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METALEPTEA

THE NEWSLETTER OF THE ORTHOPTERISTS' SOCIETY

President's Message

By ALEXANDRE V. LATCHININSKY
President
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Dear Society members,

The first months of 2017 were very exciting for our Society. As you know, during the Congress in Brazil, the goal was set to attain higher status and earn a solid impact factor for our main outlet, *Journal of Orthoptera Research*. After a series of negotiations conducted by the *JOR* editor Dr. Corey Bazelet with several big publishers, the OS Board made a unanimous decision to pursue the open access model of publication and associate it with Pensoft Publishers (http://pensoft.net/). Pensoft currently publishes over 20 different biology-related journals, including the *Journal of Hymenoptera Research*, and provides an attractive format, website design, and high-level editorial services. It was very exciting to discuss different options for the *JOR* and website layout. Corey, thanks a lot for all your great work towards raising the status of *JOR*, and thanks to the OS Board for constructive discussions and attention to detail during the negotiations with Pensoft.

Certainly, moving to Pensoft is a huge step, and such a big move comes at a cost; however, the Society's investments continue to produce solid income sufficient to cover those costs. Our plan is to keep publishing in *JOR* free of charge for the Society's members, so please don't forget to pay your 2017 dues! ☺ Non-members will be able to publish at a nominal page charge, which will be set later.

On a different subject, I am very happy to report that the Theodore J. Cohn Research Fund was able to support 11 proposals in 2017, totaling over $16,000. The award-winning proposals came from seven different countries: India, Bulgaria, Czech Republic, U.S.A., Serbia, South Africa, and Argentina, which is great evidence of the international nature of our Society. Many thanks to Dr. Michel Lecoq for chairing the Fund's selection committee (see his article in this issue) and warmest congratulations to all the awardees!

Once again, I would like to wish all Society members and their families peace, great health, prosperity, and a fruitful 2017 year!

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The 2017 Theodore J. Cohn Research Grants Funded

By MICHEL LECOQ
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Of the 14 research proposals submitted this year from 7 countries (India - 1, Bulgaria - 1, Czech Republic - 2, U.S.A - 6, Serbia - 1, South Africa - 1, and Argentina - 2), the jury selected 11 projects receiving a total of $16,094 USD.

Here is the list of the successful candidates (alphabetical order) and the title of their research project:

- **Simeon B. Borisov (Bulgaria)** - Temporal and spatial evolution of the *Poecilimon jonicus*-group in southern Greece
- **Emma Colosi (U.S.A.)** - Selection and hybridization in a field cricket contact zone
- **Cody Gale (U.S.A.)** - Investigating a photolytic metabolite in the nocturnal grasshopper *Schistocerca ceratiola* Hubbell and Walker (Orthoptera: Acrididae)
- **Gabrielle A. Gurule-Small (U.S.A.)** - Effects of anthropogenic noise on mating decisions and fitness
- **Claudia Hallagan (U.S.A.)** - The effects of advanced maternal age on multiple generations of offspring immunocompetency
- **Maxine Laubscher (South Africa)** - A morphological, acoustic, and genetic comparison of bladder grasshopper species from the Eastern Cape Province of South Africa
- **David Musiolek (Czech Republic)** - Tolerance of groundhoppers' eggs to dehydration – why do females of genus *Tetrix* search for mossy patches?
- **María Celeste Scattolini (Argentina)** - Ecological and evolutionary diversification in Scotussae genus group (Melanoplinae: Dichroplini).
- **Ryan Selking (U.S.A.)** - Radio telemetric analysis of diurnal and nocturnal activities of the leaf-masquerading true-leaf katydid genus *Mimetica* Pictet, 1888
- **Sonu Yadav (India)** - Understanding the adaptive capacity of alpine grasshoppers under climate change
- **Mariottini Yanina (Argentina)** - Bio-ecological studies of *Bufonacris claraziana* (Acridoidea: Tristiridae) and susceptibility to the biocontrol agents *Paranosema locustae* and *Beauveria bassiana*

Congratulations and our best wishes for the success of your work.

The Committee appreciated all submitted projects and, of course, I encourage unsuccessful applicants to submit new proposals to the next call for projects in early 2018. Once again, I strongly encourage students from African countries to submit proposals to the committee.

Meeting on the locust situtation in South America and the OIRSA region

By MARIO ANTONIO POOT-PECH
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The locust is one of the plagues whose mere mention causes us panic, probably because it is generally associated with periods of food shortage, hunger, and drought. In the Americas, two species of locusts are reported: *Schistocerca piceifrons* (Central America and NW of South America) and *S. cancellata* in South America (Argentina, Bolivia, Paraguay, among others). These locust species occur cyclically at a given time causing damage to crops, which requires close coordination between countries for the exchange of information, experience, and knowledge of their management.

Meeting

On Wednesday, March 24, at 10:00 am, Central America time, a meeting was held via the web between the countries of the International Regional Organization for Plant and Animal Health (OIRSA) and countries in South America. The objective was to better understand the locust situation in Argentina, Bolivia, and Paraguay and to do a general analysis in the Americas region. The meeting was conducted using 26 connected computers, each accompanied by 3-10 people, and the 14 participating countries were: Brazil, Argentina, Bolivia,

Figure 1. Distribution of the two most important locust species in the Americas. Source: Cressman and Dobson. 2001. Desert Locust Guidelines. FAO.

Peru, Paraguay, Chile, Nicaragua, El Salvador, Honduras, Costa Rica, Panama, Dominican Republic, Belize, and Mexico.

The locust situation was reviewed by the countries of Argentina, Ing. Héctor Emilio Medina, Bolivia, Ing. Luis Sánchez Shimura and Paraguay, Ing. Carmen Berni. I also gave a presentation about "Outbreak and Coordination for Locust Management" on behalf of the Plant Protection Committee of Yucatan, Mexico.

The situation, in summary form, is as follows:

Argentina. The years with outbreaks were 1954, 1961, 1989, 2010, and 2015. Currently, the pest is in low densities, however, controls are performed in certain areas, and the main provinces with constant monitoring are San Miguel de Tucuman, La Rioja, and Cordoba. The locust in this country typically has two generations but it is reported that the populations presently have up to three generations per year.

Paraguay. Now, the locust is in low density and is under constant monitoring by the departments of Boquerón and Alto Paraguay, and current training and control of small patches is carried out without presenting a risk to agricultural production.

Bolivia. At the end of January 2017, the first reports of the plague were reported in the Municipality of Cabezas, Department of Santa Cruz. At present there is a high infestation of the pest (swarms), and an aerial form has been used to control 9,635 ha of and 12,822 ha in terrestrial application. Control work continues to reduce the population. Advisory services have been received in the management of the pest from the Acridids Program of Argentina.

At the end of each presentation, the speakers were asked questions and comments were also given on the locust situation in the region.

