society website**.

And we recently funded a symposium on Orthoptera and the November meeting of the African Association of Insect Scientists (AAIS) held in the Ivory Coast. A number of presentations on various aspects of Orthoptera were given and our Central & Southern African regional representative Vanessa Couldridge won the award for the best presentation—congratulations Vanessa! Prior to the meeting, our Executive Director, Mohamed Abdellahi OULD Babah EBBE, proposed that we have a Memorandum of Understanding between the Orthopterists' Society and the AAIS as a more formalised way of for fur-

ther co-operation and the MOU was signed by Vanessa during the meeting. The MOU aims to encourage further cooperation through giving presentations at each other's meetings and providing a mechanism for Orthopterists' Society members to work with members of the **African Association of Insect Scientists**.

As part of bringing Orthoptera to the forefront at scientific meetings, we have also had symposia on Orthoptera at the recent Entomological Society of America meeting where Ricardo Mariño-Pérez won the Snodgrass Memorial Award for outstanding research by a PhD student and at the Australian Entomological Society meeting in Brisbane, where a number of members of our Society, including Hojun Song, gave presentations. And I would like to thank Zoltán Kenyeres

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and Norbert Bauer for publicising our recent congress in their recent publication "Orthopterans and Climate Change" in Hungarian in the journal Élet és Tudomány (Life & Science) 2019/49 LXXIV: 1542-1544.

Once again, I have the pleasure of commending to everyone the many excellent reports in this issue thanks to Hojun Song and Derek Woller demonstrating the continuing progress on Orthoptera and related insects.

Wishing everyone success in their work in the coming year—all the best for 2020.

The Theodore J. Cohn Research Fund: A new call for applications for 2020

(Application Deadline: March 31, 2020)

By **MICHEL LECOQ**
Chair, Theodore J. Cohn Research Fund Committee
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This research grant is primarily to fund research projects in Orthoptera (*sensu lato*) by young researchers often as part of a Master's or Ph.D., though Postdoctorates 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.

Full detailed information can be found on the Orthopterists' Society website, on the "Grants & Awards" page: **http://orthsoc.org/resources/grants-awards/the-theodore-j-cohn-research-fund/**

As usual, proposals should be submitted at the following address: Michel Lecoq, Manager, The Ted Cohn Research Fund
e-mail: mlecoq34@gmail.com

Grants supporting the Orthoptera Species File

By **MARIA MARTA CIGLIANO**
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The **Orthoptera Species File (OSF)** grants committee received and evaluated 14 proposals by applicants from 14 countries for 2020: Algeria, Argentina, Austria, Brazil, Bulgaria, China, Croatia, France, Germany, India, the Netherlands, Pakistan, Tunisia, and the USA. Of these, the 10 proposals listed below will be funded. They have been selected based on the amount of data (images, specimen records, sounds, etc.) expected to be added to the Orthoptera Species File. Also considered were the candidates' expertise, if the proposal was related to a taxonomic research project, and the budget.

OSF grants funded for 2020:

1. **Moussi Abdelhamid, Haithem Tlili** (University of Biskra, Algeria; University of Carthage, Tunisia)
   Title: Photographic database of Western Asia Acridomorpha (Orthoptera, Caelifera) type specimens deposited at NHM London
2. **Martina E. Pocco** (Museo de La Plata, CCT La Plata CONICET-CEPAVE, Argentina)
   Title: Extension of the project "Illustrating Neotropical Acridoidea species with emphasis on Romaleinae in OSF"
3. **Slobodan Ivković & Horvat Laslo** (Trier University, Germany; Elsbethen, Austria)
   Title: From lowland steppes to alpine grasslands II – Taxonomy, bioacoustics and distribution of Orthoptera in Serbia and Montenegro
4. **Marcos Fianco** (State University of Western Parana, Brazil)
   Title: The Ensifera fauna from Guartela State Park, Parana State, Brazil.
5. **Dragan Chobanov, Ionuț Iorgu, Simeon Borisov, Georgi Hristov** (Institute of Biodiversity and Ecosystem Research, Sofia, Bulgaria)
   Title: Orthoptera of the Balkan Peninsula and the Carpathian Basin II: a database of digital data in the Orthoptera Species File
6. **Karmela Adžić, Maks Deranja, Amira Aqilah Muhammad** (Faculty of Science, University of Zagreb, Croatia)
   Title: Grasshoppers and Crickets of the Adriatic Islands
7. **Marie-Pierre Chapius & A. Coeur d'Acier** (CIRAD, INRA, CBGP, Montpellier, France)
   Title: Providing OSF with range maps, images of diagnostic characters and song records for the two cryptic species discovered within *Calliptamus barbarus* (Costa, 1836)
8. **Chandranshu Tiwari** (University of Delhi, India)
   Title: Katydids of India: Documenting the acoustic diversity of katydids from North-East India.

9. **Baudewijn Odé, Roy Kleukers and Luc Willemse** (Naturalis Biodiversity Center, Leiden, The Netherlands)
Title: Grasshopper sounds on Xeno-canto
10. **Brandon Woo** (Cornell University, USA)
Title: Katydid biodiversity and bioacoustics on the Osa Peninsula of Costa Rica

A call for manuscripts

Special Issue "Locusts and Grasshoppers: Biology, Ecology and Management"

By **ALEXANDRE V. LATCHININSKY**
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Dear Colleagues,

Locusts and grasshoppers (Orthoptera: Acridoidea) are among the most serious agricultural pests worldwide. By inflicting damage to pasturelands and a wide range of crops they jeopardize food security and livelihoods of about ten percent of the world's population. Their outbreaks, which in case of locusts can escalate to transcontinental plagues, require huge efforts of national plant protection agencies and international cooperation to control them. Being extremely adaptable to recent climate changes, locusts and grasshoppers present new challenges to researchers and pest managers.

I am pleased to inform that the journal "***Insects***" (Impact Factor 2,139) just published a call for submissions to the Special Issue **"Locusts and Grasshoppers: Biology, Ecology and Management,"** for which I will serve as a Guest Editor: **https://www.mdpi.com/journal/insects/special_issues/locusts_grasshoppers**

The current Special Issue addresses some of the newest insights biology, ecology and management of these ancient enemies of agriculturists.

The deadline is 31 October 2020.

A call for DNA-grade specimens to reconsruct a comprehensive phylogeny of Ensifera

By **HOJUN SONG**
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Dear Colleagues,

Recently, I received a grant from the U.S. National Science Foundation, titled "NSFDEB-NERC: MULTIDISCIPLINARY APPROACH TO BIOACOUSTICS: Integrating phylogenomics, biophysics, and functional genomics to unravel the evolution of hearing and singing in katydids, crickets, and allies" (**NSF DEB-1937815**). This project is co-funded by the U.K. NERC and I am collaborating with Fernando Montealegre-Z, Nathan Bailey, Michael Whiting, Seunggwan Shin, Laure Desutter-Grandcolas, and Andre Nel. The overall goal is to study the evolution and genetic basis of acoustic communication, capitalizing on the most speciose and ancient lineage of the extant singing insects, the Ensifera (katydids, crickets and relatives). Our project is multidisciplinary, integrating phylogeny, functional morphology, biophysics, and comparative genomics to test key hypotheses about when, how, and why acoustic signaling has evolved over 300 million years of ensiferan diversification.

One of the main objectives of the project is to produce a comprehensive phylogeny of Ensifera based on 1,600 species and 1,000 loci, the largest phylogenetic dataset ever compiled for this group, which will serve as a robust comparative framework for studying the evolution of acoustic communication. This taxon sampling represents 10% of the known species diversity in Ensifera.

While I have already secured hundreds of DNA-grade specimens of ensiferans from around the world, there are some key taxa that I am having a difficulty to obtaining. These are Gryllacrididae and Rhaphidophoridae. So, if you have any specimens of these ensiferans preserved in 95-100% ethanol, please send me an email at **hsong@tamu.edu**. Also, if you would like to contribute your favorite ensiferans to the project, I would also love to hear from you.

Thank you so much for your help!

Updates from the Global Locust Initiative

By **RICK OVERSON**
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Hello, fellow orthopterists! 2019 marked a year of exciting developments, projects, and workshops for the Global Locust Initiative (GLI), with more slated for this year.

In March of 2019, we hosted a locust monitoring and forecasting workshop at the 13^{th} International Congress of Orthopterology in Morocco. Expert panel members included representatives from eight organizations and five continents. Panelists and audience members discussed current challenges and opportunities for locust and grasshopper monitoring and forecasting. For a complete summary, please email Rick Overson (**rick.overson@asu.edu**). Outcomes from this workshop are being used to shape future collaborative GLI projects and workshops.

In November we hosted our third GLI networking mixer at the Annual Meeting of the Entomological Society of America with fruitful discussions about potential collaborative projects for the near future (Fig. 1). Note that the GLI will also host a mixer at the XXVI International Congress of Entomology July 2020 in Helsinki, Finland (more details forthcoming).

Figure 1. GLI networking mixer participants at EntSoc 2019 in St. Louis, Missouri

This year the GLI will be hosting three parallel workshops funded by the Foundation for Food and Agriculture Research (FFAR) that will explore the infrastructure, institutional networks, and governance structures of locust and grasshopper management and research in South America, West Africa, and Australia. Through these institutional workshops, we will produce a high-level assessment of how relevant regional, national, and international organizations are linked (or not linked). We invite any interested participants across sectors (e.g., representatives from government organizations, universities, and humanitarian and development organizations) to join us. The workshops are currently scheduled as follows: Córdoba, Argentina (Feb. 26^{th}–28^{th}), Gossas, Senegal (March 26^{th}–27^{th}, tentative), and Canberra, Australia (April 20^{th}–21^{st}, tentative). A fourth synthesis workshop will take place at Arizona State University in November, 2020 where participants from each focal region will synthesize, summarize, and share information for the benefit of all partner institutions. If you are interested in attending or being involved in any part of this effort, please email Rick Overson (**rick.overson@asu.edu**).

Please feel free to contact us with any questions or to become part of the GLI network! We welcome members with interests in grasshoppers and locusts, transboundary pest issues, integrated pest management, landscape-level processes, food security, and/or cross-sectoral initiatives. We bring together interested people through workshops and networking events with the goal of facilitating research and supporting the development of sustainable solutions for the global challenge of locust and grasshopper management. We also provide opportunities for visiting scholars to conduct research at ASU's locust rearing facilities. Please visit our website (**locust.asu.edu**) for more information about the initiative, events, and news.

Reminder: Seeking Speakers for the 2020 ICE Symposium: "*Polyneoptera for our Planet*"

By DEREK A. WOLLER[1], BERT FOQUET[2], AND HOJUN SONG[3]
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Fellow Society members, we are currently seeking speakers for our symposium "*Polyneoptera for our Planet*," which will be part of the 2020 International Congress of Entomology (ICE). The congress will be July 19-24 in Helsinki, Finland and the symposium is currently scheduled for Friday, July 24, from 8 AM-10 AM. Presentations are limited to 15 minutes (8 speakers total) and submission is currently available to the public by going to this site (where more general information on the meeting and symposia can be found): https://ice2020helsinki.fi/call-for-symposia/. Then, click on the "Submit presentation abstract" icon on the upper graphic, find the scientific section "Ecology, Evolution and Behaviour, Track 2" and click on our symposium's name, and then follow the subsequent directions. All are welcome – students, postdocs, seasoned researchers, etc.! Our goal is to have a good mix of polyneopterans represented that demonstrate all the interesting work being undertaken with the group, so please spread the word to your colleagues that work on taxa beyond Orthoptera. Please also note that while you can only give a single presentation at ICE you can be a coauthor on as many presentations as you like. For general description of the symposium, please see our previous article at *Metaleptea* 39(2) pp. 13.

Regional Reports - What's happening around the world?

East Europe - North and Central Asia

By MICHAEL G. SERGEEV
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In 2019, orthopterists of North and Central Asia attended a lot of scientific meetings, including the 13th International Congress of Orthopterology, realized several projects, and organized field studies in different parts of the region. One of the most important results was "An annotated check-list of Orthoptera of Tuva and adjacent regions" by M. Sergeev, S. Storozhenko, and A. Benediktov published in "Far Eastern Entomologist." Now this list includes 95 species and subspecies, which belong to 5 families, 11 subfamilies, and 21 tribes (1 subfamily and 2 tribes are also possible). About half of the known orthopteran species are from the acridid subfamily Gomphocerinae. The number of the species from the subfamilies Locustinae and Tettigoniinae is also significant. At least several tribes, namely Bergiolini, Zichyini, Aulacobothrini, Bryodemini, and Sphingonotini, include a lot of intrinsic species of the semi-arid and arid mountains of Eurasia. The most diverse fauna of Orthoptera is in Uvs-Nuur Intermountain Basin. This region is characterized by high diversity of the semi-desert, desert, and steppe ecosystems favorable for the species associated with the arid and semi-arid regions of Eurasia.

Another huge project (the joint program of the Russian Foundation for

Female of the Large banded grasshopper, *Arcyptera fusca* (Pallas) (Photo credit: M.G. Sergeev)

Male of *Stenobothrus nigromaculatus* (Herrich-Schäffer) (Photo credit: M.G. Sergeev)

Basic Researches and the Government of Novosibirsk Region, project # 18-416-540001) was realized in Novosibirsk Region in the south-eastern part of West Siberia. This region is one of the main areas of locust and grasshopper outbreaks. Some significant upsurges of these insects have been developed during the last centennial, especially during droughts. The main goal of the project was to reveal patterns of spatial and temporal distribution of populations of the Italian locust and abundant grasshoppers in the southern part of the Region relative to global, regional, and local trends in ecosystem transformation and to evaluate some main indicative traits allowing to estimate changes of these populations. The studies of their long-term dynamics on the model plots didn't allow to support some widely distributed opinion that situation with acridid assemblages and populations is mainly determined by the precipitation levels and temperatures in May and the beginning of June. The role of the Italian locust outbreaks in changes of fluxes of some chemical elements was also shown.

During the summer season of 2019 several field studies of ecology, distribution, and diversity of the Orthopteroid insects were organized. The expeditions crossed the southern parts of West Siberian Plain and studied diversity and assemblages' distribution in the south-eastern part of the Urals, in West Baraba region, and in several parts of the Kulunda steppe for the first time. Some studies of orthopteran diversity distribution were continued in the North Caucasian area, Astrakhan State Reserve (the Lower Volga region), the Komi Republic (NE European Russia), Mongolia, Tajikistan, Turkmenistan, and Uzbekistan. A field trip was also organized to S. Kurile Islands to collect some new data about diversity and relations of local forms from the genus Podisma. Several field projects were associated with pest grasshoppers, especially in Central Asia and the Caucasus.

Some problems of applied acridology were also discussed during IV All-Russian Plant Protection Congress, "Phytosanitary technologies in ensuring independence and competitiveness of the agricultural sector of Russia," in Saint Petersburg (September 9–11). Several plenary presentations were related to locust and grasshoppers. The general distribution patterns and long-term dynamics of pest species, and new technologies and products (especially bioacridicides) were discussed. Additionally, some presentations concerning pest species were done during concurrent sessions.

Central & Southern Africa

By VANESSA COULDRIDGE
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The 23rd biennial Meeting and Scientific Conference of the African Association of Insect Scientists (AAIS) was held in Abidjan, Côte d'Ivoire, from the 18th to 22nd November 2019. The theme of this year's conference was "Biodiversity and sustainable development in Africa: contribution of insect science to the development of agriculture and improvement of human, animal and environmental health." The conference was well-attended, with a total of around 300 presentations given by delegates from 25 countries. Topics were diverse and included insect biodiversity and taxonomy, invasive species, biological control, insects for food and feed, beneficial insects, disease vectors, pest control, and the impacts of climate change on insects. Presentations were in either English or French.

The Orthopterists' Society generously provided sponsorship to the conference, thus assisting researchers specifically working on Orthoptera to be able to attend and present their work. In total, there were 15 presentations on Orthoptera included in the programme (see below), presented by delegates representing eight countries: Belgium, Cameroon, Côte d'Ivoire, France, Kenya, Nigeria, South Africa, and Tunisia). Four of these presentations focused on the biodiversity, taxonomy, and ecology of orthopteran fauna, nine were on edible orthopteran species as a source of food for human consumption, one was on grasshoppers as bio-indicators, and one on locust pest control. The large number of talks concerning orthopterans as a food source highlights issues surrounding food security on the continent and the search for alternative sources of protein. This is a very active field of study in many countries, with research topics ranging from nutritional content of edible species, to rearing and processing of insects,

Signing of the MoU between the OS and AAIS. From left: Mohamed Abdellahi Ould Babah EBBE (Executive Director of OS), Vanessa Couldridge, Saliou Niassy (President of AAIS), Joseph Tamesse (past president of AAIS)

to palatability and commercialisation of final products. In addition, much of the orthopteran diversity of Africa is relatively unexplored, and this was discussed in a number of talks, where species richness, biodiversity, and abundance of Orthoptera from different regions was studied. This is particularly relevant in light of increasing anthropogenic disturbances.

To strengthen the relationship between the AAIS and the OS, a memorandum of understanding (MoU) between the two societies was signed during the general assembly on the final day of the conference. The aim of this MoU is to foster capacity building and collaborations between the two societies and their members.