Results

1. Analysis of the problem

The meeting was a very important and much-needed event. There were 4 important aspects to consider:

A) Information in real time. Although locusts are a migrant plague, capable of invading different regions or countries, there is no information about the locust situation in real time, and this is an important aspect in making decisions.

B) Training. Constant training is required on different locust-related topics: identification, sampling, control, and diffusion focused primarily on preventive strategies.

C) Documentation (handbooks, emergency plan, and diffusion). This requirement is due to having solid information for development activities in the field to make decisions too.

D) Research. This is a necessary component for efficient locust management, from aspects of biology, habits, forecast, control, and new alternatives in ecological management.

2. Challenges

The first step for regional locust coordination has already taken place with this meeting and the important thing is to give it continuity, the challenges being:

A) Continuity of the Locust Technical Group

B) Creation of a regional strategy for the surveillance of locusts.

C) Training of human resources in locust management.

D) Elaboration of a contingency plan.

E) Creation of a periodical bulletin

Figure 2. *S. cancellata* (photo by Héctor Medina) and chemical control in Bolivia (Luís Sánchez).

that updates the situation of locusts in the Americas and indicates what is occurring with the pest at any given time.

3. Next actions

Within the framework of the OIRSA meeting and South America the following actions were proposed:

A) A next meeting with proposals for the schedule. The attendees will send proposals for the organization of the schedule that they believe is the most important to be addressed.

B) OIRSA will receive the proposals and prepare the agenda, and also receive the research and training topics that are deemed relevant for analysis.

C) An emergency plan will be developed. I will be the person responsible for the and this plan will be sent to the group for analysis.

D) Elaboration a proposal to concentrate information for the "Locust Bulletin", which indicates the status of the locust on the continent.

E) A face-to-face meeting will be held in the context of some other phytosanitary meeting, with the state of Yucatan, Mexico proposed as a site, and at a date to be defined.

Locust scouts benefit from FAO trainings

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FAO Consultant

In the framework of the Food and Agriculture Organization's (FAO) Programme to improve national and regional locust management in Caucasus and Central Asia (CCA), a series of trainings on locust monitoring and information management were conducted in March and April of 2017. The trainings took place in Bukhara (Uzbekistan), Stavropol (Southern Russia), and Baku (Azerbaijan). Over 50 locust specialists from Armenia, Azerbaijan, Georgia, Russian Federation, and Uzbekistan participated in week-long courses presented by two FAO International Consultants, Nadiya Muratova (GIS Expert) and Alex Latchininsky (Senior Locust Expert).

During the theoretical part of the trainings, participants learned about biology, ecology, and population dynamics of the three locust species present in CCA: the Italian locust *Calliptamus italicus* (L., 1758), the Moroccan locust *Dociostaurus maroccanus* (Thunberg, 1815), and the Asian migratory locust *Locusta migratoria migratoria* L., 1758.

Figure 1. Alex Latchininsky teaches the basics of acridology to Uzbekistan trainees in Bukhara.

Hands-on portions of the trainings were devoted to practical methods of locust species and age identification, egg-pod, nymph and adult density assessment and survey implementation. Participants learned to use GPS devices for measuring areas and distances in addition to marking survey locations.

Special attention was given to standardizing locust information. For these purposes, standard FAO survey and spray monitoring forms were adapted to CCA and translated into 10 national languages. During the trainings, participants learned to fill out paper and electronic versions of these forms. For the latter type, FAO provided the countries with tablet computers with Automated System of Data Collection (ASDC) software. FAO has developed the ASDC in order to unify locust information collection and sharing across all CCA countries. Based on ASDC, a locust GIS with forecasting and mapping capabilities is currently being developed in CCA. At the trainings, participants took part in practical exercises on ASDC usage in the field

during locust surveys. Participants also learned to use entomological survey and collecting equipment provided for the trainees by FAO.

All three trainings were a big success and contributed to strengthening capacities of national locust management services in CCA countries. Feedback from the participants was very positive. Pre- and post-training tests revealed that trainees significantly increased their knowledge of locust biology and monitoring. For example, in Uzbekistan, the participants assessed their locust knowledge at an average of 6.6 before training and 9.2 after training on a 10-point scale, which is a 39% increase.

FAO launched the CCA locust Programme in 2011. It has an estimated $7.8 million budget and covers ten countries: Afghanistan, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russian Federation, Tajikistan, Turkmenistan, and Uzbekistan. The main donors are Japan/JICA, USAID, Turkey, and FAO (Regular Programme and Technical Cooperation Programme). The strategic objective is to reduce occurrence and intensity of locust outbreaks in CCA, thus limiting threat or damage to crops and rangelands, and safeguarding rural population food security and livelihood, as well as minimizing impact on human health and the environment. The immediate objective is to improve national and regional locust management in ten countries of CCA and adjacent areas. To learn more, visit the FAO "Locust Watch – CCA" website http://www.fao.org/ag/locusts-CCA/en/index.html available in English and Russian.

Figure 2. Damed Sultanov, the Acting Director of Plant Protection Department of Azerbaijan Ministry of Agriculture (second left) explains the local specialists how to use the ASDC on tablet computer.

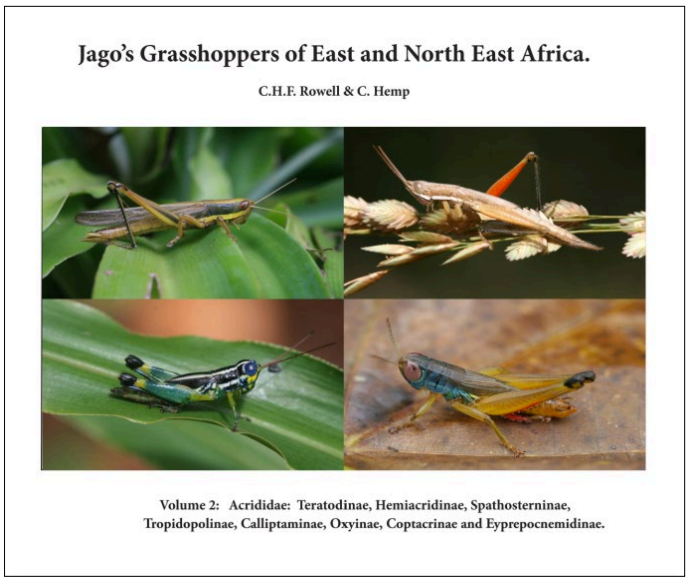
"Jago's Grasshoppers of East and North East Africa" now available!

The second volume of "*Jago's Grasshoppers of East and North East Africa*" by Hugh Rowell and Claudia Hemp is now available to purchase from on-demand printing site Blurb. This volume focuses on various subfamilies of Acrididae and it represents an important contribution to our field. For the rationale and history behind this publication, please see Hugh Rowell's article in *Metaleptea* 35(3).