Orthoptera presentations at the 23rd AAIS conference:

- Impact of agricultural activities on Acrididae fauna in southern Tunisia. **Ben Chouikha M., et al.**
- Morphology and aspects of the bio-ecology of *Gryllotalpa microptera* Chopard 1939 (Orthoptera: Gryllotalpidae) in west region of Cameroon. **Simeu Noutchom A., et al.**
- Genetic and acoustic diversification of bladder grasshoppers (Orthoptera: Pneumoroidea). **Couldridge V.C.K., et al.**
- Effects of anthropogenic disturbances on diversity, abundance and distribution of grasshopper species (Orthoptera: Acrididea) in the littoral region of Cameroon. **Yetchom-Fondjo J.A., et al.**
- Cricket based biscuits: Stability, relative value and consumer acceptance. **Ayieko M.A. & Rono D.**
- Nitrogen-to-protein conversion factors of four orthopterans: implications for food and nutritional security. **Fombong F.T., et al.**
- Edible grasshoppers of the coastal sacred Kaya Kauma forest and their role in enhancing food security in Kilifi County, Kenya. **Kioko E., et al.**
- Physico-chemical characteristics of oil from two colour polymorphs of *Ruspolia differens*: implications for industrial application. **Kinyuru J.**
- Changements morphométriques et description des oeufs du grillon domestique (*Acheta domestica* Linnaeus, 1758; Orthoptera: Gryllidae) en captivité a Korhogo (Nord Côte d'Ivoire). **Douan B.G., et al.**
- An overview of the distribution and consumption of edible orthopterans in Nigeria. **Alamu O.T. & Oke O.A.**
- Effet de la farine du criquet migrateur *Locusta migratoria capito* sur la croissance des poulets de la race locale a Ambositra, Madagascar. **Randriamananoro J.J. & Raharitsimba V.A.**
- Criquets migrateurs africain (*Locusta migratoria*): une source de revenus pour les populations de l' extreme -Nord Cameroun. **Miantsia, F.O., et al.**
- The microbial diversity associated with processed and unprocessed marketed edible grasshoppers (*Ruspolia differens*) determined using culture-dependent molecular techniques. **Mugo L., et al.**
- Valeurs indicatrices des acridiens de trois régions du Cameroun. **Wandji A.C., et al.**
- Novacrid, a fungal biopesticide to control locust and grasshoppers. **Kooyman C. & Dussart J.F.**

Delegates at the 23rd AAIS conference.

Theodore J. Cohn Research Grant Reports

On the study of gregarine parasites in Orthoptera

By JORGE HUMBERTO MEDINA DURÁN
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If you look at any living thing in detail, you might notice that all of them are like zoos full of fantastic symbionts that somehow have adapted to live in their particular hosts. Although commonly overlooked, symbiotic relationships are quite common in every environment in the world. Hosts are like a big hotel where the guests (not always very welcome) occupy different structures in the organisms they inhabit, sometimes helping their hosts, but sometimes damaging them instead. Ultimately, all symbionts are important actors on the evolution of their hosts and we should pay more attention on how they are influencing biological interactions.

In the last few years, I have been interested in such biological interactions with a systematic approach. Particularly, I focus on a group of endosymbionts known as gregarines. These unwelcome guests are unicellular eukaryotes that parasitize the body cavities of marine, freshwater, and terrestrial invertebrates, such as annelids, mollusks, echinoderms, and arthropods. Gregarines belong to the phylum Apicomplexa, which also include well-studied vertebrate parasites responsible for diseases, like malaria and toxoplasmosis. On the other hand, gregarines have been little-studied even though they are regarded as one of the most diverse clades and they may unveil important clues in the evolution of their economically important relatives (Desportes, 2013; Simdyanov et al. 2017).

It is believed that gregarine diversity is directly influenced by the diversity of their hosts. If you think about the fact that some invertebrate groups are among the most specious, it's not hard to imagine that the potential species-richness in gregarines is large. However, when you compare the currently known diversity of gregarines and their hosts, it's evident that there is a glaring discrepancy between the two interactants. The most extreme situation occurs when you compare insect and gregarine diversity; of the about one million described insect species, only approximately 2,200 (less than the 0.25% of total insect diversity) have been reported with gregarine parasites (Clopton, 2002). The remaining insects have not been studied yet, but they surely harbor these common parasites.

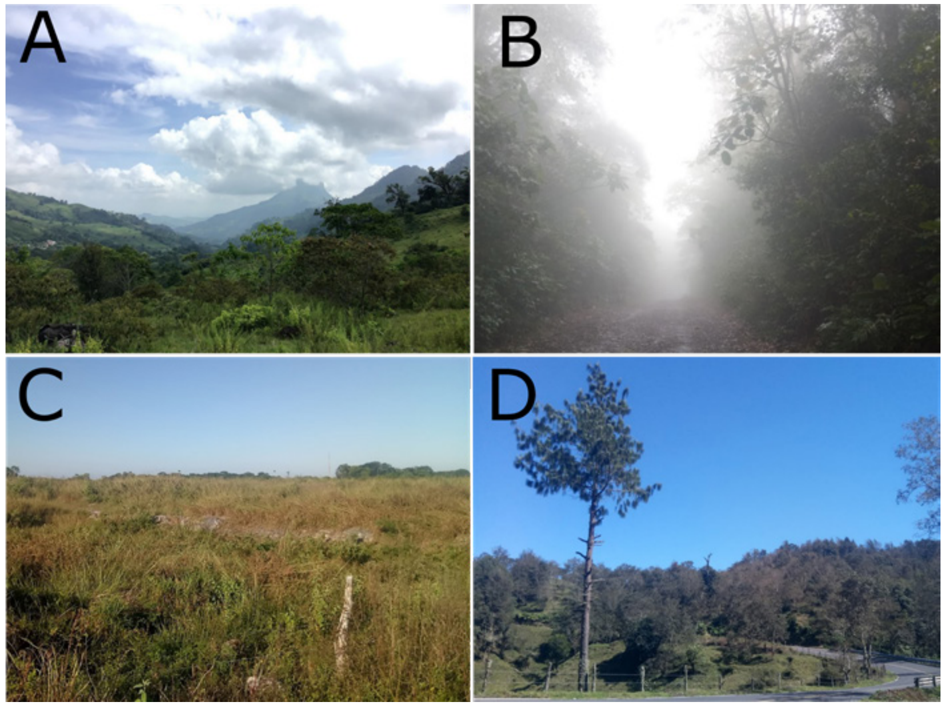

Figure 1. Landscapes from different collecting sites. A) cloud forest in Tlanchinol, Hidalgo; B) cloud forest in Xilitla, San Luís Potosí; C) grasslands in Tizimín, Yucatán; D) template forest in Tezihutlán, Puebla

Insects are great hosts to study gregarines under different approaches. If you want to study gregarines, you need to find a model organism that has high abundances and is easy to collect and maintain. Among all kinds of insects, Orthoptera turns out to be an ideal model that complies with the requirements described above. So, during my undergrad and Master's studies, I collected orthopterans from different sites looking for their gregarine parasites, with the aim to get cells for morphological and life cycle analysis, scanning electron microscopy imaging, and DNA-grade material. These are all necessary data for gregarine identification to species level.

I was able to undertake some expeditions in Mexico, particularly Hidalgo, Queretaro, San Luis Potosi, Puebla and Yucatan (Fig. 1). In all those regions, I studied gregarines of orthopterans, such as *Taeniopoda centurio*, *T. eques*, *Schistocerca piceifrons*, *S. nitens*, *Sphenarium purpurascens*, and *Conocephalus ictus*. Although every place has its weather, ecosystems, humidity, and Orthoptera

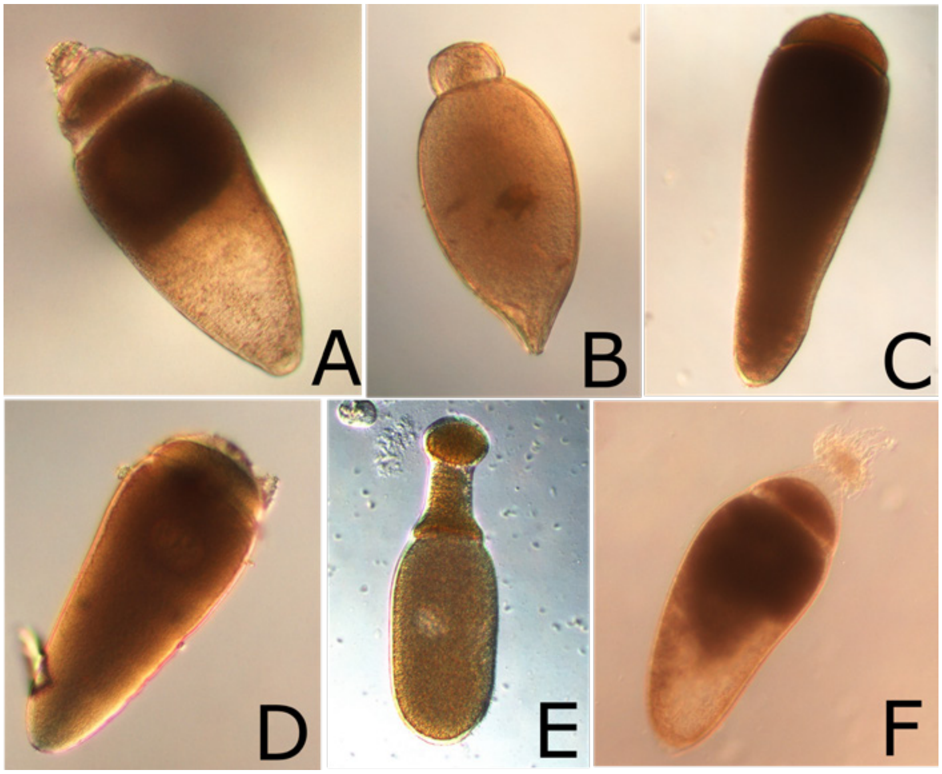

Figure 2. Gregarine morphological diversity in some Orthopteran hosts. A) trophozoite from *Conocephalus ictus*; B) gamont from *Schistocerca nitens*; C and D) gamonts from *Xyleus* sp., E) trophozoite from *Taeniopoda centurio*; F) trophozoite from *T. centurio*

community, I have been able to find gregarines in every site and grasshopper species (Fig. 2), which have made me realize how persistent this biological interaction is.

In every field expedition there are always challenges I must deal with. Sometimes Orthoptera or gregarine communities are not as abundant as I would wish, sometimes the weather is not ideal for collecting bugs, some regions even have local disputes for land properties, and you must be aware of where it is safe to catch bugs and where it is not! Really good stories have come up for every single one of these expeditions. I can tell one anecdote from a field trip to Yucatan in October 2018, for which I was supported by the Ted Cohn fund. In that expedition, I helped my colleague Bert Foquet and my now-advisor Hojun Song in the tracking of the central American locust, *S. piceifrons*. Although my main objective was to collect grasshoppers and hunt for their gregarines, the work I was helping them with was time-demanding, starting before dawn and didn't finish until late night. All that physical and mentally demanding work led to a heatstroke and a car accident! (for an entertaining narration of that adventure, I refer to the Ted Cohn grant report of Bert in the previous issue). I finally had a little bit of time to look for my parasites at the end of our mission; my colleague Bert got his desired data and I got gregarine cells to continue with my research on the taxonomy and systematics of orthopteran gregarines. Besides, I was able to learn about the swarm behavior on locusts and I saw the marching of nymphs with my own eyes!

Ultimately, the gratification of being in the field often surpasses any inconveniences that you face. Collecting bugs with friends and family, meeting awesome and supportive people, and visiting outstanding places are just a few examples of why I love to do this. Thanks to the support of many people and organizations my fieldwork on Orthoptera have let me gain expertise in both this awesome insect order and their tiny neglected parasites. With all this work, I have been able to contribute in the descriptions of new gregarine species (see Medina-Durán et al. 2019), and I am still working on descriptions of some others with the samples and data I have gathered from these expeditions. During the advance of my research new questions have come up, such as the effect of these parasites on their hosts, their specificity, and the coevolutionary patterns between the two clades. Since I am starting my Ph.D. studies in Ecology and Evolutionary Biology in the Song Lab, I am excited that I am about to address these questions!

Acknowledgments

To the Orthopterists' Society for financial support to conduct my field expedition trip to Yucatan through the Ted Cohn research grant for young researchers. To Dr. Rosaura Mayén-Estrada and Biól. Margarita Reyes-Santos for aid in material I used in the field. To the Comité Estatal de Sanidad Vegetal de Yucatán (CESVY), especially Dr. Mario Poot, for the support in the field work.

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Genetic diversity in populations of *Anonconotus italoaustriacus* Nadig, 1987 (Insecta, Orthoptera) in North-East Italy

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Anonconotus is a genus of endemic Orthoptera Ensifera present in the Alps and the Apennines. In Italy there are several *Anonconotus* species mostly located in the western Alps, and only one in the eastern Alps: *Anonconotus italoaustriacus* Nadig, 1987 (Fig. 1) (Galvagni and Fontana, 2004; 2005). This species lives only above 2000 m in mountain heliofile grassland characterized by the presence of *Juniperus* sp., *Rhododendron* sp., and *Erica* sp. (Fontana et al., 2002; Massa et al., 2012). To date only four populations have been reported in the Italian territory, more precisely: the population of the Belluno Dolomites (Vette Feltrine, Busa delle Vette, BL), Scilliar Group (Alpe di Siusi, BZ), the population of San Candido (Monte Elmo, BZ), and the Baldo Group (Monte Altissimo, TN) (Massa et al., 2012). Moreover, other populations of *A. italoaustriacus* are spread in the area of the High Tauren in Austrian territory (Illich et al., 2010; Zuna-Kratky et al., 2017).

Anonconotus italoaustriacus is a medium-sized species with 17 mm medium-long males and 21 mm medium-long females, characterized by green to brown colors. This species is micropterous (the males have small tegmina that are used to court the female) and typically consists of small populations with low density of individuals.

Because of its restricted range to a few locations scattered between Italy and Austria, *A. italoaustriacus* has been included in the IUCN Red List as an endangered species (www.iucnredlist.org). Studies focusing on its populations are therefore advisable to guarantee their conservation.

The purpose of this study was to study the different populations of this important endangered species and to identify the effective area occupied by the species in northeastern Italy. After a careful analysis of the distribution of the population, genetic analysis was carried out to characterize the populations present in the territory and to verify possible differences among them.

Figure 1. *Anonconotus italoaustriacus* in natural environment a. male of Vette Feltrine, b. female of Monte Elmo. (Photo by Marangoni F.)

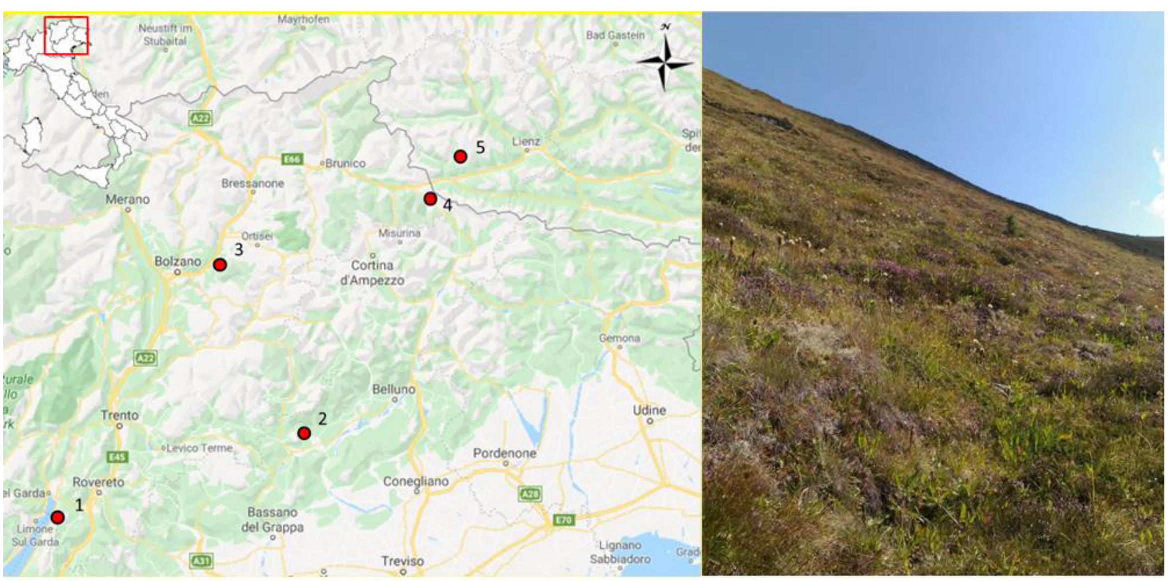

Figure 2. The image on the left shows the areas in which the populations of *A. italoaustriacus* have been sampled. 1. Monte Altissimo N45.810242 E10.888061. 2. Vette Feltrine N46.093044 E11.844104. 3. Alpi di Siusi N46.511438 E11.589616. 4. Monte Elmo N46.713666 E12.386886. 5. Heinkerkalm N46.870157 E12.419225. The photo on the right shows the typical environment that in which A. italoaustriacus lives.

Materials and Methods

In the summer seasons of 2018 and 2019 all areas in which populations were reported from the literature (Galvagni and Fontana, 2005) were sampled, including Monte Elmo, Alpi di Siusi, Monte Altissimo, and Vette Feltrine (Fig. 2). In the summer of 2019 Austrian populations were sampled at Hainkerkalm.

A maximum of 20 specimens were taken in each station in the two-years of samplings. Collected samples were preserved in absolute ethanol (99%) and at low temperatures according to standard methodology for animals destined for genetic analysis (Dutto, 2010). The "salting out" method Patwary (1994) was used to extract the DNA from the metaphemoral muscle. A fragment of the mitochondrial cytochrome *c* oxidase subunit I (COI) gene was amplified from each specimen. The PCR products were purified with enzymes: exonuclease (GE Healthcare) and Antarctic phosphatase (New England Bio Labs) and sequenced at BMR Genomics. The electropherograms of the sequenced samples were visualized and aligned using the Clustal W software available on program MEGA X (Kumar, 2018) and corrected manually, where necessary, based on the chromatograms obtained. The relationships between the different haplotypes were analysed using the TCS software 1.21 (Clement et al., 2000) set by default with a connection limit of 95%. The significance of the population structure was studied by analysing the molecular variance (AMOVA) (Excoffier et al., 1992; 2010).