To order, please visit Blurb. Each volume is priced at $130.19.

Volume 1: http://www.blurb.com/b/7826846-jago-s-grasshoppers-of-east-and-north-east-africa

Volume 2: http://www.blurb.com/b/7789277-jago-s-grasshoppers-of-east-and-north-east-africa



The Orthoptera Species File Grant Reports

Type diversity of Pyrgomorphidae II: Genève, Zürich, Wien, Stockholm, Uppsala and København

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On June of 2016, thanks to the OSF Grant "Supplement to Enhancing digital content for Pyrgomorphidae (Orthoptera: Caelifera) in the Orthoptera Species File". I visited the next six European museums:

1. Muséum d'Histoire Naturelle (MHNG), Genève, Switzerland.
2. Eidgenössische Technische Hochschule (ETHZ), Zürich, Switzerland.
3. Naturhistorisches Museum (NMW), Wien, Austria.
4. Naturhistoriska Riksmuseet (NHRS), Stockholm, Sweden.
5. Museum of Uppsala University (UZIU), Sweden.
6. Zoological Museum of the University of Copenhagen (ZMUC), Denmark.

Table 1 is a summary of the Pyrgomorphidae photographed. In the column of Pyrgomorphidae, both valid species and synonyms are included. I photographed both sexes when available. In some cases, when there was enough time, I photographed non-Pyrgomorphidae material, mainly Mexican and *Schistocerca* types.

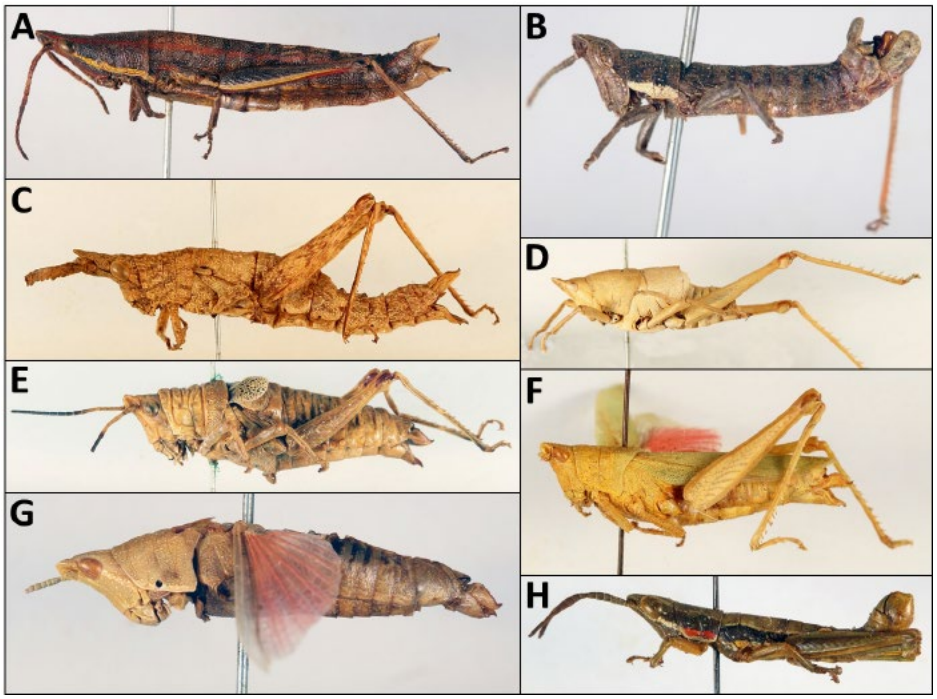

Figure 1. Pyrgomorphidae types from MHNG. A. *Dyscolorhinus squalinus* Saussure, 1899 (♀, LT) Madagascar; B. *Ichthyotettix mexicanus* (Saussure, 1859) (♂, LT) Mexico; C. *Geloius nasutus* Saussure, 1899 (♀, LT) Madagascar; D. *Sphenarium mexicanum* Saussure, 1859 (♀, LT) Mexico; E. *Greyacris profundesulcata* (Carl, 1916) (♀, HT) Australia; F. synonym *Pyrgomorpha capensis* Bolívar, 1904 (♀, HT) South Africa; G. *Pyrgomorpha inaequalipennis* Bolívar, 1904 (♀, PT); H. *Neorthacris acuticeps nilgirensis* (Uvarov, 1929) (♂, HT) India.

For each specimen, three images were obtained: lateral and dorsal views plus labels. In the case of the five fossils from ETHZ, only labels and a single image from above were captured.

Table 1. Summary of the images obtained.

Museum	Specimens Pyrgomorphidae	Non-Pyrgomorphidae	Fossils	Total	Images Total
MHNG	31	17		48	147
ETHZ	6		5	11	28
NMW	40	2		42	126
NHRS	84	1		85	255
UZIU	21	4		25	75
ZMUC	6	1		7	21
	188	**25**	**5**	**218**	**652**

1. Muséum d'Histoire Naturelle (MHNG), Geneve, Switzerland

Founded in 1820 and with more than 15 million specimens, MHNG is the largest collection in Switzerland. The collections of Louis Jurine of Hymenoptera, Coleoptera, Lepidoptera, and Hemiptera are held in the museum. Concerning Orthoptera, type material of 963 species (both valid and synonyms) are held here mainly through the efforts of H. Saussure (1829-1905), C. Brunner von Wattenwyl (1823-1914), L. Redtenbacher (1814-1876), and F.J. Pictet (1809-1872), among others. Although worldwide in scope, 346 out of 963 type species are from the

Figure 2. *Dictyophorus cuisinieri* (Carl, 1916) (♀, HT) Guinea (MHNG).

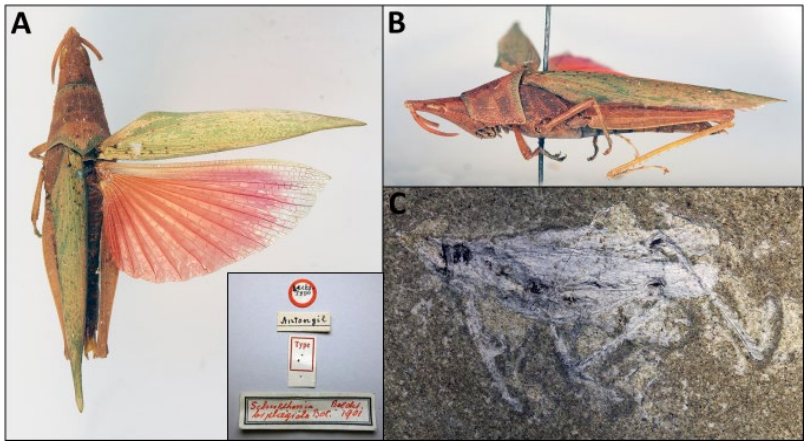

Figure 3. Pyrgomorphidae types from ETHZ. A & B. *Schulthessia biplagiata* Bolívar, 1905 (♀, LT) Madagascar; C. *Miopyrgomorpha fischeri* (Heer, 1865) (♂, HT) Germany (Miocene).

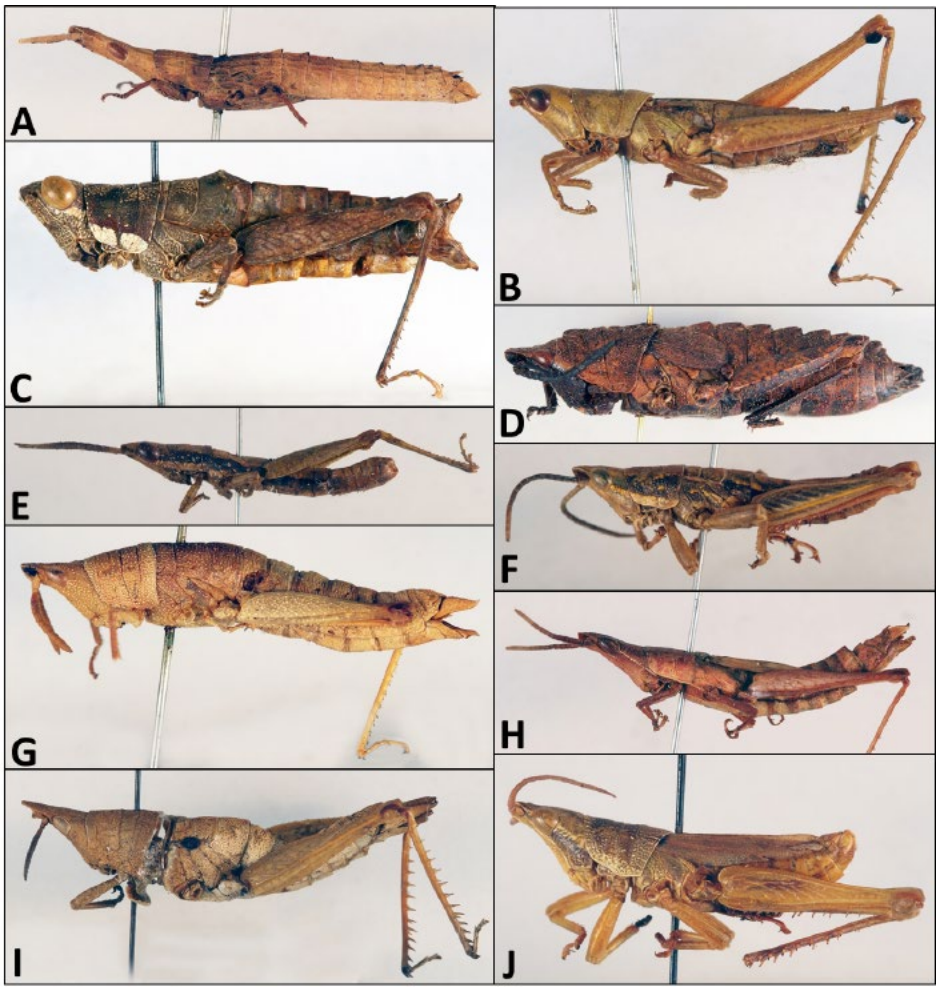

Figure 4. Pyrgomorphidae types from NMW. A. *Algete bunneri* Bolívar, 1905 (♀, HT) Brazil; B. *Chlorizeina unicolor unicolor* Brunner von Wattenwyl, 1893 (♂, ST) Myanmar; C. *Kuantania aptera* Kevan, 1963 (♀, HT) Vietnam; D. *Maura bolivari modesta* Bolívar, 1904 (♀, HT) Tanzania; E. *Orthacris filiformis* Bolívar, 1884 (♂, LT) Sri Lanka; F. *Stenoscepa picta* (Bolívar, 1884) (♂, LT) Ethiopia; G. *Sphenacris crassicornis* Bolívar, 1884 (♀, HT) Mexico; H. *Zarytes squalinus squalinus* (Saussure, 1884) (♀, HT) India. I. *Uhagonia sphenarioides* Bolívar, 1905 (♀, HT) Madagascar; J. *Tagasta insularis* Bolívar, 1905 (♂, LT) Indonesia.

Americas; this is mainly due to the expedition of Saussure to Mexico and the West Indies (1854-1856). However, the networking of Saussure allowed him to describe species from other parts of the World, such as Madagascar, Asia, South America, and Africa. Hollier & Hollier (2013) provided a very complete history of Saussure that helps to understand the collection of Geneve. For Pyrgomorphidae, there is type material from 24 species (both valid and synonyms) (Figs. 1 & 2). I am especially indebted to Peter Schwendinger and John Hollier for all their help and assistance during my visit.

2. Eidgenössische Technische Hochschule (ETHZ), Zürich, Switzerland

The Entomological Collection of ETHZ holds more than 2 million specimens, including 5,200 primary types specimens. Concerning Orthoptera, it holds type material of 21 species (both valid and synonyms). Regarding Pyrgomorphidae, there is type material of six species (both valid and synonyms) (Fig. 3). Among them, one of particular importance is the fossil *Myopyrgomorpha fischeri*, which is currently placed as Pyrgomorphidae, but was originally described as *Oedipoda fischeri*. The types are mainly from species described by A. V. Schulthess-Rechberg (end of 19th-beginning of 20th centuries) and I. Bolívar (1850-1949). It is precisely Bolívar in 1905 who dedicated to Schulthess the Malagasy pyrgomorphid *Schulthessia biplagiata*. I thank

Figure 5. *Parapetasia femorata* Bolívar, 1884 (♀, HT) Gabon (NMW).

the curator Rod Eastwood for all his assistance, especially for helping me to obtain the fossil material of different species of *Oedipoda*.

3. Naturhistorisches Museum (NMW), Wien, Austria

The insect collection of NMW holds more than 10 million specimens. Regarding Orthoptera, primary type material of 1,664 taxa (both valid and synonyms) are deposited here. This was due primarily through the efforts of C. Brunner von Wattenwyl (1823-1914) (594 taxa) and L. Redtenbacher (1814-1876) (199 taxa). Type material is worldwide in scope: 545 taxa are from Central and South America, 388 from Tropical Asia, 169 from Africa, 126 from Temperate Asia, 110 from Europe, 62 from Australasia, 52 from Pacific, and 39 from North America). Concerning Pyrgomorphidae, there is type material of 32 species (both valid and synonyms) (Figs. 4 & 5). Several types that I did not find in BMNH, London, UK, were found here. I thank Sussane Randolf and Ulrike Aspöck for their help during my short stay.