Results and Discussion

Three populations of *A. italoaustriacus* were found in north-east Italy from the samples collected during the summer seasons of 2018 and 2019. In the two years of samplings, no specimens were retrieved in Monte Altissimo. Probably, this population is extinct since the last available report is from Krauss, 1909. During the First World War this area was heavily damaged and populations of *A. italoaustriacus* could have been drastically reduced or even become extinct (Galvagni and Fontana, 2005). In the areas studied here, the different populations are present only in small areas such as slopes characterized by vegetation with alpine heliophilous grassland (Monte Elmo and Alpi di Siusi) or in small portions of territory as emerged for the area of the Vette Feltrine. The population of the Vette Feltrine, in particular, is located only on a glacial formation colonized by the alpenrose, *Rhododendron* sp.

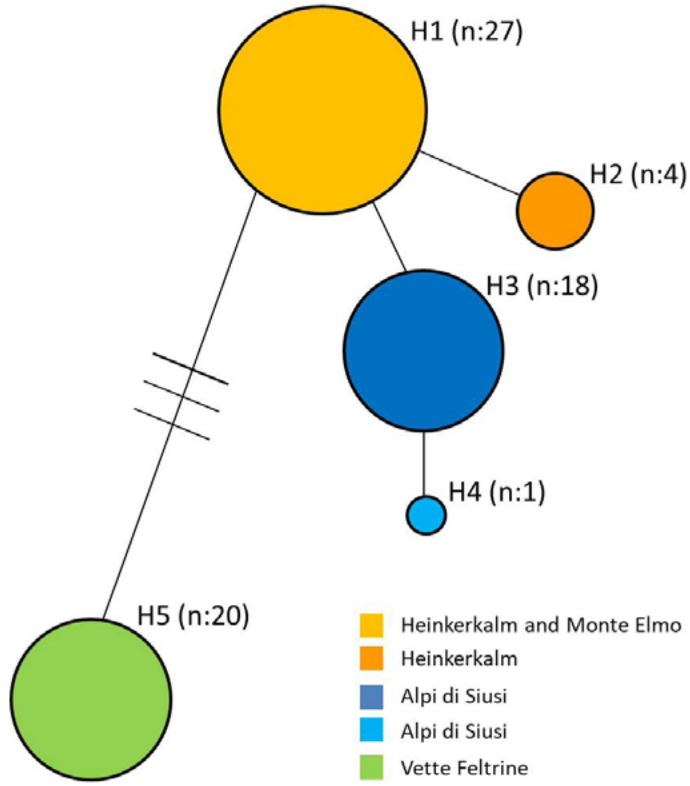

Figure 3. Network TCS for COI gene.

For each site, the actual area of dispersion of the species was estimated. It emerged that Monte Elmo was the locality with the largest area of dispersion with 41.752 m^2, followed by the area of the Alpi di Siusi with 39.726 m^2 and finally the area of the Vette Feltrine with 2.350 m^2. An increased range was found in Alpi di Siusi, compared to the area occupied in the 2018 summer season (Buzzetti et al., 2019). In the Austrian area, no study of the species distribution was conducted because a single sampling was carried out in 2019.

The analysis of the mitochondrial gene (COI) of 71 specimens sampled during the 2018 and 2019 summer seasons yielded 66 sequences 479 bp long. A comparison of these sequences with the BoldSystem database showed a similarity of > 99% with *Anonconotus* sp. To date, no sequences of the species *A. italoaustriacus* are available in the database.

The TCS network (Fig. 3) showed that the 4 populations studied were characterized by a total of 5 haplotypes. The most frequent haplotype, of H1 ($n = 23$) included samples from the Monte Elmo and Heinkerkalm populations. The Austrian population was also represented by a second haplotype, H2 ($n = 4$). The other two Italian populations were represented by 3 haplotypes, two present exclusively in the Alpi di Siusi, H3 and H4 ($n = 18$ and $n = 1$, respectively), and one present in the Vette Feltrine, H5 ($n = 20$). The network showed that the population of the Vette Feltrine was the most phylogenetically distant, given the high number of different bases between it and the other populations.

A clear geographical pattern appeared when performing the AMOVA analysis. All the populations resulted in being genetically different from each other ($p < 0.01$). Even if populations of Monte Elmo and Hainkerkalm shared one haplotype (H1), the AMOVA test considered them as different populations. If we consider the location of the two areas of interest and the ecology of *A. italoaustriacus*, it could be assumed that these two populations have recently separated from each other and the time elapsed has probably not been sufficient to fix mutations. However, further analysis extending the number of samples, taking into consideration the whole area of the species, are necessary to support that the Monte Elmo is an offshoot of the Austrian populations of the High Tauren. The Vette Feltrine population showed the highest number of mutations. This could be due to the fact that it separated early from other populations and remained isolated in the southernmost area of the range.

In conclusion, this study showed that out of four *A. italoaustriacus* populations previously reported in Italy, to date, only three are remaining, although in two sites they occupy an area greater than 30.000 m^2, but the populations were characterized by low detectability. This species is still threatened by the loss of its habitat, due to the intensive grazing in alpine grassland. This supports the classification of *A. italoaustriacus* as an endemic species to be protected, to prevent the extinction of it on the Eastern Alps. The genetic analyses showed that all the populations investigated in this study are separated from each other. Further analysis considering other molecular markers (e.g., COII) and new samples covering the whole distribution area will add more information regarding this important species. Subsequent bioacoustical analyses will be carried out to verify if the singing of these areas also differ.

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The impacts of traffic noise on fitness-related traits in the Pacific field cricket, *Teleogryllus oceanicus*

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The reach of anthropogenic noise is expansive, impacting even relatively protected habitats. For instance, over 83% of the continental United States experiences vehicular noise, including lands such as national parks and wildlife conservancies (Barber et al. 2010). Unfortunately, many animals are unable to find preferred habitat that is not impacted by anthropogenic noise (Barber et al. 2010, Buxton et al. 2017). Furthermore, most forms of anthropogenically induced environmental change impose novel selective pressures that are stronger than those historically experienced (Ghalambor 2007). Evolutionary change could theoretically offer an avenue to respond to such disturbances, but is often too slow to keep pace with rapid environmental change. This leaves animals with the options to leave their homes or make phenotypically plastic adjustments that facilitate persistence. Recent research, however, suggests

Figure 1. Photo of adult male (left) courting an adult female (right) *Teleogryllus oceanicus*.

many phenotypically plastic responses are often maladaptive (Schlaepfer, Runge, & Sherman, 2002, Battin, 2004).

Anthropogenic noise has dramatic effects on animal behavior and physiology (e.g. Wright et al. 2007, Barber et al. 2010, Kight & Swaddle 2011, Kunc et al. 2016). Noise could have negative impacts on fitness and reproductive success through effects on signals and signaling strategies (e.g. Lampe et al. 2014, Orci et al. 2016), mate competition behaviour, mate preferences and location (e.g. Cunnington & Fahrig 2013), and parental investment (e.g. Nedelec et al. 2017). Furthermore, organisms that use acoustic signals to attract mates may be disproportionately negatively affected by anthropogenic noise. In a series of two experiments supported by funds from the Orthopterists' Society, we 1) investigated whether experience with traffic noise primes receivers (females in this case) for locating mates in noisy environments once they reach adulthood through developmental plasticity (Gurule-Small and Tinghitella 2018), and 2) investigated the life-history consequences of exposure to chronic traffic noise (Gurule-Small and Tinghitella 2019). The Pacific field cricket, *Teleogryllus oceanicus* (Fig. 1), is an ideal study system as they live in habitats exposed to various degrees of anthropogenic disturbance (urban lots to untouched fields across the Pacific), are relatively short-lived, have well-characterized mating behaviors, and produce a sexual signal that overlaps in frequency with traffic noise. In both experiments we used a common experimental design in which we reared field crickets under recorded masking noise (that overlaps in frequency with the crickets' signal), non-masking noise from which we removed the frequencies that overlap with the crickets' song, or silence (Fig. 2).

In the first experiment, we 1) asked if pre-reproductive exposure to traffic noise impacts adult females' ability to locate a mate, and, if so, 2) does developing in noise facilitate mate location when searching in noisy environments? After rearing in one of the three treatments, at sexual maturity, females underwent a single phonotaxis trial in which we tested their ability to locate a simulated male. We found that exposure to vehicular traffic noise hindered females in locating a simulated calling male, regardless of the acoustic condition (masking, non-masking, silence) under which females were tested; those reared in masking noise took longer to contact the speaker broadcasting male song (Gurule-Small and Tinghitella 2018). This difference was driven by the amount of time it took females to begin moving in the search for the male, rather than the search time once she got moving. Taking longer to locate a potential partner in a polygynandrous mating system could limit lifetime mating opportunities and potentially reduce the number of or viability of offspring.

In the second experiment, we employed the same treatments, but exposed animals to the noise tracks or silence chronically, throughout life. Elucidating the lifetime fitness consequences of noise is difficult in long-lived vertebrate systems, so following an invertebrate carefully throughout life revealed new insights into the consequences of exposure to traffic noise. We assessed how a comprehensive suite of life-history traits responded to noise exposure and found that chronic exposure to masking noise delayed maturity and reduced adult lifespan (Gurule-

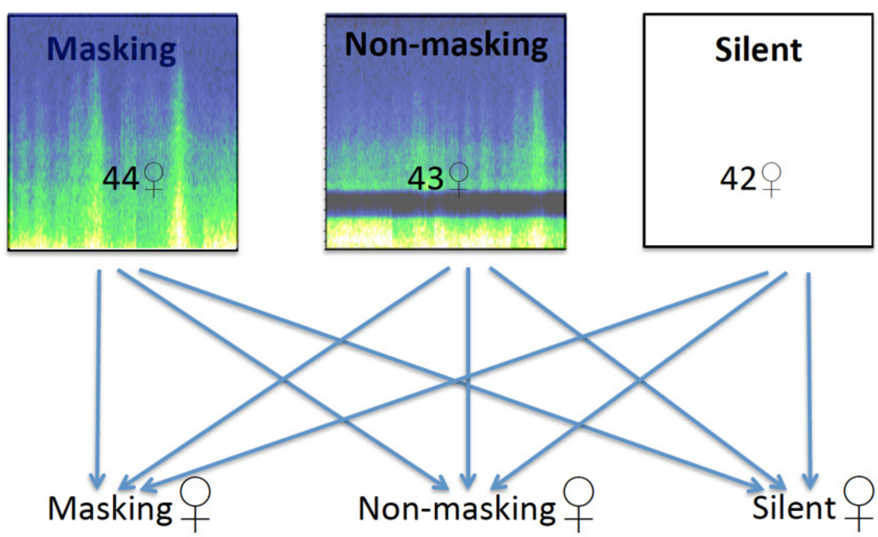

Figure 2. Visualization of female rearing conditions (top boxes) and assignment to mate location trials (bottom).

Small and Tinghitella 2019). Crickets exposed to masking noise spent 23% longer in vulnerable juvenile stages and had adult lives that were 13% shorter. In sum, our results highlight numerous ways in which exposure to traffic noise may reduce invertebrate fitness and we encourage future work that considers the effects of anthropogenic disturbance on suites of traits because the effects of disturbance on growth, survival, and reproduction may amplify or nullify one another.

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Orthoptera Species File Grant Reports

Photographic database of North African Acridomorpha (Orthoptera, Caelifera) type specimens deposited at NHM London

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The Northwestern African countries (Western Sahara, Morocco, Algeria, and Tunisia) represent original biogeographical zones in terms of diversity of ecosystems and biotas. For a long time, entomologists from all around the world contributed to the knowledge of North African Orthoptera. Entomologists, such as Bonnet, Finot, Vosseler, Chopard, Uvarov, Krauss, Harz, Dirsh, Mistshenko, and Johnston have improved our knowledge on the African orthopterans. Almost all the specimens collected by the authors previously mentioned have been deposited in, and referenced from, European museums.

Until recently, Chopard's book " Orthoptéroïdes de l'Afrique du Nord" published in 1943 was viewed as a foundation of North African orthopterans' knowledge. In the last few years, the checklist of Orthoptera from North Africa has been updated and digitized by Louveaux et al. (2019) as an internet knowledge database under the name of "Orthoptères Acridomorpha de l'Afrique du Nord-Ouest" version 2.1. This work is available online as **AcriNWAfrica** and includes a huge quantity of data, with information on each species, including diagnoses, photos, distribution maps, and keys for families, subfamilies, genera and species.

At a worldwide level, the checklist proposed by the Orthopterists' Society, accessible as **Orthoptera Species File (OSF)** v. 5.0/5.0 contains all the described species of Orthoptera of the world. For Northwest African Caelifera, part of the information proposed in AcriNWAfrica is accessible in the OSF. The latter site, however, lacks the large information on species variation and distributions that could be generated by taking into account all the specimens deposited in Museums. To improve biodiversity

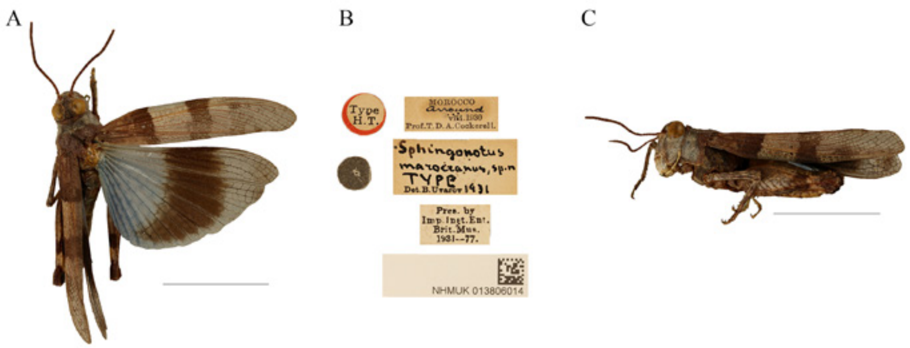

Figure 1. Habitus of *Sphingonotus (Sphingonotus) maroccanus* Uvarov, 1930: A–C, Holotype male, dorsal view (A), labels (B), lateral view (C). Scale bar 1 cm.

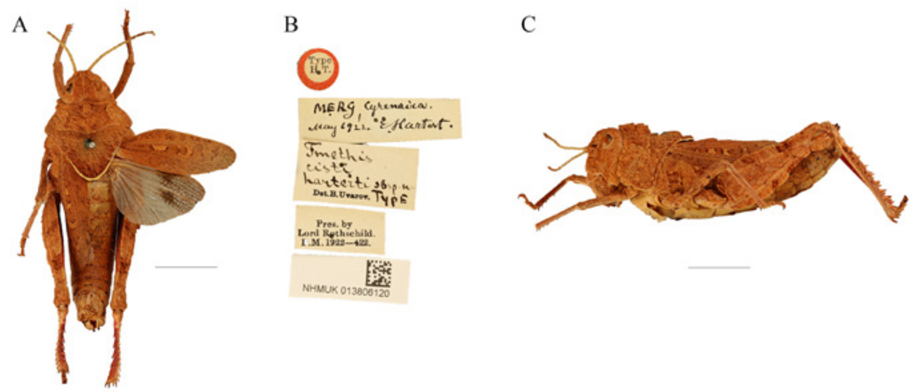

Figure 2. Habitus of *Tmethis harterti* Uvarov, 1923: A–C, Holotype female, dorsal view (A), labels (B), lateral view (C). Scale bar 1 cm.

Figure 3. Habitus of *Paraeumigus montanus* (Werner, 1931): A–C, Syntype female, dorsal view (A), labels (B), lateral view (C). Scale bar 1 cm.

knowledge, these data can actually be incorporated into a database provided it is validated by specimen examination and re-identification. From this perspective, the Natural History Museum, London, is one of the most important depositories of holotypes and other specimens from the countries in our study area, fully complementary with the collections of the MNHN used to build the AcriNWAfrica website.

The main objective of the project:
The main objective of our project was to generate a photographic database for the North African Acridomorpha (Orthoptera, Caelifera) type specimens deposited at NHM, London. By browsing the OSF website, we observed that many holotype specimens deposited in the NHM had not been photographed and published yet on the website. In addition, there were almost no images of the external genitalia of these specimens, despite their importance for the identification of taxa.

Two weeks inside the NHM, London:
We visited the museum from 1st of April to 15th of April 2019. We had the opportunity to explore the Orthoptera collection of NHM, London and their high quality preservation, guided by the senior curator in charge, Ben Price, and his colleague, Judith Marshall.

Examination and digitalisation:
Our observations were facilitated by the systematic classification of the specimens in the boxes and of boxes in the collection. The specimens were photographed with a Canon EOS 5DS R camera fitted with Canon 100mm EF 2.8L Macro IS USM lens, with a size scale of 1cm. Labels were also photographed. Then, we edited the images using Adobe Photoshop CS6 2012. Genitalia images were also taken using the same camera fitted with a Canon macro lens MP-E 65mm f/2,8. Identifications of all photographed specimens were checked.

Results:
During our research visit, we examined 45 boxes and about 80 male and female specimens of caeliferans with different taxonomic status (holotype, allotype, paratype, syntype, or neotype). These specimens represent 3 families, 9 subfamilies, 40 genera and 45 species. More than 200 photographs of specimens in lateral and dorsal view, plus their labels, were taken.

Name of our data source: © The Natural History Museum [formerly British Museum (Natural History)], London (BMNH), photo Haithem Tlili & Abdelhamid Moussi [Source used for image].

Making information available via modern technologies:

In addition to the principal goal of our project, we provided for each specimens examined a « Quick Response Code QR » with a « Barcode Number eg. NHMUK 012345678 ». These supplementary data will eventually enable easy access with the QR Code Reader Apps.

Forthcoming publications:
Based on the supplementary information collected during our research visit of the NHM, London, we are going to prepare two publications:

- An updated list of the type specimens of Caelifera (Orthoptera) from North Africa deposited at NHM, London.
- A new species of the genus *Leptopternis* Saussure, 1884 (Acrididae: Oedipodinae) from Morocco.

Perspectives:
We aim to expand this study on caeliferans to other geographical regions of Africa, particularly to countries from North-East Africa (Libya and Egypt), but also countries from Western Asia.