4. Naturhistoriska Riksmuseet (NHRS), Stockholm, Sweden

The Entomological Collection of NHRS holds more than 3 million specimens. Regarding Orthoptera, 1,062 taxa (both valid and synonyms) are deposited here. This collection is very historical and worldwide in scope thanks to the efforts of C. De Geer (1720-1778) (42 taxa), C. Stål (1833-1878) (407 taxa), B.Y. Sjöstedt (1866-1948) (412 taxa), and L. Chopard (1885-1971) (55 taxa), among others. Concerning Pyrgomorphidae, there is type material of 64 species (both valid and synonyms) (Figs. 6 & 7). I want to acknowledge Niklas Apelqvist for his assistance.

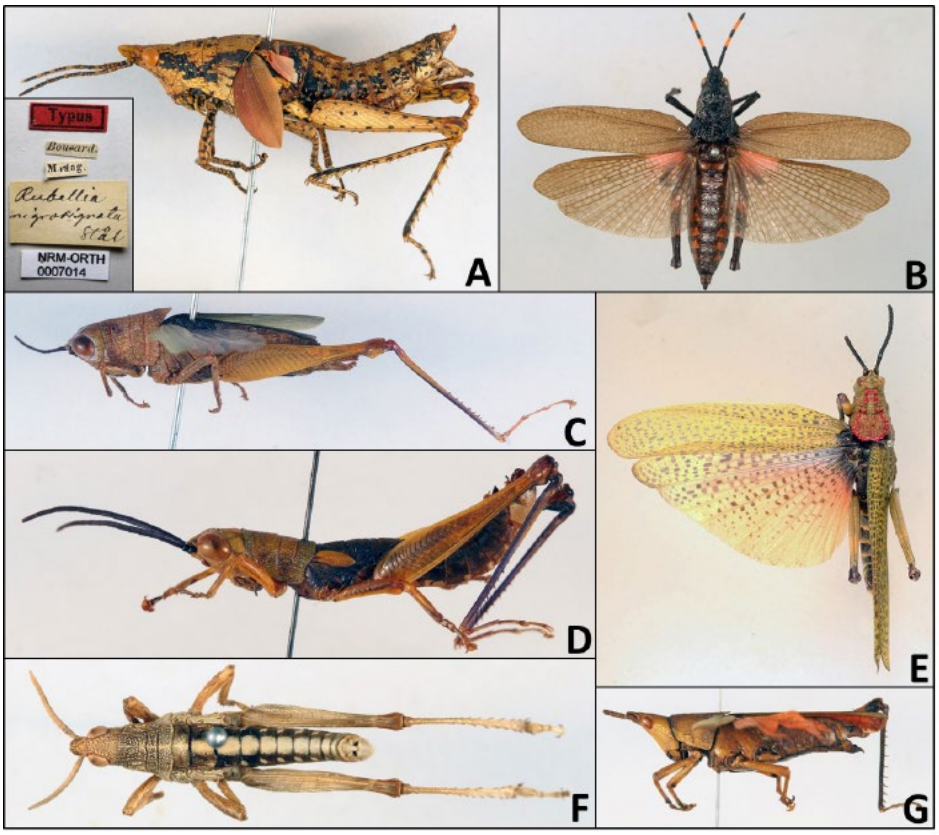

Figure 6. Pyrgomorphidae types from NHRS. A. *Rubellia nigrosignata* Stål, 1875 (♀, HT) Madagascar; B. *Maura rubroornata* (Stål, 1855) (♂, ST) South Africa; C. *Spinacris viridis* Willemse, 1933 (♀, HT) Philippines; D. *Meubelia atriantennis* (Willemse, 1932) (♂, HT) Philippines; E. *Phymateus morbillosus sjostedti* Bolívar, 1904 (♂, HT) South Africa; F. *Parasphena nairobiensis* Sjöstedt, 1933 (♂, HT) Kenya; G. *Tagasta hoplosterna* (Stål, 1877) (♀, HT) Philippines.

5. Museum of Uppsala University (UZIU), Sweden

This museum holds more than 2 million insect specimens. For Orthoptera, there are 119 taxa (both valid and synonyms) deposited here. 17 of them are from C. Linnaeus (1707-1778) and 98 of them are from C.P. Thunberg (1743-1828). Wallin (2001) and Wallin & Wallin (2001) treated with detail both Linnean and Thunberg types deposited at UZIU. For Pygomorphidae, there are 14 taxa with primary types. It was a plea-

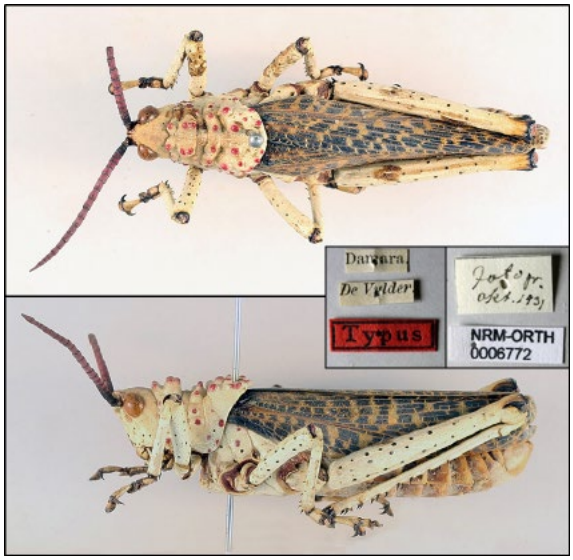

Figure 7. *Phymateus baccatus* Stål, 1876 (♂, HT) Namibia (NHRS).

Figure 8. Original boxes used by Thunberg at UZIU.

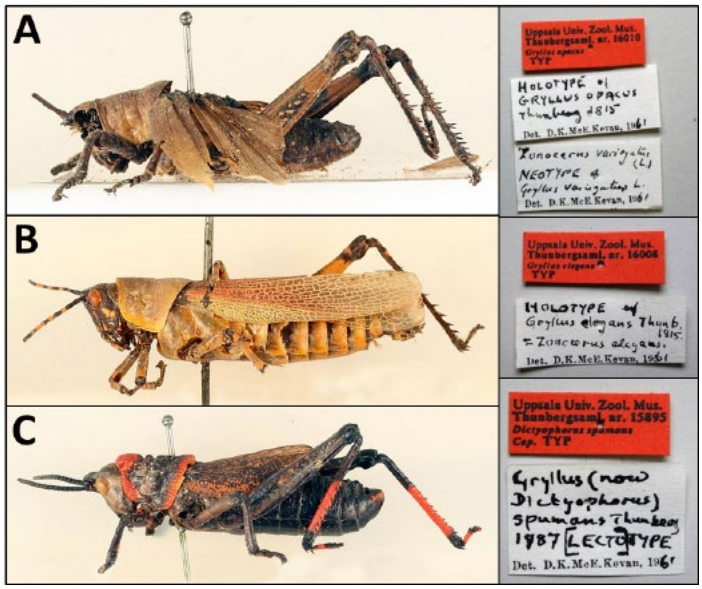

Figure 9. Pyrgomorphidae types from UZIU with their respective labels. A. *Zonocerus variegatus variegatus* (Linnaeus, 1758) (♂, NT) Africa; B. *Zonocerus elegans elegans* (Thunberg, 1815) (♂, HT) Africa; C. *Dictyophorus spumans spumans* (Thunberg, 1787) (♂, LT) South Africa.