Acknowledgements:
First of all, we thank the Orthopterists' Society for funding this project via a 2019 OSF Grant. We thank Ben Price and Judith Marshall from the Natural History Museum (NHM) from London (United Kingdom) for their kind support for our research visit of the Orthoptera collection. We also thank Laure Desutter-Grandcolas for the support of our application for this grant. Our warm thanks go also to Ioana Chintauan-Marquier for her help in improving the report.

Re-inventory of grasshoppers (Acrididae: Gomphocerinae: Hypernephiini) of North and Central Asia

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North and Central Asia occupies huge areas of the former USSR, Mongolia, and adjacent territories of China. The general distribution of Orthoptera in this region reflects the southern thermophilic character of these insects and their common association with open habitats, such as different grasslands, openings, bogs etc. There are a lot of endemic genera, species, and subspecies in the mountains of the southern part of the region. This diversity is associated with a high diversity of biomes and natural regions.

One of the most interesting and intriguing groups of the gomphocerine grasshoppers is the tribe Hypernephiini. This tribe was erected by Leo Mistshenko in 1973 (Mistshenko, 1973: 95) for several brachypterous and apterous genera of Gomphocerinae. He described three main morphological traits of these genera: reduced wings (up to full absence), well-developed fastigial foveolae, and more or less straight or explicitly excised posterior dorsal edge of the pronotum. Mistshenko (1973) included several genera in the tribe, namely *Hypernephia* Uvarov, *Eclipophleps* Serg. Tarbinsky, Oreoptygonotus Serg. Tarbinsky, *Saxetophilus* Umnov, *Ptygippus* Mistshenko, *Anaptygus* Mistshenko, and *Dysanema* Uvarov. Several genera and many new species were described after the main publications of Mistshenko. The Orthoptera Species File [Cigliano et al., 2019] currently includes 13 genera and 48 species: *Anaptygus* Mistshenko – 6 species, Asonus Yin – 6, *Caucasippus* Uvarov – 1, *Dysanema* Uvarov – 4, *Eclipophleps* Serg. Tarbinsky –13, *Grigorija* Mistshenko – 1, *Hebetacris* Liu – 1, *Hypernephia* Uvarov – 2, *Oknosacris* Liu – 1, *Oreoptygonotus* Serg. Tarbinsky – 7, *Ptygippus* Mistshenko – 1, *Saxetophilus* Umnov – 4, and *Stristernum* Liu – 1.

The main **objectives** of this project were **(1)** to check type specimens and the Hypernephiini collections of Zoological Institute (Saint Petersburg), the collections of Novosibirsk State University and Institute of Systematics and Ecology of Animals (Novosibirsk), and published descriptions of genera and species of Hypernephiini

Figure 1. Holotype (male) of *Eclipophleps glacialis* Bey-Bienko

Table 1. List of species for which photographs were taken.

Species	Holotype	Allotype/ paratypes	Additional specimens
Eclipophleps beybienkoi Maljkovskij	male	female	–
E. bogdanovi Serg. Tarbinsky	male	female	–
E. carinata Mistshenko	male	–	–
E. confinis confinis Mistshenko	male	female	–
E. confinis levis Mistshenko	female	–	male
E. glacialis Bey-Bienko	male	female	–
E. kazacha Maljkovskij	male	female	–
E. kerzhneri Mistshenko	male	female	–
E. kozlovi Mistshenko	male	–	–
E. lucida Mistshenko	male	female + phallic complex	–
E. similis Mistshenko	female	–	male
E. tarbinskii tarbinskii Oristshenko	male	female	–
Saxetophilus petulans Umnov	male	female	–
S. mistshenkoi Naumovich	male	female	–
Grigorija beybienkoi Mistshenko	female	–	–
Oreoptygonotus tibetanus Serg. Tarbinsky	female	–	–
Ptygippus brachypterus Mistshenko	female	–	male
Anaptygus rectus Ragge	–	female	–
Caucasippus rufipes (Fischer de Waldheim)	–	–	female + male

and to analyze their possible relations on the basis of morphological traits; **(2)** to organize a field trip to the central part of the Altay-Sayan Mts and to make some new attempts to find the northernmost populations of these grasshoppers; **(3)** to add new pictures of type specimens and other museum specimens; **(4)** to add new data about distribution of local species including georeferenced points; **(5)** to re-invent existing data in the OSF and to correct them (when needed); **(6)** to develop a new spatial scheme for the region based on the distribution of the life zones and mountain systems; **(7)** to characterize species distribution on the basis of the new spatial scheme.

Methods. A set of the following approaches and methods were used for field studies: **(1)** qualitative and quantitative samples of grasshoppers will be taken along transects crossing altitudinal series of ecosystems and the geographic coordinates of all sampling locations will be determined using GPS/Glonass; **(2)** main characteristics of vegetation and soils will be determined for each of the studied terrestrial ecosystem. Laboratory studies were based on the following complex of methods and approaches: **(1)** digital mapping of species distribution; **(2)** an analysis of existing geographical schemes for the region, their evaluation and development of the scheme applicable for the OSF; **(3)** a comparative analysis of published data for the region; **(4)** preparation of photographs of the habitus, diagnostic traits and labels of type specimens and other museum specimens from the collections of Novosibirsk State University, Institute of Systematics and Ecology of Animals and Zoological Institute (Petersburg); **(5)** comparative analyses of traits of museum specimens from the collections of Novosibirsk State University, Institute of Systematics and Ecology of Animals (Novosibirsk) and Zoological Institute (Petersburg) and traits described in published articles and revisions of the genus *Eclipophleps* and the general composition of the tribe.

Results. We organized the field trip to the central part of the Altay-Sayan Mts. and tried again to find the northernmost populations of the tribe Hypernephiini. We explored the mountain ecosystems of Academician Obruchev Range above the timberline, but without success. This means the northernmost known locality of this tribe remains in SE Altay (Kurajskiy Range, southern slope) (50° 07’ N – *Eclipophleps glacialis* Bey-Bienko) (Sergeev, 2016) (Fig. 1).

We studied the collections of Zoological Institute (Petersburg), Novosibirsk State University, and Institute of Systematics and Ecology of Animals, mainly holotypes and paratypes, took a lot of photographs (>1,800) of whole specimens, their labels, and some important details. Some pictures

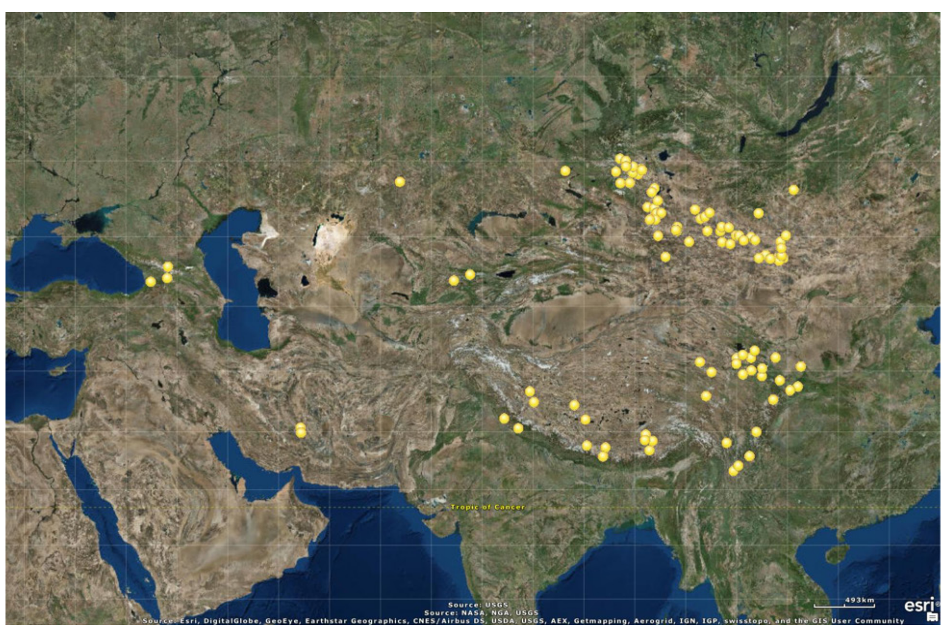

Figure 2. General distribution patterns of the Hypernephiini grasshoppers

(137) of 17 species from 8 genera were selected (commonly lateral, dorsal and ventral views of type specimens) and added to the OSF database (see Table 1).

All applicable publications and labels of the museum specimens were analyzed. In almost all cases, the georeferenced points and altitudes were determined on some printed maps and/or by Google Earth Pro (© Google, 2019) and/or ArcGIS Explorer (© Esri, 2014) instruments. The geographic coordinates of some localities were corrected after the analysis of some old publications about the expeditions (e.g., in Tibet). More than 100 localities were added. Now the OSF database includes geographic coordinates for almost all species of the tribe. The geographic distribution of the Hypernephiini is very interesting and strange (Fig. 2). These short-winged forms settle mainly in the arid mountains of East Kazakhstan and Mongolia. Some genera are limited by the mountains of Tien Shan, Zagros, the East Himalayas, Tibetan Plateau, and Hengduanshan. Some members of these groups are extremely abundant and may be pests, others may be very rare.

The composition of the tribe and relations between different genera should be revised in the future. For instance, Sergeev (1995) proposed to include some other genera in this tribe. "Fauna Sinica" (Zheng, Xia, 1998) also includes some several additional genera from this grasshopper group (as the members of Asoninae and Dysaneminae; both subfamilies were synonymized by Sergeev (1995)). Besides, based on the general distribution patterns of several genera we suspect that at least some of them could be divided into two separate genera each.

Unfortunately, almost all problematic taxa are described from China and their types are in some regional collections. Additionally, note that the OSF includes some duplicate remarks for several species from this group but under different generic names.

Acknowledgements

The authors wish to express their sincere thanks to A.V. Gorochov (Zoological Institute, St. Petersburg) for advice, interactions, and cooperations during our studies in the collections of ZI and to all collectors of specimens. MGS is also indebted to all companions during the field trips to Tuva and adjacent areas.

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Orthoptera of the Eastern Balkans and the Carpathian Basin (Bulgaria, Macedonia, NE Greece and Romania): a database of collections, literature and digital data in the Orthoptera Species File with additional data for Kazakhstan

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According to a recent estimate (IUCN SSC Grasshopper Specialist Group), about 1083 species of Orthoptera occur within the borders of Europe as regarded in the Fauna Europaea (http://www.faunaeur.org/). Over 40% of these taxa are represented on the Balkan Peninsula. Including the Carpathian Basin this percentage grows over 50 (e.g. Heller et al. 1998. Articulata 7: 1-61). This richness is the result of the combination of a variety of habitats, glacial and interglacial refugia, high levels of endemism and migration events. The connections with the Anatolian Plate and Europe over long geological periods provided migration routes for species of different origin and produced communities of mixed origin; the complex geomorphology provided land bridges for latitudinal and altitudinal expansions of some species, at the same time being barriers for others and in combination with the diverse climate resulted in vast evolutionary radiation.

For the present project we selected the territory of the Central and Eastern Balkan Peninsula, and the Carpathian Basin (incl. Romania, Bulgaria, Republic of Macedonia, and Northeastern Greece) as target territory for collecting data to contribute to the Orthoptera Species File. This area has a high level of endemism (over 30%), includes many local endemics, and is characterized by many unique and representative communities. We estimate the faunal richness at about 310 valid taxa of the species and subspecies category. Additionally, over 50 taxa described from the concerned region are presently considered synonymic.

The proposed project aimed to contribute to the Orthoptera Species File database with information on Orthoptera from nature, collections, literature, and databases covering the region of the Central and Eastern Balkan Peninsula and the Carpathian Basin on the territories of Bulgaria, NE Greece, Macedonia, and Romania. Additionally, any interesting records and materials available from outside these areas may be added.

Realization

During this project we performed field trips around the Balkans – Greece, Bulgaria, Romania, Republic of North Macedonia, Montenegro (for sampling sites, see Fig. 1). A special trip was organised to Kazakhstan in 2016 that was an addition to the project as an opportunity to collect data in this poorly known area.

Special trips were organized in Kazakhstan (June 7 – July 11, 2016), Montenegro (July 6–9, 2017), Greece – mainland (May 30 – June 7, 2017), Greece – Aegean islands and mainland (May 13–30, 2018). Photo samplings in Bulgaria, Romania, and Republic of North Macedonia have been performed on occasion during the whole period, 2016–2018.

As we delayed completing the project we also added field photos from 2019 taken during trips financed by other sources.

Remarks

Results from the trips in 2016 are reported in an intermediate report published in *Metaleptea* 37(2). During this project we realized that photos of both rare and very common taxa of Orthoptera are missing in the OSF database. Also, museum specimens are much better represented than live animals in the OSF photo archive. Hence, we concentrated our effort on uploading photos of grasshoppers, crickets, and bushcrickets in their natural environment as well as for some interesting taxa, plus photos of the habitat they were found in. The latter types of photos were given priority over photos of dead specimens and sound recordings.

Preliminary ideas for field trips were almost fully covered in the end with some exceptions due to worsening conditions for field trips in some areas or surcharges due to poor costs planning for the trip in Centra Asia. Now we know that additional costs should be considered for such remote poorly developed areas for covering accidental car repairs, much higher prices in case of lack of fuel, etc.

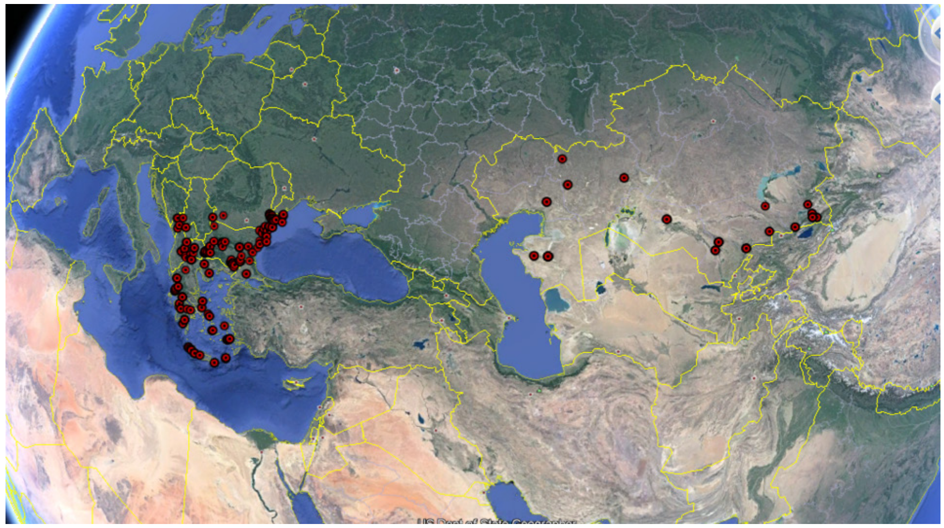

Figure 1. Sampled localities in the Western Palaearctic (Balkans and Kazakhstan) (as seen on Google Earth, 2019).

Results

Our results currently cover only photos uploaded into the OSF database. Within the project period we uploaded 575 photos of 221 taxa and their habitats taken in vivo (or a few living in captivity) comprising 197 species with 24 additional subspecies from the Balkans and Central Asia collected in 2016, 2017, 2018, and 2019. We contributed mostly with photos of endemic taxa and poorly known ones,

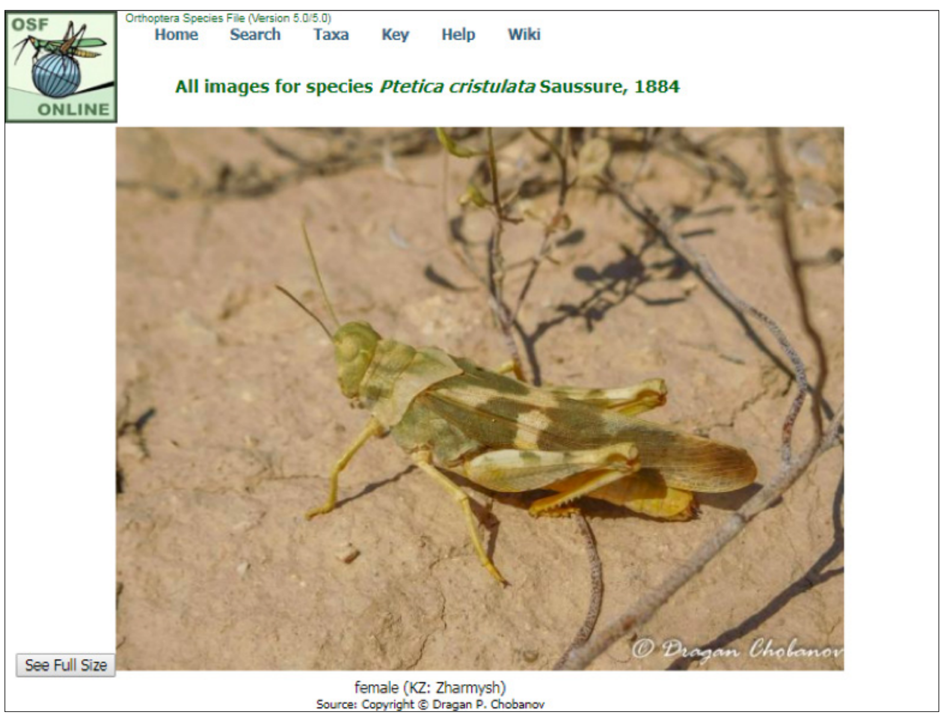

Figure 2. Photo of a poorly known species from a monotypic genus occurring in Central Asia uploaded in OSF.

Figure 3. Data for a specimen record of *Ptetica cristulata* included in OSF.

including ca. 32 with distribution in Central Asia (Kazakhstan). For most of the taxa photos were uploaded for the first time to OSF (Fig. 2). For all specimens, precise collecting data was also provided (Fig. 3).

Conclusions

Results do not always fully reflect planning, especially when live animals are considered and seasons, politics, and chance may pose significant obstacles during field trips... a vehicle can surprisingly break down in the middle of nowhere or the season that started early this year may surprise you the next and the planned trip to catch early species may result in a search of first instar nymphs that you have to raise on the road. Yet, we were happy with the diversity of beautiful rare orthopterans we have met, photographed, and recorded. The uploaded 575 photos of 221 taxa and their habitats are just part of the growing sample of photos and still unprocessed recordings we collected and continue to collect. This does not mean we will stop our contributions to the OSF. This largest database for Orthoptera needs to be supplemented and our data will be uploaded regularly.

Table 1. Uploaded photos by taxa and country

Country	Number of taxa	Number of photos taken
Greece	68	186
Bulgaria	55	120
Romania	50	87
Kazakhstan	35	99
North Macedonia	23	67
Montenegro	6	13
Serbia	1	2
Russia	1	1

Table 2. Genera we paid main attention to

Genera with highest number of taxa sampled	Number of taxa
Poecilimon	38
Isophya	13
Eupholidoptera	9
Chorthippus	9

The OSF grants are a great opportunity and relief for scientists with low scientific support in their own country. We appreciate this funding possibility with public, educational, and scientific purpose, and thank the Orthopterists' Society in cooperation with the Illinois Natural History Survey for supporting our project!

National Meeting of the Locust Campaign 2019, Mexico

By **MARIO A. POOT-PECH[1], E. GARCIA-LUCAS[2], J. FERIA-GARCIA[2], M.J. GARCÍA-RAMÍREZ[3] & R. MUNGUIA-ROSALES[1]**
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The Central American Locust (CAL), *Schistocerca piceifrons piceifrons* Walker 1870 (Orthoptera: Acrididae), is the most important locust species in Mexico and Central America. In Mexico, despite the efforts to survey and monitor CAL populations, outbreaks are still difficult to predict and could cause significant damage if preventive management is not carried out.

The origin of the campaign against CAL goes back to 1924 when "the law of plagues" was published; however, Felipe II, since 1593, in the courts of Madrid, enacted the ordinances for the control of locusts, which was the first regulation against this pest in Mexico. Management of CAL in Mexico is through a locust permanent campaign coordinated by SENASICA (National Service for Agri-Food Health, Safety and Quality) with influence on 11 States (Fig. 1). Around of 475,000 ha per year of grassland, maize, sugar cane, and forest vegetation are monitored. The most important breeding zone in Mexico and Central America is the Yucatan Peninsula (Yucatan, Campeche, and Quintana Roo States) with around 400,000 ha, of which the cultivated rangelands are the principal biotopes of the locust.

Figure 1. Influence of the locust campaign in Mexico.

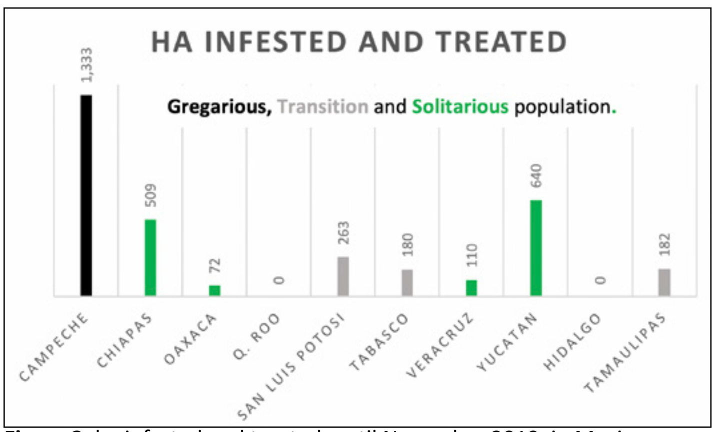

Figure 2. ha infested and treated, until November 2019, in Mexico.

Figure 3. Locust meeting 2019, Mexico.

The strategies in the campaign operations are survey, intervention actions (biological or chemical control), locust field officers or croppers training, diffusion of the locust campaign, and an analysis-evaluation at the end of each program. A locust campaign development meeting was held in November 27-29, 2019 with the objective of coordination among States and creating agreements to reduce the possibility of locust outbreaks through early detection-intervention. This event was developed in two parts: the locust campaign meeting and a technical workshop.

Locust Campaign Meeting

In general, the situation in Mexico in 2019 was of low population in solitary phase, except for Campeche State where the gregarious phase was present. In this state in January-March swarms arrived from Yucatan State and reached two generations (June-September and October-December to the present), however, it is decreasing because monitoring actions were strengthened as well as control strategies. January to November was detected and treated by ground: 3,289 ha where 455 ha was treated with the fungal pathogen Metarhizium acridum. Additionally, Guerrero State has a Locust Surveillance Program.

Problems

- In January, the swarms arrived to areas of difficult access in Campeche State: forest zone, also difficult to control.
- Remoteness and inaccessibility of the primary locust breeding areas of hopper bands, cultivated rangeland mix with forest area, are hard to locate.
- The inaccessibility of the breeding areas of CAL in the forest continue to complicate planning and implementing of effective control operations.

Results

- The locust campaign emphasized the need for a permanent system of well-organized surveys of areas that have recently received rains, been flooded, or are swarm migration routes, backed up by control capabilities to treat hoppers and adults efficiently in an environmentally safe and cost-effective manner.
- Only Campeche State has gregarious populations, however this has been reduced by coordination efforts between State and Federal Government.
- The other states will continue

Figure 4. Support of drone in night control on swarm and explanation about development of emergency/contingency protocols.

Figure 5. 5th instar nymph and gregarious adult of *S. piceifrons piceifrons*.

doing continuous monitoring for early detection.
- There was no damage in agriculture.

Perspectives

- In the 2020 locust program the use of remote sensing will be included, emphasizing mating-raining periods and previous oviposition.
- With historical information of locust outbreaks, a forecast (stochastic models) on possible outbreaks in subsequent years will be obtained for every State.
- Continue with the use of drones as support for monitoring and control operations (aerial applications), emphasizing preventive applications with *M. acridum*.
- Continue training with the field locust officers.
- Probably presence of patches and gregarious formations in Yucatán State.

Technical workshop in the field on Locusts

One of the objectives of the locust workshop is to increase the technical capacity of the field locust officers and to improve response mechanisms to locust outbreaks, which led to the development of the locust workshop. The content was surveying of bands and swarms (by ground and drone), development of emergency/contingency protocols, insecticide evaluation of low-high impact, and development of GIS (Geographic Information System).

Recap of 2018/2019 ESA Organized Meetings: "Small Orders, Big Ideas (Polyneoptera)"

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In 2014, an orthopteroid member symposium was organized for the first time at the annual Entomological Society of America (ESA) conference, with presentations by both students and seasoned researchers and topics covering many of the extant orders of Polyneoptera (Blattodea (+Isoptera), Dermaptera, Embiidina, Grylloblattodea, Mantodea, Mantophasmatodea, Orthoptera, Phasmatodea, Plecoptera, and Zoraptera). This symposium quickly became a tradition and due to the overwhelming success in its first four years (see recap reports in *Metaleptea* 35(1), 36(1), 37(1), and 38(1)), we applied in 2018 to establish it as an "organized meeting" instead of a "member symposium." While the general concept remains unaltered, the Organized Meeting, known as "Small Orders, Big Ideas (Polyneoptera)," is now essentially guaranteed to be a mainstay at ESA conferences for years to come because organized meetings are more likely to be approved each year. Also, the goal is to have Derek and Hojun co-organize the meeting each year with the assistance of a student. Derek and Hojun's roles will be to apply for the meeting and assist the student as needed while he/she will invite speakers, moderate the meeting, and write the recap for *Metaleptea*, which will give students great experience in organizing scientific meetings.

Over the last two years, the ESA conference took place, respectively, in Vancouver, Canada, and St. Louis, Missouri, U.S.A. during which we had, respectively, 10 and 9 speakers. As before, part of the success of this Organized Meeting is the good mix between graduate students and experienced postdocs, professors and other researchers. Moreover, we attracted keynote speakers from abroad each of the two years. In 2018, Fernando Montealegre-Z traveled all the way from the United Kingdom to dive into the acoustic world of orthopterans, while in 2019 Clint Kelly flew in from

Figure 1. ESA, 2018 Speakers & Organizers (left to right): Dan Johnson, Kevin Judge, Hojun Song, Nathalie Baena-Bejarano, Derek A. Woller, Fernando Montealegre-Z, Laurel Symes, Bert Foquet, Sydney Brannoch, Sean Schoville, Timothy K. O'Connor, and Jantina Toxopeus. Not pictured: Douglas Lawton.

Figure 2. ESA, 2019 Speakers & Organizers (left to right): rear: Clint Kelly, Jeffrey Cole, Deanna Zembrzuski, Janice S. Edgerly, Abigail Hayes, JoVonn Hill; front: Michael Milam, Bert Foquet, Derek A. Woller, James A. Robertson, and Jorge Medina-Duran.

Canada to tell us the exciting story of sexual selection and alternative mating strategies in Wellington tree weta. Furthermore, in 2018, we had presentations from Dan Johnson, Timothy K. O'Connor, Douglas Lawton, Sean Schoville, Nathalie Baena-Bejarano, Jantina Toxopeus, Kevin Judge, Sydney Brannoch, and Laurel Symes (Fig. 1). In 2019, we had JoVonn Hill, Jeffrey Cole, Jorge Medina-Duran, Michael Milam, Janice S. Edgerly, James A. Robertson, Abigail Hayes, and Deanna Zembrzuski (Fig. 2). Together, these talks covered several of the Polyneopteran orders (Embiidina, Grylloblattodea, Mantodea, Phasmatodea) and a large variety of orthopterans. Moreover, a diverse amount of topics were discussed, ranging from conservation and detection via acoustics to mating and egg production to gut parasites.

If you would like to learn more about the presentations, a brief abstract and figure for most of the talks are provided below for the last two years. As part of the tradition, every year the Organized Meeting is concluded with a dinner in a local restaurant where all speakers are invited, as well as anyone else interested in attending (e.g., Fig 3).

Finally, we have a request for students working on polyneopteran insects. As mentioned earlier, every year, one of the organizers of this Polyneoptera get-together is a student, which has been Bert's role for the last two years. Not only is this a unique opportunity to learn about the organization of Symposia, Organized Meetings, and even conferences, it also brings you in contact with some of the most interesting researchers focusing on Polyneoptera. Ideally, the student will have been a presenter in the Organized Meeting, but it's not required. If the meeting is approved for the 2020 ESA meeting, two students who presented in the 2019 meeting have already volunteered to be co-organizers. If you don't feel like you want to take up this responsibility in 2021 and beyond, but still want to present during our Organized Meeting next year or in the future, feel free to also contact Derek and Hojun! They are looking forward to your response!!

Figure 3. ESA, 2019 Speakers, Organizers, and Friends enjoying burgers across the street from the convention center. A good time was had by all!

ESA, 2018: Vancouver, Canada

Orthoptera in ecological foodwebs and crop systems, over 50 years: Analysis of annual data on abundance, hatching, weather, climate, and seasonal patterns in Alberta, Canada

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During years of field experiments in Alberta, we documented, with previous collaborators, the abundance of Orthoptera and their role in avian diets. Small overwintering grasshoppers, mainly *Psoloessa delicatula* and *Eretettix simplex*, and the early hatching species *Aeropedellus clavatus*, are important in the diets of grassland songbirds on dry mixed grass. Grasshoppers exceed 70% of the diet of nestlings in May and June. In field studies in dry grass (short grass) in southeastern Alberta, we also documented the prominence of larger overwintering grasshopper species, especially *Xanthippus corallipes*, as food for nestlings of the burrowing owl (*Athene cunicularia*), an endangered species. Field evidence from pellets, feces, and observations showed that grasshoppers (especially *Melanoplus bivittatus*) are important in the diets of burrowing owls (based on pellet analysis), game birds, and even coyotes. Recently, a new field study (S. Meyhoff) has shown that late-season grasshoppers are important components of diets of plains sharp-tailed grouse (*Tympanuchus phasianellus jamesi*). Sharp-tailed grouse crop contents analysis indicated that the small flightless grasshopper (*Melanoplus dawsoni*), made up over 80% of all insects consumed. Other Orthoptera, such as *Chorthippus curtipennis*, *Melanoplus gladstoni*, and *Ceuthophilus*, are utilized. We found that local grasshoppers are high in nutrients, including linoleic acid and associated lipids essential for growth and development in birds, and protein. Grasshopper species known for risk to agricultural crops are surveyed in late-season, currently by Alberta Agriculture and Forestry. Earlier raw data are available back to 1970, and abundance maps back to 1920. The results are used in methods of forecasting (Blakley, Johnson, and Meers poster, ESA2018). Additional sampling of non-pest species is conducted, and also serves in validation of age structure and abundance. Relative abundance of grasshopper species varies among regions of Alberta, and results in differences in ecology and diets of birds. For example, we identified 9,224 grasshoppers during a field study in southern Alberta, in which the proportion of *Melanoplus bruneri* ranged from 0.1% to 3.7%, while this species was a dominant species in more northern grassland and forest areas. A total of 46% of 4,371 grasshoppers collected in northeastern pastures near Cold Lake, Alberta, were identified (DJ) as *Melanoplus bruneri*, and observed to be common in the daily diets of birds at the site (Gurski, Gurski, Johnson, Jaronski, Kawchuk, and Wojnowski poster, ESA2018). We are using daily weather records and studies of individual species to assess the history and timing of grasshopper abundance throughout the year in order to produce a comparative record of probable value to grassland foodwebs, especially wild birds and insectivorous mammals. Developmental models developed for grasshoppers for this purpose are applied, along with spatial models of timing and degree of aggregation. The results will allow improved estimation of biomass, species, and age class, with regard to avian food availability, over years and regions.

Melanoplus gladstoni, taken by Dan Johnson at his research site.

Do specialized orthopteroid herbivores co-speciate with their host plant?

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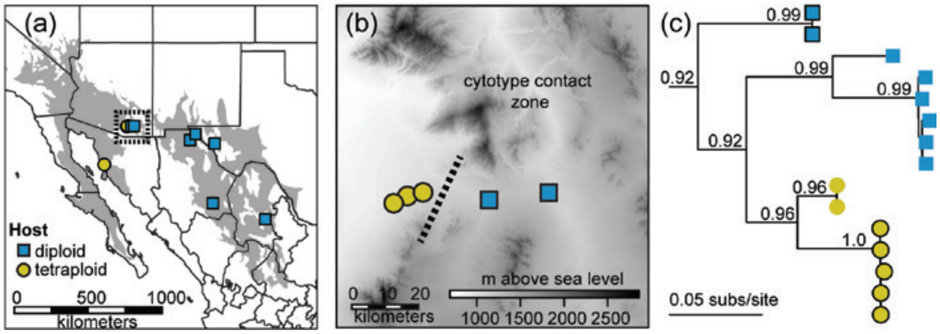
Identifying the processes that link plant and insect diversification is an enduring challenge in evolutionary biology. Adaptation to novel host plants can drive divergence between herbivore populations, but there is little phylogenetic evidence that herbivores co-speciate with their hosts. Population-level studies may be better suited to detect co-speciation in progress and assess its contribution to insect diversification. We tested for co-divergence between creosote bush (*Larrea tridentata*, Zygophyllaceae) and its community of orthopteroid herbivores. Creosote bush is a dominant desert shrub that has diversified through polyploidy since its arrival in North America ~1 Mya. Diploid, tetraploid, and hexaploid populations (cytotypes) of creosote bush are parapatrically distributed across the Chihuahuan, Sonoran, and Mojave Deserts, where phenotypic differences



Example of phylogeographic pattern consistent with host-associated differentiation in the stick insect Diapheromera covilleae. (a) Geographic sampling for preliminary COI sequencing. Boxed area near contact zone between diploid and tetraploid creosote bush shown in next panel. (b) Sampling near cytotype contact zone. (c) Phylogeny COI from available samples. Tips with outlined symbols are represented in cytotype contact zone shown in panel (b). Deep divergence between nearby populations on alternative hosts is consistent with an effect of host plant on reproductive isolation.

among cytotypes can affect interactions with herbivores.

We hypothesized that a community of specialized orthopteroid herbivores may co-diversify creosote bush through host plant adaptation. To address this, we tested the prediction that population structure of multiple herbivore species would correspond to host plant cytotype. We are using genome-wide reduced-representation sequencing (ddRAD and RADcap) to survey genetic diversity and population structure of four orthopteroid species: the grasshoppers *Bootettix argentatus* and *Ligurotettix coquilletti*, the katydid *Insara covilleae*, and the stick insect *Diapheromera covilleae*. Sampling spans the full distribution of each species, with particular emphasis on contact zones between plant cytotypes. Final dataset will include 100-500 individuals of most species, and ~50 individuals of *Diapheromera*. Preliminary mitochondrial (COI) data and ddRAD sequencing indicate that major phylogeographic breaks in two herbivore species coincide with contact zones between creosote bush cytotypes. *Bootettix* populations to the east and west of the contact zone diploid-tetraploid contact zone are deeply divergent. Limited ddRAD data suggest a shallower divergence between populations on tetraploid and hexaploid host plants, but this was not supported by available COI data. A deep divergence between *Diapheromera* COI haplotypes maps precisely to the contact zone between diploid and tetraploid host plants. Neither COI nor pilot ddRAD data support host-associated differentiation in *Ligurotettix* populations. Insara data are forthcoming.

Our ongoing work on this system will more robustly test whether host plant adaptation contributes to reproductive isolation and thus divergence between herbivore populations on different creosote bush cytotypes. This work has the potential to highlight an under-appreciated link between plant and insect diversification.