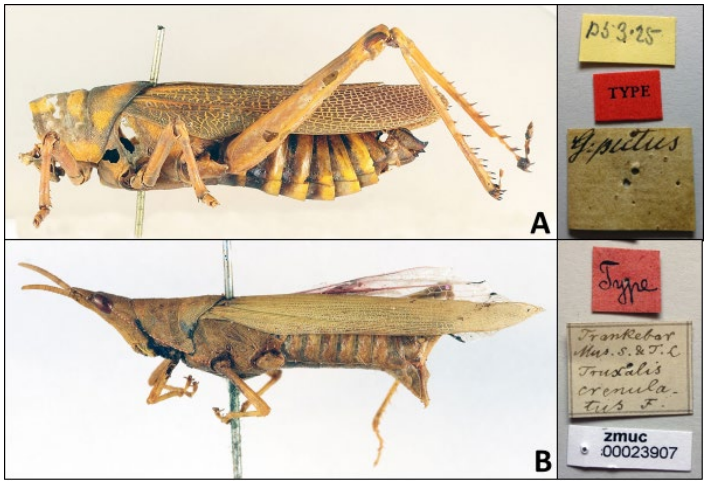

Figure 10. Pyrgomorphidae types from ZMUC with their respective labels. A. *Poekilocerus pictus* (Fabricius, 1775) (♀, HT) India; B. *Atractomorpha crenulata crenulata* (Fabricius, 1793) (♀, ST) India.

sure to see that historical material and even more because it was in the original boxes (Fig. 8). In Figure 9, I selected some lateral views, plus the labels of this historical material. Although relatively little material, it required extra time to carefully take the images due to its age. I want to thank Hans Mejlon for his help during my stay.

6. Zoological Museum of the University of Copenhagen (ZMUC), Denmark

The entomological collection of this museum holds more than seven million specimens both pinned and in ethanol. There are about 10,500 primary types, including nearly 8,000 described by J.C. Fabricius (1745-1808). Concerning Orthoptera, there are 57 taxa (valid and synonyms) deposited here. For Pyrgomorphidae, there are five species, mostly from Fabricius (Fig. 10). I thank Henrik Enghoff for his help in accessing the collection.

In total, for the six museums: 652 photographs were taken of 218 type specimens and are in the process of being uploaded to OSF. A special acknowledgment is given to Isabel C. Velásquez de la Cruz for her help in obtaining images and specimens manipulation.

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Report for the first stage (2016) of grant "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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I. Trips in Bulgaria

The team undertook two trips to Bulgaria to collect photos and sound recordings.The first trip took place in the period May 12th-16th with the participation of D. Chobanov, I. Iorgu, and S. Borisov as the team members. We also got help from a colleague from Romania, Liviu. The trip was specially designed to acquire data on the genus *Myrmecophilus* (ant crickets) from Bulgaria. Therefore, we mostly spent our time busily turning stones and chopping wood with ant nests (Figs. 1 and 2). We got used to carrying an axe and being frequently covered by biting ants. As a result, from two reported (and an additional one expected, but unpublished) taxa, we now can say that at least four species of *Myrmecophilus* occur in Bulgaria. Possibly, in terms of elevation, this is the second highest locality of ant crickets of this genus in Europe (after Southern Greece), with *M. hirticaudus* (Fig. 3) and *M. acervorum* (Fig. 4) found at 1650 m altitude in the Pirin Mountains.

Figure 1. Looking for ant crickets under stones.

Figure 2. Looking for ant crickets under bark of a dead tree.

Figure 3. *Myrmecophilus hirticaudus*.

Figure 4. *Myrmecophilus acervorum*.

Figure 5. *Gryllomorpha dalmatina*.

The second trip took place in the period July 17th-27th with the participation of D. Chobanov and I. Iorgu as the team members. We travelled to the Black Sea and the mountains of Rila and photographed various bush-crickets, crickets, and grasshoppers, including rarely-photographed species (Fig. 5).

II. The trip to Kazakhstan

The trip to Kazakhstan took place between June 7th and July 11th. Preparing for the trip, I, and my two companions, Maya and Boyan, stuffed our big car with a lot of equipment (including PC's, sound recorders, light traps, electric generator, additional big batteries, a tent, sleeping bags, barrels with altogether 50 liters of water for drinking and washing, canned and fresh food, cages for live specimens, tubes and boxes for dead specimens, etc., etc.), so that three people could hardly fit inside. We started from Sofia, Bulgaria, driving through Bucharest (Romania; to meet the project co-workers, Ionuţ and Elena Iorgu), Moldova, Ukraine, and Russia. Driving for over 3400 km from Sofia to

Figure 6. The author is checking the light tower for crickets.

Figure 7. Cooking the dinner.

Figure 8. Arranging the material from the last night.

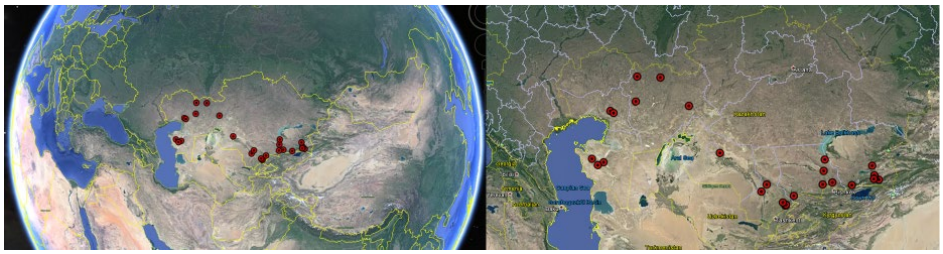

Figure 9. Sampled localities at two different scales (left – Kazakhstan in the northern part of the Eastern Hemisphere as seen in Google Earth; right – Kazakhstan itself).

Figure 10. *Phytomastax robusta*, male.