Defining the nutritional landscape of grasshopper communities in Eastern Australia

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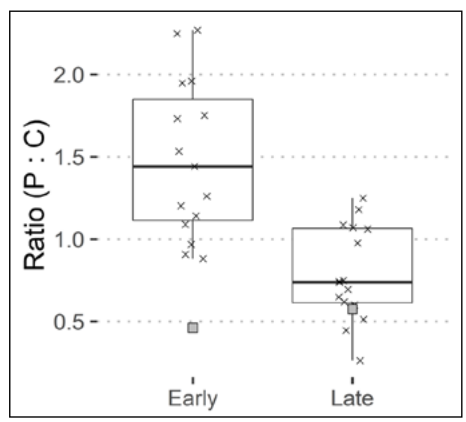
Studies using the geometric framework for nutrition have shown that most animals regulate among food sources to achieve an optimum balance of macronutrients (intake target; IT), typically protein (P) and carbohydrate (C) for herbivores. When an animal is unable to reach this target, such as during a drought or other environmental perturbation, there are physiological consequences. However, few studies have compared the intake targets of free-living herbivore populations with their available nutrient landscapes to determine how easily herbivores can reach their intake target through time and space. In this study, we measured intake targets for three grasshopper species and the nutrient contents of their host plants. We included three spatially distinct locations in New South Wales, Australia and two time points roughly four weeks apart in late 2017. In both spatial and temporal scales, grass protein content significantly differed whereas carbohydrate content stayed relatively constant. Grasshopper intake target ratios were mismatched with the available C:P ratios. Intre- and intra species intake targets were divergent between and within landscapes. Our results suggest that grasshoppers will shift their IT to address nutritionally suboptimal landscapes. Grasshopper migration might be needed to locate nutritionally optimal landscapes. Further study is needed to give mechanistic explanations and to understand the physiological consequences of being in a suboptimal nutritional landscape.



Grasshopper population intake targets with available nutritional landscape. Boxplot and Xs represent grass nutrients. Top: spatial change in intake targets and grass protein (P) : carbohydrates (C). Bottom: temporal change in C. terminifera intake targets and grass P : C.

The genetic basis of physiological niche conservatism in ice crawlers (*Grylloblatta*)

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A central challenge in ecology and biogeography is to determine the extent to which physiological constraints govern the geographic ranges of species, and whether physiological traits can evolve in response to global change. Cold-specialized insects such as ice-crawlers are potentially threatened by rising global temperatures. Most importantly, declines in snowpack could expose them to more extreme maximum and minimum temperatures, from which they were previously insulated by the overlying snow. Using a comparative framework that examines closely related populations across environmental gradients, as well as deeply genetically divergent species, I examined whether thermal tolerances vary (and therefore evolve), as well as the genetic basis of thermal stress responses in ice crawlers. There seems to be limited evidence that thermal tolerance evolves in an ecologically significant manner, although there is a trend of greater breadth at low latitudes. Genomic analysis of gene expression suggests ice-crawlers may have lost their temperature stress response over time, when compared to other Neopteran insects, including the sister clade Mantophasmatodea. I also examine other critical physiological traits, including thermal preference, metabolic rate and desiccation resistance, to argue that ice-crawler species exhibit physiological niche conservatism. Presumably this has evolved in response to their narrow, relatively constant microenvironments in cave and alpine sites. While cold-temperature specialization has made ice-crawlers successful in their unique habitats in North America for tens of millions of years, these evolutionary constraints are likely to exacerbate the impact of future climate change on ice-crawler abundance, distribution and possibly species diversity.

Ice-crawler (*Grylloblatta* sp. nov.) from the Sierra Nevada Mountains in California. Photo by: Sean Schoville.

Cretaceous fossils shed light on the evolution of Tridactyloidea (Orthoptera: Caelifera)

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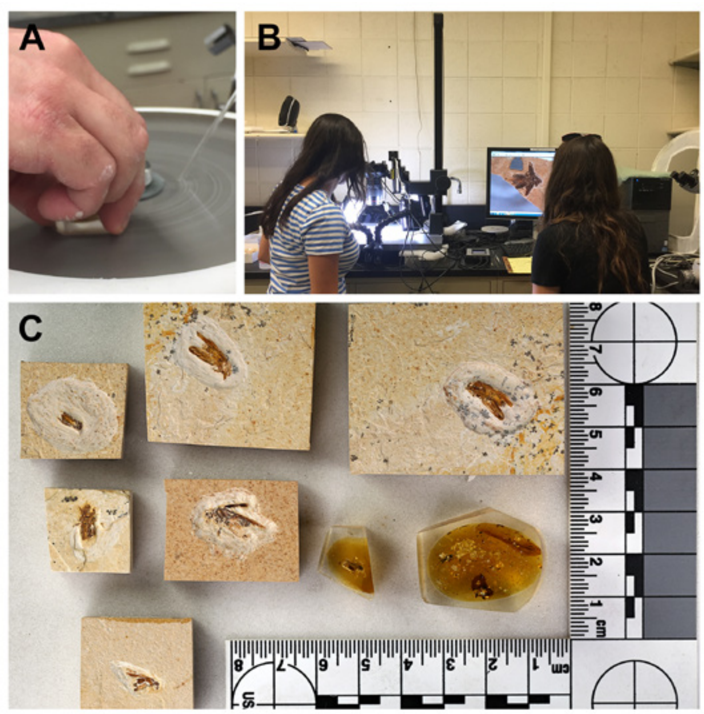
Mud crickets (Ripipterygidae), pygmy mole crickets (Tridactylidae), and sangropers (Cylindrachetidae) are small (0.5 cm) to medium (9 cm) size orthopterans which comprise the superfamily Tridactyloidea. This group is associated with semiaquatic and fossorial habits and displays morphological traits for these behaviors. A set of morphological and molecular characters support its placement as a monophyletic group at the base of the caeliferan radiation. Tridactyloids are an ancient group with a scarce fossil record. To date, only thirteen fossil species are known in the group. Most of the records are from the Cretaceous, but the range in age extends from the Early Miocene to Early Cretaceous. The distribution of this group include geological formations around the world (England, Brazil, Siberia, Mongolia, Russia, Burma (Myanmar), France, Dominican Republic). The goal of this research was to identify and describe new fossil taxa from the Lower Cretaceous Crato Formation of Brazil and from mid-Cretaceous Burmese amber. The amber fossils were embedded at Heads Laboratory in an epoxy resin, cut and polished. Photographs were taken with different equipment, and observation proceeded using stereomicroscopes. We reviewed three fossil samples from Burmese amber and eleven fossil specimens from the Crato Formation. Our study resulted in the discovery of new taxa at the specific, generic, and family levels. Important highlights of this research are the discovery of a new family of tridactyloids with



Procedure and samples studied in our research: A) Polishing of embedded samples at Heads Laboratory (M. Jared Thomas). B) Photograph preparation from Crato Formation of Brazil (Left: NBB and right: Valeria Estrada-Corredor, High School volunteer summer 2017). C) Sorted samples from Nanjing institute of Geology Paleontology and Chinese Academy of Sciences and AMNH Collection.

an adult and a nymph from Burmese amber and multiple new genera from the Crato Formation. We corroborated a more widespread distribution of the subfamily Dentridactylinae as suggested by previous authors. These contributions are considerably expanding our knowledge of the oldest fossil tridactyloids, further attesting to a much greater Cretaceous diversity than previously realized.

ESA, 2019: St. Louis, Missouri, U.S.A.

The Grasshopper Fauna of the Imperiled grasslands of the Southeastern United States

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For the last 200 years, the idea that the southeastern United States was historically covered in vast forests and swamps has been widely perpetuated. However, we are beginning to understand that large areas of the Southeast were once covered by natural grasslands of various types. These communities have decreased in area greatly since European settlement, and many are considered highly imperiled. Even with their diminished size, these grasslands contribute significantly to the biodiversity of the region (e.g. 927 endemic plant species in the longleaf pine savanna ecosystem). Grasshoppers are often one of the most conspicuous members of the invertebrate fauna in these grassland communities. Based on current taxonomy, more than half of the regional fauna, 130 taxa (62% of the Southeastern fauna and 17% of the North American fauna) are endemic or are near endemics to the region, and a significant proportion (82%) of the endemic Southeastern fauna is associated with grasslands of various types. Further, different grassland types within the region support distinct faunas that have biogeographic affinities with the more extensive grasslands of western North America. For example, the biota of the prairies of the Southeast share species with the tall grass prairies of central North America; whereas, the biota of sandhill habitats share species and genera with the arid habitats of the southwestern United States. This introductory synthesis of the southeastern grasshopper fauna further demonstrates that these communities are rich in endemic species that contribute significantly to the biodiversity of the region and that of North America and are important targets for conservation efforts.

Description of two new species of eugregarines (Apicomplexa: Eugregarinorida) parasitizing the gut of *Taeniopoda centurio* (Orthoptera: Caelifera: Romaleidae)

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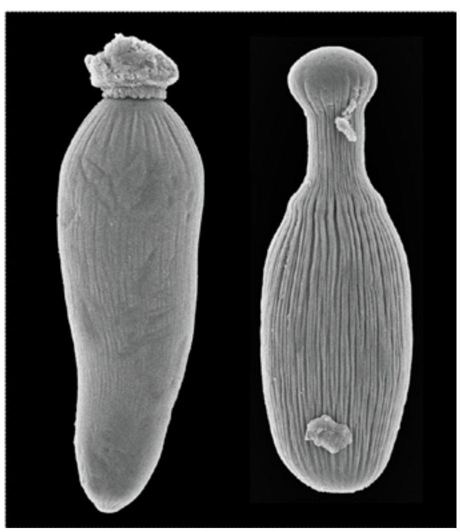
Eugregarines are parasites that belong to the phylum Apicomplexa and can be commonly found parasitizing the digestive tract of insects. Although it is thought that they can be one of the most diverse groups of eukaryotes, the studies on gregarine diversity are uncommon, and for example, these parasites have been described from less than 1% of the total insect diversity. In orthopterans, the reports of eugregarines are scarce and most of them are based on the morphology of the cells and line drawings, leading to a gap in the evidence about their ultrastructure and phylogenetic placement. As an attempt to contribute to the knowledge of the diversity of eugregarines in orthopterans, we have carried out a survey of the eugregarines that parasitize the digestive tract of the Mexican lubber grasshopper *Taeniopoda centurio*, which is a common species in the northeastern mountain ranges of Mexico, and in some areas, it may even become a plague. The main objective of this work is to provide morphological, ultrastructural and phylogenetic information based on SSU rDNA gene, about two new eugregarine species, *Amoebogregarina taeniopoda* and *Quadruspinospora mexicana* found parasitizing the gut of *T. centurio*. Although both eugregarine species parasitize the same host, they are morphologically very dissimilar in all their life cycle stages and their ultrastructure. The phylogenetic analysis showed that the two species are phylogenetically distant from each other and are placed in two different clades comprising two eugregarines superfamilies. Our findings showed that a single insect host can harbor more than one, phylogenetically distant eugregarine species. Also, we showed the first record of an *Amoebogregarina* species in Mexico and a *Quadruspinospora* species in the New World.



Scanning electron microscopy of *Quadruspinospora mexicana* (left), and *Amoebogregarina taeniopoda* (right).

Stepping to spin or to run? How embiopterans resolve the conflicting functions of their unique front feet

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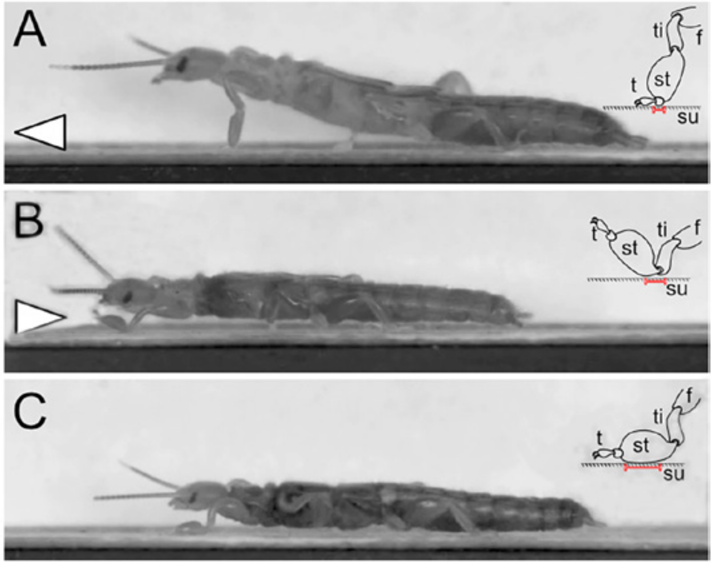

A webspinner (*Antipaluria urichi* (Clothodidae)) running after being touched with a paint brush, filmed with high-speed videography. The inset drawings show the typical position of the front foot, where f = femur, ti = tibia, st = spin tarsus, t = tarsal segments 1 and 2, and su = substrate. (A) The webspinner is running forwards. Her front foot is raised up and the silk ejectors are not touching the substrate. The inset shows the "tiptoe" position typical of the forward gait, (B) She is in a backwards run after being touched on the head with the brush. The inset shows the "heel walk" position, which results in lifting the silk ejectors up and off the substrate. (C) She has placed her front foot flat against the substrate. This position is potentially problematic because any pressure added to the silk ejectors will cause silk to be released making an efficient escape from a predator difficult. This "mistake" occurs more often during the backwards run and very rarely during the forward run.

tian-Albrechts-Universität, Kiel, Germany

Webspinners, in contrast to other arthropods that spin silk, utilize their front feet for silk production. The front basitarsi are packed with silk glands and festooned with ejectors. However, employing the same leg for alternative functions rather than for pure locomotion potentially imposes constraints and compromises. We found morphological and experimental evidence for a passive pressure-induced silk spinning mechanism induced by external mechanical stimuli. Thus, when they press their silk ejectors against the substrate, liquid silk dope firmly adheres via an adhesion disc and then is sheered into dozens of nano-scale fibers as the foot is pulled back. When webspinners move forwards by stepping with their front feet, passively ejected silk has the potential to interfere with their forward progress, especially if they are running from a predator. Using high-speed videography, we discovered that they "tiptoe" by touching only the claws and first two tarsal segments against the ground, lifting up the silk ejectors; this behavior allows them to run forward without releasing silk. But, they have trouble running fast forward because of this odd gait. In multiple trials, we found that they solve this problem by running backwards— if we touched them on the thorax or head, they chose to run fast backwards, a style of running that is unique for this order of insects. During the backwards run, they "heel walk" with their front feet—again, another style that keeps the silk ejectors from contacting the substrate—and they are able to do so faster than when they travel forward.

Evolutionary significance of oviposition techniques in stick and leaf insects (Phasmatodea)

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Stick and leaf insects (Phasmatodea) employ a wide range of egg-laying techniques, largely corresponding to their ecological niche, including dropping or flicking eggs to the forest floor, gluing eggs to plant substrate, skewering eggs through leaves, ovipositing directly into the soil, or even producing a complex ootheca. They are the only insects with highly species-specific egg morphology across the entire order, with specific egg forms that correspond to oviposition technique. We review our recent findings published previously wherein we investigate the temporal, biogeographic, and phylogenetic pattern of evolution of egg-laying strategies in Phasmatodea. Our molecular results unequivocally demonstrate that the ancestral oviposition strategy for female stick and leaf insects is to remain in the foliage and drop or flick eggs to the ground, a strategy essential for maintaining their masquerade. We infer two addition major key innovations in the evolution of Phasmatodea including (1) the hardening of the egg capsule in Euphasmatodea; (2) the repeated evolution of capitulate eggs (which induce ant-mediated dispersal, or myrmecochory).

Morph formation in the wing polyphonic sand cricket, *Gryllus firmus*

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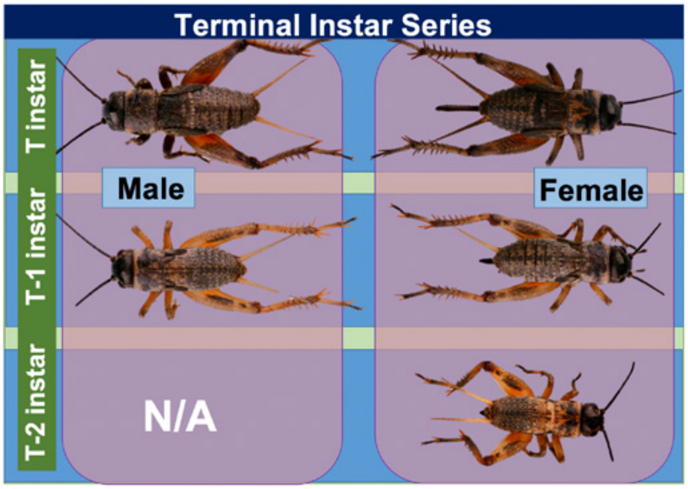
The sand cricket, *Gryllus firmus*, exhibits a wing dimorphic developmental trajectory based on environmental signals. The individual cricket senses its environment and develops into either a flight-capable dispersive morph or a flightless reproductive morph depending on conditions. This phenotypically plastic response allows the insect to stay and reproduce when conditions are good or fly away when conditions are poor before commencing reproduction, a classic trade-off between investment in reproduction



Last three nymphal instars in *Gryllus firmus*.

versus dispersal. Very little is known about the developmental or morphological differences between morphs. In this study, a longitudinal ontogenetic allometric framework was used on two genetically selected lines of *G. firmus* to characterize developmental morphology. Distinct and reliable morphological characteristics were detected for the terminal instars before adulthood, furthermore no traits were significantly different enough to be utilized to distinguish presumptive morph during development. This supports the hypothesis that the cricket's morphological fate isn't determined until the last two nymphal instars.

Examining the effects of biopesticides on the nutritional physiology of *Melanoplus sanguinipes*, a rangeland grasshopper

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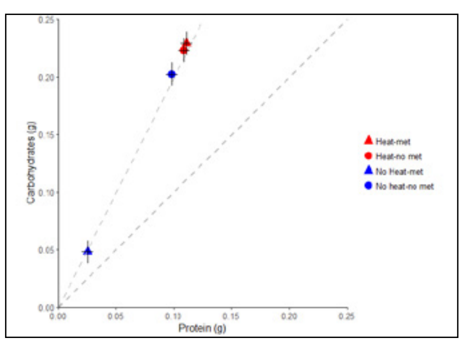
Significant amounts of research have gone into developing biological pesticides to manage grasshopper outbreaks, however due to grasshoppers immune functions biopesticide applications are often less effective than traditional pesticides. Current research shows that the balance of macronutrients is important for immune function in insects and that insects often will alter their nutritional status to help fight infections. The nutritional effects of *Metarhizium anisopliae var. acridum* has been tested with the Australian plague locusts (*Chortoicetes terminifera*), showing infections of this pathogen increased carbohydrate consumption and decreased protein consumption in grasshoppers. Our research tested the effects of the fungal pathogen, *Metarhizium* DWR, on the dietary macronutrient balance (termed: Intake Target) of *M. sanguinipes*, with and without thermoregulation, to determine if pathogens significantly influence diet selection. We hypothesized that using a closely related species of *Metarhizium* to infect *M. sanguinipes* will result in carbohydrate biased ITs on the treatment group without thermal regulation, and no change in the macronutrient ratios of the treatment group with thermal regulation, We found no significant difference in the ITs of all treatment groups of *M. sanguinipes*, all treatments had in IT of 1:2 P:C ratio. We found a significant difference in survival of the metarhizium with thermal treatment group and the metarhizium without thermal treatment group, where the thermal treatment group was able to rescue themselves from infection. We will use the outcomes of these experiments to inform future studies testing how ecologically relevant diets play a role in the immune function of *M. sanguinipes*.



The nutritional effects of *Metarhizium anisopliae var. acridum* (Met) and thermoregulation (Heat) on food intake in the Australian plague locusts (*Chortoicetes terminifera*).

Sexual selection and alternative mating strategies in Wellington tree weta

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Sexual selection is arguably nature's most powerful evolutionary process in that it overcomes natural selection in males and females to produce incredible phenotypic diversity within and between the sexes and across taxa in remarkably short periods. There are few better examples in nature of intense sexual selection shaping male morphology and behaviour than the Wellington tree weta (*Hemideina crassidens*). The Wellington tree weta exhibits strong sexual dimorphism with males possessing tremendously enlarged jaws relative to females. This species also exhibits extraordinary variation among males in phenotype, a hallmark of alternative mating strategies. My research comprehensively addresses the proximate and ultimate causes of this tremendous phenotypic variation with specific attention given to how the observed phenotypic variation is maintained in the wild, how the environment mediates sexual selection on male phenotype, and how investment in sexually selected traits trades-off against other fitness-related traits like immunity.

Gaudy grasshoppers (Orthoptera: Pyrgomorphidae) on stamps

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Entomophilately is the activity to collect insect-related stamps, the first stamp with an insect was issued in 1892 and since then, thousands have been released (Hamel, 1990). In the cultural context "insects" refers to terrestrial arthropods, including groups such as spiders, myriapods, and terrestrial crustaceans. There have been some works treating groups such as scorpions, cockroaches, beetles and scarabeids (Gómez and Junghans, 2002, 2016; Gómez et al., 2015; Kabourek, 2017). In other cases, revisions per country have been made, such as for Mexico (Mendoza et al., 2006).

The family Pyrgomorphidae (Orthoptera: Caelifera) contains some of the most colorful grasshoppers in the world, which is why they are also known as gaudy grasshoppers. Currently, there are 487 valid species in 149 genera in this family. This lineage is distributed mainly in Africa and Asia, but there are several genera known from Mexico and South America as well as Australia. Pyrgomorphs are easily diagnosable by the presence of a groove in the fastigium of vertex and very distinctive phallic. Some are known to exhibit aposematic coloration and, in most cases, this is enhanced by the presence of a unique mid-dorsal abdominal gland or foam production through spiracles and openings in pronotum. Some are plagues whereas others are used for human consumption (Mariño-Pérez, 2018).

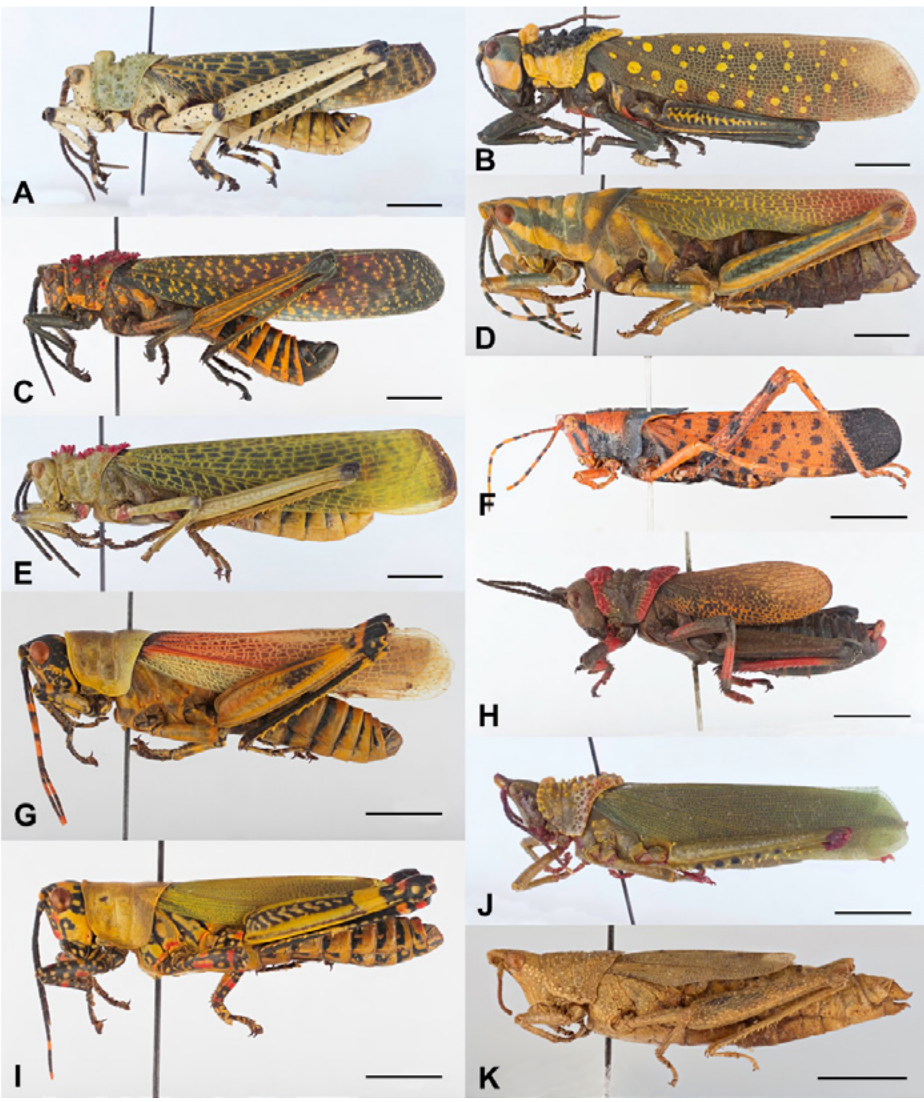

Figure 1. Pinned specimens of some species of Pyrgomorphidae present on stamps. **A.** *Phymateus leprosus*, **B.** *Aularches miliaris*, **C.** *Phymateus saxosus*, **D.** *Poekilocerus pictus*, **E.** *Phymateus viridipes*, **F.** *Petasida ephippigera*, **G.** *Zonocerus elegans*, **H.** *Dictyophorus spumans*, **I.** *Zonocerus variegatus*, **J.** T*aphronota calliparea*, **K.** *Pyrgomorpha vignaudii*. Scale bar = 1 cm.

As part of the introductory part of my dissertation about systematics and evolution of the family Pyrgomorphidae, besides the general characteristics and economical importance of the family, I was gathering information regarding cultural importance. Entomophilately is a well-known branch of ethnoentomology and, by consequence, I conducted research online looking for stamps with pyrgomorphs. I found a website (**http://www.asahi-net.or.jp/~CH2M-NITU/indexe.htm**) where a compendium of stamps with insects is provided. This website was the starting point of my research. Subsequently, other websites such as Ebay.com and hipstamp.com helped me to find stamps. Finally, I obtained the book "Atlas of the insects on stamps of the world" by Dennis Hamel (1991). This work compiles all the stamps with insects until 1990. After a year and a half, I was able to purchase the great majority of the stamps except for five.

It is precisely their bright colors and the relationship with humans, both as pests and as food, for the reason of their presence on stamps. The great majority of the stamps contain or a colorful species or a species of agricultural importance (in some cases, both characteristics). In Fig. 1, I show a collection of pinned specimens for comparative purposes, they cover species present in 31 out of the 38 stamps.

Methods

For the images of Fig. 1, the specimens were photographed using the Visionary Digital BK Plus Imaging System in combination with a Canon EOS 7D camera using 65 and 100 mm lenses to take multiple images at different depths of field. After this, Adobe Lightroom 3 (v.3.2) was used to import the photos and transform them from RAW files to TIFF's and then Zerene Stacker (v.1.02) was employed to stack the image slices into a single focused image. Finally, Adobe Photoshop CS5 Extended was utilized, when necessary, to adjust light levels, background coloration, sharpness, and to add an accurate scale bar. For the stamps, a standard scanner was used. For the five stamps unable to obtain in physical format, I provide the best image possible found online.

Results

A total of 38 stamps from 25 countries in four continents representing 16 species in 10 genera are presented. Although I conducted thoughtful research on several websites and the Atlas of Insects on stamps of the world (Hamel, 1991), this was not exhaustive and maybe some stamps are missing.

The stamps are arranged by chronological order with notes about country, name on stamp, monetary value, geographical correspondence, morphological accuracy, proper identification, and previous references.

1. 1967, Mali, *Phymateus cinctus* (Fig. 2)
Value: 50F
Geographical correspondence: Yes, this species is distributed in West Africa.
Morphological accuracy: Yes, despite the drawing is not in color, the pronotum detail and tegmina and wings pattern corresponds to *P. cinctus*.
References. p. 64 (b/w photo), p. 212 (Hamel, 1991).

2. 1969, Zimbabwe [Rhodesia], *Phymateus viridipes* (BUSH LOCUST) (Fig. 3).
Value: N/A.
Geographical correspondence: Yes, *P. viridipes* is distributed within Zimbabwe.
Morphological accuracy: Although an artistic representation, the general coloration, including the wing pattern corre-

Figures 2-20. FROM LEFT TO RIGHT AND UP TO DOWN. **2.** *Phymateus cinctus*, Mali, 1967. **3.** *Phymateus viridipes*, Zimbabwe, 1969. **4.** *Zonocerus elegans*, Malawi, 1970. **5a & 5b.** *Phymateus viridipes*, Rwanda, 1973. **6.** *Pyrgomorpha vignaudii*, Ethiopia, 1977. **7.** *Zonocerus variegatus*, Mali, 1978. **8.** *Phymateus viridipes*, Lesotho, 1978. **9.** *Phymateus viridipes*, Botswana, 1981. **10.** *Zonocerus variegatus*, Angola, 1983. **11.** *Zonocerus variegatus*, Republic of the Congo, 1985. **12.** *Phymateus viridipes*, Eswatini, 1988. **13.** *Dictyophorus spumans*, Zimbabwe, 1988. **14.** *Dictyophorus* sp., Zambia, 1989. **15.** *Phymateus iris*, Zambia, 1989. **16.** *Zonocerus variegatus*, Ghana, 1991. **17.** *Petasida ephippigera*, Australia, 1991. **18.** *Zonocerus elegans*, Rwanda, 1993. **19.** *Pyrgomorphula serbica*, Serbia, 1996. **20.** *Poekilocerus bufonius*, Burkina Faso, 2002.

sponds to *P. viridipes*.
Hamel (1991) identified it as *Phymateus iris*. However, the only name that appears in the stamp is Bush Locust.
References. p. 251 (Hamel, 1991).

3. 1970, Malawi, *Zonocerus elegans* (ELEGANT GRASSHOPPER) (Fig. 4).
Value. 4d.
Geographical correspondence: Yes, *Z. elegans* is found in Malawi.
Morphological accuracy: Yes, although an artistic representation, the general coloration and tegmina corresponds to *Z. elegans*.
References. p. 278 (b/w photo) (Hamel, 1990); p. 29 (b/w photo), p. 205 (Hamel, 1991).

4. 1973, Rwanda, *Phymateus viridipes* (Figs. 5a & 5b).
Value: 20c and 80F.
Geographical correspondence: Yes. *P. viridipes* is distributed in Rwanda.
Morphological accuracy: Yes, the wing coloration and pronotum spines are characteristic of this species.
Both stamps say "*Phymateus brunneri*" which first was a valid species, later it was synonymized with *P. viridipes* and currently is a subspecies under *P. viridipes*. This genus is in need of revision.
References. p. 255 (Hamel, 1991).

5. 1977, Ethiopia, *Pyrgomorpha vignaudii* (as *Poekilocerus vignaudii*) (Fig. 6).
Value: 25c.
Geographical correspondence: Yes, the species was described from Ethiopia and has a distribution through all central Africa.
Morphological accuracy: Yes. Indeed the tegmina in females are short and never reach the tip of abdomen. The color could be green or brown.
References. p. 137 (Hamel, 1991).

6. 1978, Mali, *Zonocerus variegatus* (Fig. 7).
Value: 90F.
Geographical correspondence: Yes, Mali is within the distribution range of the variegated grasshopper.
Morphological accuracy: It is an artistic representation lacking details. However, the few elements present fit well into the description of this species.
The name in the stamp says "*Lopocerus variegatus*"
References. p. 212 misidentified as Coleoptera (Hamel, 1991).

7. 1978, Lesotho, *Phymateus viridipes* (Fig. 8).
Value: 10c.
Geographical correspondence: Yes, the Green Milkweed Locust is distributed in Tropical East, Central and Southern Africa.
Morphological accuracy: Yes, although an artistic drawing without much detail, the wings have blue coloration, which is present in this species.
References. p. 200 (Hamel, 1991).

8. 1981, Botswana, *Phymateus viridipes* (nymph) (Fig. 9).
Value: 10t.
Geographical correspondence: Yes, the Green Milkweed Locust is found in Botswana.
Morphological accuracy: Yes, the last instar nymphs of *P. viridipes* have the coloration portrayed in the stamp.
The name in the stamp says "Elegant Grasshopper" which corresponds to *Zonocerus elegans*, which is also found in Botswana.
References. p. 98, p. 526 (b/w photo) (Hamel, 1991); p. 10 (b/w photo) (Gómez and Junghans, 2002).

9. 1983, Angola, *Zonocerus variegatus* (Fig. 10).
Value: Kz. 10.
Geographical correspondence: Yes, *Z. variegatus* is distributed in Angola.
Morphological accuracy: Yes, despite being an artistic interpretation, this adult female has a yellow ring close to the tip of hind femur which is characteristic of this species.
References. p. 82 (Hamel, 1991).

10. 1985, Republic of the Congo, *Zonocerus variegatus* (adult and nymph) (Fig. 11).
Value: 125F.
Geographical correspondence: Yes, Variegated grasshopper is distributed in West Africa.
Morphological accuracy: Yes, both nymph and adult have a yellow ring close to the tip of hind femur. The presence of this ring separates it from the other species, *Z. elegans*.
References. p. 118 (Hamel, 1991).

11. 1988, Eswatini [as Swaziland], *Phymateus viridipes* (Fig. 12).
Value: E1.
Geographical correspondence: Yes, *P. viridipes* is found in Eswatini.
Morphological accuracy: Yes, the Wing pattern and pronotum spines are characteristic for this species.
References. p. 276 (Hamel, 1991).

12. 1988, Zimbabwe, *Dictyophorus spumans* (Short-horned Grasshopper) (Fig. 13).
Value: 35c.
Geographical correspondence: Yes, *D. spumans* is present in Southern Africa including Zimbabwe.
Morphological accuracy: Yes, the drawing is very detailed incorporating the characteristic pattern of the species.

13. 1989, Zambia, *Dictyophorus* sp. (PYRGOMORPHID GRASSHOPPER) (Fig. 14).
Value: 10.40 K.
Geographical correspondence: Yes, the genus *Dictyophorus* is distributed through Sub Saharan Africa.
Morphological accuracy: Yes, most likely the drawing is referring to *D. griseus*, a common species in the area.
References. p. 305 (Hamel, 1991).

14. 1989, Zambia, *Phymateus iris* (BUSH LOCUST) (Fig. 15).
Value: 15K
Geographical correspondence: The genus is in need of revision. It is unclear if *P. iris* is distributed in Zambia.
Morphological accuracy: The pronotum sculpture and wing coloration corresponds to *P. iris* nevertheless *P. viridipes* is a widespread species with similar characteristics and reported for Zambia.
References. p. 305 (Hamel, 1991).

15. 1991, Ghana, *Zonocerus variegatus* (Fig. 16).
Value: 50c.
Geographical correspondence: Yes. This species is distributed in Ghana.
Morphological accuracy: Yes, the coloration pattern corresponds to *Z. variegatus*.
The stamp only indicates "ZONOCRUS".

16. 1991, Australia, *Petasida ephippigera* (nymph) (Leichhardt's Grasshopper) (Fig. 17).
Value: 80c.

Figures 21-39. FROM LEFT TO RIGHT AND UP TO DOWN. 21. *Phymateus viridipes*, Ghana, 2002. **22.** *Poekilocerus pictus*, Nepal, 2002. **23.** *Petasida ephippigera*, Australia, 2003. **24.** *Aularches miliaris*, Indonesia, 2003. **25.** *Parasphena* sp., The Gambia, 2003. **26.** *Zonocerus elegans*, Republic of the Congo, 2010. **27.** *Zonocerus variegatus*, Kenya, 2011. **28.** *Zonocerus elegans*, Tanzania, 2011. **29.** *Phymateus morbillosus*, Tanzania, 2011. **30.** *Phymateus leprosus*, Tanzania, 2011. **31.** *Dictyophorus spumans*, Tanzania, 2011. **32.** *Taphronota calliparea*, Chad, 2013. **33.** *Zonocerus variegatus*, Democratic Republic of the Congo, 2013. **34.** *Phymateus saxosus*, Madagascar, 2013. **35.** *Phymateus viridipes*, Tanzania, 2013. **36.** *Dictyophorus spumans*, Burundi, 2014. **37.** *Poekilocerus pictus*, Central Africa Republic, 2015. **38a & 38b.** *Phymateus saxosus*, Central Africa Republic, 2015. **39.** *Phymateus saxosus*, Madagascar, 2016.