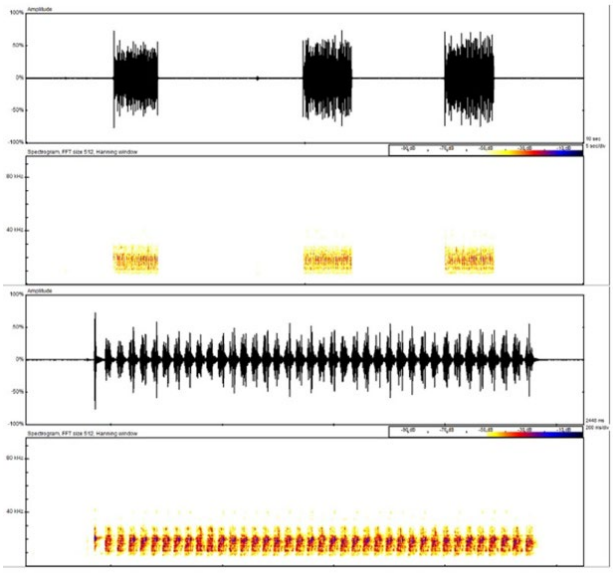

Figure 11. Oscillogram (first and third from top) and spectrogram (second and fourth from top) at two different speeds of the song of *Glyphonotus coniciplicus*.

Dossor in western Kazakhstan (our first collecting area) with only two stops for sleeping took about 100 hours.

After that, each day we followed more or less the same schedule. After finding a place to sleep, we would set up a tent and, simultaneously, started preparing the light traps (Fig. 6) and light dinner (both for us and our temporary pets collected as nymphs or still refusing to sing) (Fig. 7). After that, Boyan and Maya perched around the light and I started wandering in the surroundings with a head light to look for crickets and bushcrickets. About midnight or later, after the hunt was over, I would sit in the car surrounded by cages with crickets waiting to record their songs and in the meantime fixing the already recorded ones for future studies on their morphology, chromosomes, and DNA. After a few hours of sleep, with the first hot sun rays, we packed the tent, set an awning, and started organising the material from the previous night (Fig. 8), fixing additional animals until the heat would become unbearable. Then, we packed and headed to the next evening stop some 300-600 km ahead.

Altogether we drove about 18 000 km, of which some 11 500 km was in Kazakhstan. Though we expected the bad roads, some surprises arose, for example driving on a dirt road about 400 km between Atyrau and Aktobe for almost two days changing between only first and second gear! However, no matter the poor conditions and the corruption, we were lucky to see such nice views in this country of eagles and camels! This way, we sampled some 30 sites (Fig. 9) and photographed and collected many beautiful orthopterans, including some interesting and less known species of the genera *Glyphonotus*, *Bergiola*, *Lithoxenus*, *Montana*, *Gomphomastax*, *Phytomastax*, *Ptetica*, *Dociostaurus*, etc. (Fig. 10). I recorded over 120 WAV files of the

calling/courtship songs of about 25 species (mostly Tettigoniidae) that will contribute to the OSF database and to the knowledge of these intriguing taxa (Fig. 11).

As a result of the first year of the project we uploaded 206 photos and corresponding locality data of 99 taxa of orthopterans from Kazakhstan, Bulgaria, and Romania. Many of those represent poorly-known species with no image or locality data in OSF. Uploading of more photos and recordings of male calling songs is in preparation.

Theodore J. Cohn Research Grant Reports

Testing for reductions in age-associated damage upon dietary restriction and RNAi-mediated knockdown of neuropeptide F in *Romalea microptera*

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Non-model organisms play an integral role in the investigation of evolutionarily conserved responses to nutrient deprivation and environmental stress. The eastern lubber grasshopper (*Romalea microptera* (Palisot de Beauvois, 1817)(Romaleidae)) is a large and abundant generalist that is typically considered a prolific pest throughout Florida and the southeast (Fig. 1). In contrast to those conventional views, Dr. John Hatle, myself, and the rest of the team in the Hatle lab at the University of North Florida see the lubber grasshopper as a perfect candidate for inexpensive and novel biomedical research. With increasing economic and moral imperatives forcing the paradigm away from reactive medicine and towards preventative healthcare, understanding how lifestyle decisions like the composition and timing of diet influence the aging and the onset of age-related disease is an important and open question. Unlike the fruity fly or other small insect research models, our lubber's large size allows for individualized tracking of important metrics, such as feeding rate and fecundity, while providing an abundance of tissue for multiple organism-wide, tissue-specific analyses.

Figure 1. A close-up of a colorful lubber grasshopper used in our experiments. Eastern lubbers collected in Miami, FL have little melanin deposition relative to their darker Jacksonville neighbors that we collect near the University of North Florida.

Caloric restriction, a significant reduction in caloric intake without malnutrition, consistently extends lifespan in short-lived organisms while slowing the onset of age-related disease in longer-lived animals. Interestingly, more permissive and practical versions of dietary restriction, such as amino acid restriction and intermittent fasting (i.e., regimens that limit aspects of diet outside of pure caloric intake), have demonstrated an almost equally potent benefit to weight loss and disease resistance as total caloric restriction, even in the absence of any reduction in calories whatsoever. These findings underscore the importance of a sensation of food

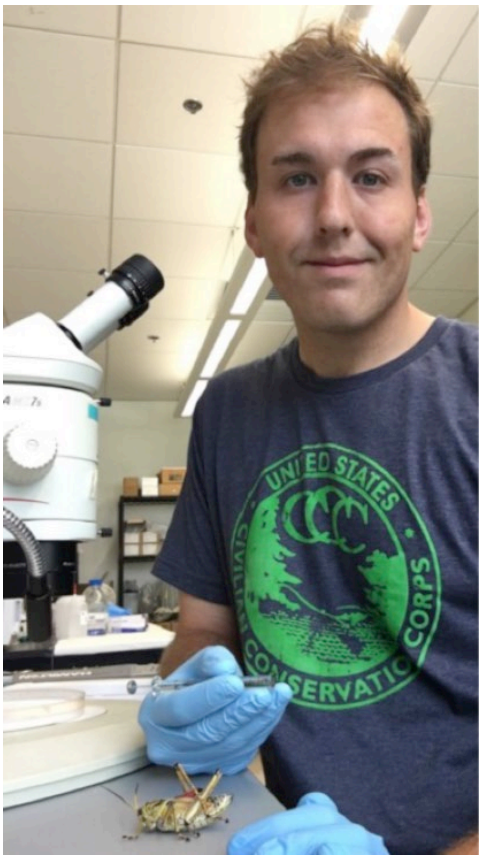

Figure 2. After animals completed their daily meal, grasshoppers on restrictive diet regimens were injected with a feeding stimulant (or milli-Q H2O) and access to food was suspended until the following day. In contrast, animals on ad libitum diets were injected at the same time, but access to food was never restricted.

Figure 3. Adult grasshoppers were isolated and housed in separate containers in order to track individual feeding rate, fecundity, and injection timing.

withdrawal and the stimulation of appetite in promoting the benefits of dietary restriction, while highlighting the counter-balanced perils of unrestricted eating and near-constant satiety to promote mortality (Fig. 2 & 3).