Geographical correspondence: Yes, this species is endemic to Kakadu National Park, Northern Territory. The Jawoyn and Gundjeibmi people of Western Arnhem Land call this grasshopper Alyurr. This particular area has one of the highest lightning incidences of the world and precisely Alyurr means children of Namarrgon, the lightning man. Namarrgon is frequently depicted with axes hanging from his body, which represent the grasshopper antennae (Lowe, 1995).
Morphological accuracy: Yes, despite it being a nymph, the color patterns are accurate and the diagnostic characteristic of the extension of posterior border of pronotum is shown.

17. 1993, Rwanda, *Zonocerus elegans* (LE CRIQUET PUANT) (Fig. 18).
Value: 70 FRW.
Geographical correspondence: Yes, both species of Zonocerus can be found in Rwanda.
Morphological accuracy: The specimen depicted maybe corresponds to the other species, *Z. variegatus* due to tegmina coloration (yellow). It is usually pinkish in the posterior border in *Z. elegans*. However, the yellow ring close to the tip of hind femur is not clear.

18. 1996, Serbia [as Yugoslavia], *Pyrgomorphula serbica* (nymph) (as *Pyrgomorphela serbica*) (Fig. 19).
Value: 1,10.
Geographical correspondence: Yes, the Serbian Stick Grasshopper has a very restricted distribution in Serbia (16 km^2), currently is listed as Critically Endangered by the IUCN (Chobanov et al., 2016).
Morphological accuracy: Yes, although is an artistic representation, the general form corresponds to a female nymph of *P. serbica*, the four wing pads characteristic of last instar nymphs are evident.

19. 2002, Burkina Faso, *Poekilocerus bufonius* (Fig. 20).
Value: 10F.
Geographical correspondence: Yes, the species has a wide distribution in the northern half of Africa and Arabian Peninsula.
Morphological accuracy: Yes, the color pattern is characteristic to this species.

20. 2002, Ghana, *Phymateus viridipes* (Bush-hopper) (Fig. 21).
Value: C4500.
Geographical correspondence: No, *P. viridipes* is found in Africa but south of the Equator.
Morphological accuracy: The illustration is quite simple and there are not enough details to determine even to genus *Phymateus*.

21. 2002, Nepal, *Poekilocerus pictus* (as *Poecilocerus pictus*) (SHORT HORN GRASSHOPPER) (Fig. 22).
Value: 5R.
Geographical correspondence: Yes, this species is distributed in Afghanistan, Bangladesh, Nepal, Pakistan, Maldives,

Sri Lanka, Buthan and India.
Morphological accuracy: Yes, the color pattern corresponds to *P. pictus*.

22. 2003, Australia, *Petasida ephippigera* (nymph) (Leichhardt's Grasshopper) (Fig. 23).
Value: 50c.
Geographical correspondence: Yes.
Morphological accuracy: Yes, this version is more caricature with an anthropomorphized head but still is accurate in color patterns of the body and wing pads.

23. 2003, Indonesia, *Aularches miliaris* (Belalang setan) (Fig. 24).
Value: 1500.
Geographical correspondence: Yes, this species is distributed in India and South East Asia.
Morphological accuracy: Yes, although the drawing is simple, it possesses the diagnosis characters of the species such as the yellow dots in the tegmina, pronotum form and abdomen coloration.

24. 2003, The Gambia, *Parasphena* sp. (Fig. 25).
Value: D10.
Geographical correspondence: No, this genus is exclusively distributed in East Africa.
Morphological accuracy: Yes, this is an adult female which possesses diagnostic characteristics of the genus, such as irregular lateral pronotal carinae and absence of tegmina (Rowell et al., 2015).

25. 2010, Republic of the Congo, *Zonocerus elegans* (Fig. 26).
Value: 300F.
Geographical correspondence: Yes, *Z. elegans* is distributed in the country.
Morphological accuracy: Yes, the body color pattern corresponds to the species.

26. 2011, Kenya, *Zonocerus variegatus* (Fig. 27).
Value: K65/-.
Geographical correspondence: Yes, Kenya has both species of the genus.

27. 2011, Tanzania, *Zonocerus elegans* (Fig. 28).
Value: Shs. 600/=.
Geographical correspondence: Yes. This species is widely distributed in Tanzania.
Morphological accuracy: Yes, the pink coloration at tegmina is characteristic of this species. Judging by the size of the abdomen, it could be a female.
The name in the stamp has two typos: "Elegent Grasshopper" (*Zanocerus Elegans*).

28. 2011, Tanzania, *Phymateus morbillosus* (Fig. 29).
Value. Shs. 700/=.
Geographical correspondence: No, this species is only distributed in South Africa.
Morphological accuracy: Yes, the coloration pattern, particularly the red head and pronotum corresponds to the species.
The name in the stamp is incorrect "Foam Locust (*Dictyopharus Spumans*)".

29. 2011, Tanzania, *Phymateus leprosus* (Fig. 30).
Value: Shs. 700/=.
Geographical correspondence: No, this species is only distributed in South Africa, Lesotho and Eswatini.
Morphological accuracy: Yes, this species has the particular coloration pattern in the legs and a pair of protuberances in the anterior part of pronotum characteristic of *P. leprosus*.
The name in the stamp is incorrect "Green Milkweed Locust (*Phymateus Yiridipes*).

30. 2011, Tanzania, *Dictyophorus spumans* (Fig. 31).
Value: Shs. 700/=.
Geographical correspondence: No, this species has a southern distribution. *D. griseus* is the one found in Tanzania.
Morphological accuracy: Yes, a key characteristic of *D. spumans* is the coloration pattern showed in the stamp with hind tibia and anterior and posterior margins of pronotum different than black (red in this case, although there are other morphs).
The name in the stamp is incorrect "Mole Cricket (*Gryllotalpa Africana*)".

31. 2013, Chad, *Taphronota calliparea* (CRIQUET OKU) (Fig. 32).
Value: N/A.
Geographical correspondence: Yes, *T. calliparea* is widely distributed in the Sub-Saharan Africa and it is likely to be found in Chad.
Morphological accuracy: It appears photography was manipulated because the combination of colors is not characteristic of this species. Nevertheless, the pronotum sculpture corresponds to *T. calliparea*.

32. 2013, Democratic Republic of the Congo, *Zonocerus variegatus* (Fig. 33).
Value: 650 Fc.
Geographical correspondence: Yes, *Z. variegatus* is distributed in DRC.
Morphological accuracy: Yes, the characteristic yellow ring close to the tip of hind femur is present as well as the tegmina coloration.

33. 2013, Madagascar, *Phymateus saxosus* (Fig. 34).
Value: 600 MGA.
Geographical correspondence: Yes, *P. saxosus* is endemic to Madagascar.
Morphological accuracy: Yes, the body, tegmina and wings coloration and pronotum sculpture pattern corresponds to the species.

34. 2013, Tanzania, *Phymateus viridipes* (AFRICAN BUSH GRASSHOPPER) (Fig. 35).
Value: 2000/-.
Geographical correspondence: Yes, *P.*

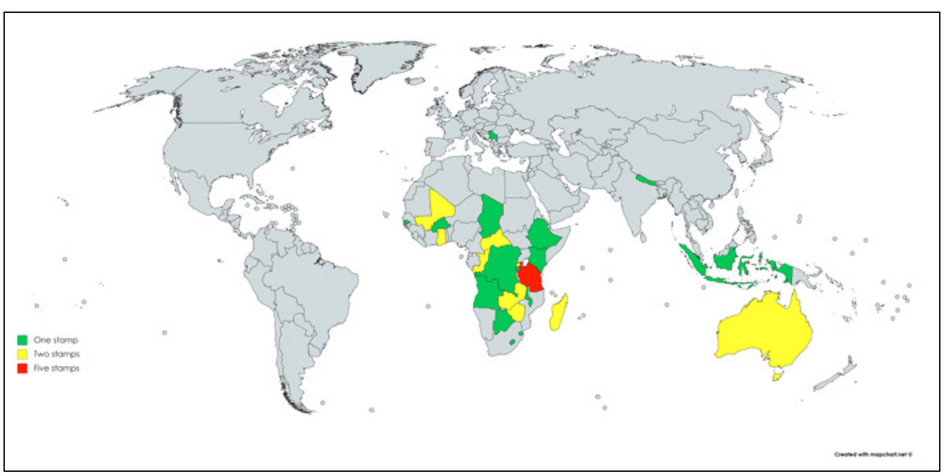

Figure 40. Pyrgomorphidae stamp richness per country. Created with mapchart.net ©.

viridipes is distributed in Tanzania.
Morphological accuracy: Yes, color pattern and pronotum spines correspond to *P. viridipes*.

35. 2014, Burundi, *Dictyophorus spumans* (Fig. 36).
Value: N/A.
Geographical correspondence: No. The species distributed in Burundi is *Dictyophorus griseus*. *D. spumans* has a distribution in Southern Africa.
Morphological accuracy: Yes. The color pattern corresponds to *D. spumans*.

36. 2015, Central Africa Republic, *Poekilocerus pictus* (Fig. 37).
Value: 750F.
Geographical correspondence: No, this species is distributed in Afghanistan, Bangladesh, Nepal, Pakistan, Maldives, Sri Lanka, Bhutan and India.
Morphological accuracy: Yes, the color pattern corresponds to *P. pictus*.

37. 2015, Central Africa Republic, *Phymateus saxosus* (Figs. 38a & 38b).
Value. 750F and 2650F.
Geographical correspondence: No, this species is endemic to Madagascar.
Morphological accuracy: Yes, in both stamps the coloration pattern and pronotal spines corresponds to *P. saxosus*.

38. 2016, Madagascar, *Phymateus saxosus* (Fig. 39).
Value: 2500 MGA.
Geographical correspondence: Yes, this species is endemic to Madagascar.
Morphological accuracy: Yes, the tegmina, wing an abdomen color pattern matches *P. saxosus* plus the characteristic spines of the pronotum.

Discussion

Approximately 40% of the 487 species within the lineage Pyrgomorphidae are found in Africa (including Madagascar) (Cigliano et al., 2020). This richness is reflected in the stamps as well because 33 out of the 38 stamps are from Africa. There are only two stamps from Asia (Indonesia and Nepal) and Australia, and one from Europe (Serbia). Concerning Africa, Tanzania has five stamps, eight countries two stamps and 13 countries one stamp (Fig. 40).

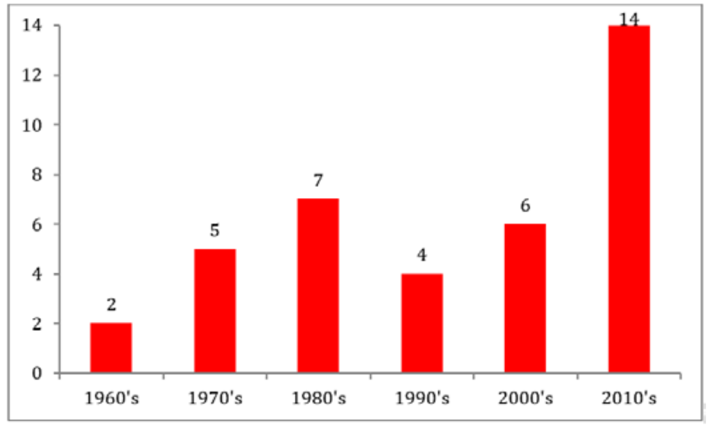

Figure 41. Number of stamps with Pyrgomorphidae by decade.

The first stamp was issued by Mali in 1967. Since then, stamps have been released in a consistent pace with 4-7 stamps per decade until the 2010s decade where 14 have been issued so far (Fig. 41).

In general, the species depicted on the stamps are of economic importance, such as the ones in the genera *Aularches*, *Dictyophorus*, *Phymateus*, *Poekilocerus* and *Zonocerus* (COPR, 1982). They are abundant, and easy to see due to its size and aposematic coloration. Even though the nymphs are presented in five stamps and although some pyrgomorphs illustrated in the stamps are free interpretations of the artists, the great majority possesses enough characteristics allowing their identification. Interestingly, in some cases the species portrayed are not distributed in the country and perhaps were chosen due to their agricultural importance in other regions or by their colorfulness.

Acknowledgements
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Treasurer's Report

By PAMELA MIHM
Treasurer
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The Statement of Assets as of December 31, 2019 and the 2019 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; you will note that the 2019 endowment was received in December, 2018, so it does not show in the 2019 receipts. The second largest use of cash was publishing the *Journal of Orthoptera Research* (*JOR*). The Society also supported the International Congress of Orthopterology (ICO) in Morocco with a grant for the Locust Opera, a grant to the ICO, and travel grants to students and young professionals. If you have any questions, please contact me at p.mihm@regency-multifamily.com.

Orthopterists' Society
Statement of Cash Receipts and Expenditures
(1/1/19 through 12/31/19)

Cash Receipts	
Dues	$4,705.00
Publications	2,620.00
Community Foundation endowment	11,891.81
Royalty and revenue sharing	4,416.87
Book reimbursements	318.58
Donations	50.00
Transfer cash from Vanguard & Wells Fargo	31,200.00
Proceeds from sale of investments	36,900.00
University of Illinois allocation (Note 5)	0.00
Total Cash Receipts	$92,102.26
Cash Expenditures	
Publisher JOR	$4,297.61
Pensoft Publishers	11,246.92
JOR assistance	13,500.00
Research grants (Ted Cohn)	17,231.00
Executive director remuneration	1,500.00
Ed. Metaleptea remuneration	1,500.00
Assistant Ed. Metaleptea remuneration	500.00
Webmaster remuneration	1,000.00
JOR editor remuneration	3,000.00
Maintenance of Orthoptera Species File	142,500.00
Grants-Orthoptera Species File	28,930.00
Locust opera grant	10,000.00
Congress Morocco contribution	7,000.00
2019 Congress travel-Board/Plenary Speakers	11,893.97
2019 Congress travel grants	2,205.41
Locust Opera	2,000.00
Uvarov award	2,500.00
Young Professional awards	5,000.00
AAIS meeting support	5,722.00
Professional fees (income tax preparation and audit)	4,710.00
Accounting reimbursement	12,000.00
Purchase Vanguard bonds (Note 6)	30,000.00
Other	2,409.98
Total Cash Expenditures	$310,646.89
Cash Receipts over Cash Expenditures	$(218,544.63)
Beginning Cash Balance	230,364.08
Ending Cash Balance	**$11,819.45**

Orthopterists' Society
Statement of Assets
(As of December 31, 2019)

Cash	
Paypal cash balance	$432.66
Chase Bank	11,386.79
	$11,819.45
Investments at market value	
Vanguard:	
Grants (Note 1)	$421,454.10
Operating (Note 2)	787,985.45
	1,209,439.55
Wells Fargo at Nov. 30, 2019:	
AAAI (Note 3)	14,605.69
Endowment (Note 4)	37,283.01
Operating (Note 2)	272,288.58
Grants (Note 1)	86,988.00
	411,165.28
Total assets	**$1,632,424.28**

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.
Note 5: The 2019 University of Illinois allocation was received in December 2018.
Note 6: $30,000 of higher risk investments were sold and $30,000 of lower risk investments were purchased.

Editorial

By HOJUN SONG
Editor, *Metaleptea*
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Greetings from Australia! I am writing this editorial from Canberra, Australia where I will be spending the next 6 months as a Fulbright Scholar at the Australian National Insect Collection (ANIC).

As far as grasshoppers are concerned, Australia is a very unique place. It is estimated that there are approximately 750 species of grasshoppers in Australia, 90% of which are endemic. However, of these, only 274 species have proper scientific names, which means that there are nearly 500 undescribed but "known" species, all belonging to the subfamily Catatopinae (Acrididae). The late Dr. Ken Key (1911-2002), who was instrumental in establishing the ANIC, devoted his life for studying the Australian grasshopper diversity and collected throughout the vast landscape of Australia. Throughout his career, he discovered numerous grasshoppers new to science, but because proper taxonomic descriptions would take time, he utilized a kind of numbering system, called the ANIC system, to assign tentative genus and species numbers to these newly discovered insects. For a new genus, Key assigned "Genus Novum" followed by a specific number, such as Genus Novum 46, within which he simply assigned "sp. 1, sp. 2, etc." to show that there are distinct species. Unfortunately, Key passed away before describing these new genera and species, leaving behind hundreds of unnamed species. I came to realize this dire situation of taxonomic impediment when I visited the ANIC in 2009 before conducting a field expedition in Western Australia. The overwhelming diversity of the Australian grasshoppers and the sheer amount of work needed to restore taxonomic expertise to these insects seemed daunting at that time, but I thought to myself that one day I would have an opportunity to study their taxonomy. The idea of coming back to Australia has stayed with me for many years, and now I am finally here to start learning and documenting this amazing fauna.

As any academics would know, I have found myself spending way too much time in front of my computer, responding to emails, working on student papers, grant proposals, and preparing course presentations for the past 10 years, which has kept me away from doing taxonomic work. I have been yearning for the oppotunity to take a break from my daily grind as a faculty member. I am very excited at the possibility of spending uninterruped hours in front of a microscope studying these interesting grasshoppers!

This is another fine issue of *Metaleptea* featuring how active our society is. I am thankful to all of the contributors, including regional representative and past awardees. I would also like to thank our Associate Editor, Derek A. Woller, for his continued assistance in the editorial process.

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 2020, so please send me content promptly. I look forward to hearing from you soon!