Building off of these observations, recent genetic knockdown of the appetite-stimulating hormone Neuropeptide Y (NPY) (and its functional invertebrate counterpart, Neuropeptide F (NPF)) identified the potent peptides as important players in promoting the salutary effects of dietary restriction on longevity (see Chiba et al. 2015). This was certainly a surprise to researchers familiar with orexigenic hormones like NPY and NPF, as these appetite stimulants play very detrimental roles in the promotion of gorging, obesity, and mortality upon an excess of food. Nevertheless, differential downstream responses to factors such as energy balance and hormone concentration were clearly suggested, so we set out to investigate how supplementing the peptide hormone across various nutritional states would impact physiology and healthspan.

Along with an injection of a truncated NPF peptide (or milli-Q water as a control), animals were given either unlimited access to food or a 40% restricted meal based on a sham-injected control group. Hence, while the NPF peptide would promote feeding (see Fig. 4) in animals on dietary restriction (NPF-DR), those animals were not given additional access to food that would 'satisfy' the supplemented hunger signals (stopping them from taking in more of the calories than sham-injected animals on 40% dietary restriction). In contrast, other NPF-injected animals were given free access to food (e.g., NPF + ad lib, known as NPF-AD) or restricted to the same amount as the baseline ad libitum fed controls (NPF + full diet, known as NPF-FD; data not included). This allowed for the analysis of NPF signaling across a full spectrum of dietary intake and peptide supplementation, and provided a direct diet-matched comparison of peptide-injected animals to sham-injected animals independent of food intake. After a prolonged diet and injection regimen, animals were dissected and individual tissues were isolated and flash-frozen for analysis. In addition to several physiological metrics taken throughout the experiment (such as reproductive investment), tissue-specific analysis of oxidative damage provided a snapshot of somatic integrity across treatment groups.

Interestingly, while unbridled feeding induced by neuropeptide injection and free access to food resulted in a significant increase in age-

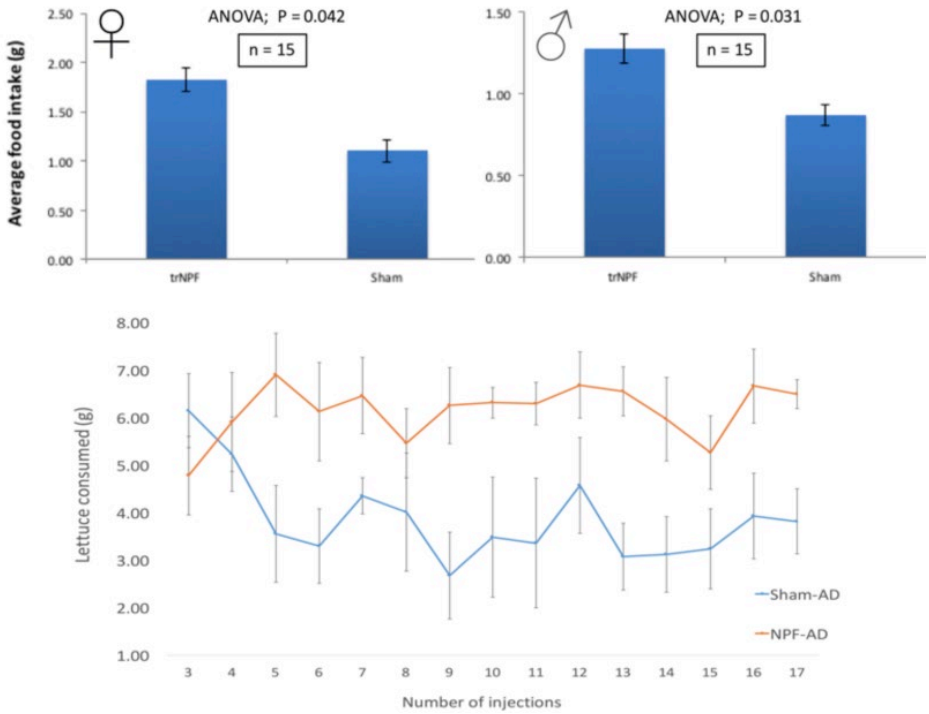

Figure 4. In addition to altering organ growth and reproductive physiology, neuropeptide F injections stimulated food intake relative to sham-injected controls. Top: Feeding rate of NPF-injected animals after standardization of feeding-state according to protocols created by the VD Broeck lab – see Van Wielendaele et al. 2013). Bottom: Long-term changes in feeding rate of ad-libitum fed animals from the general experiment.

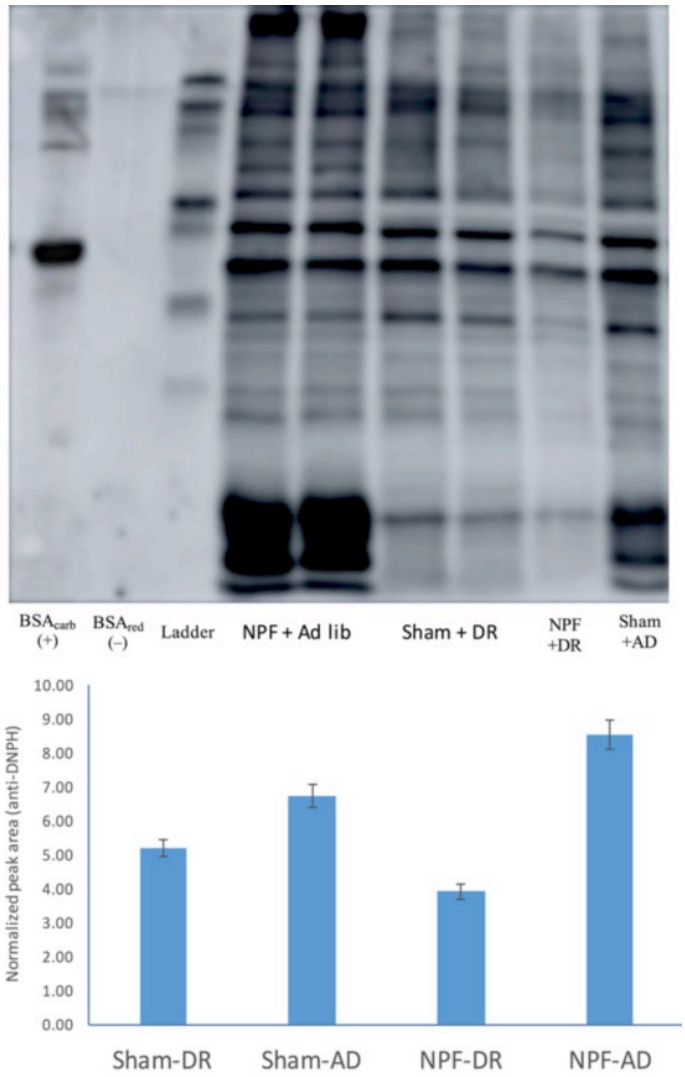

Figure 5. Tissue-specific fingerprints of oxidative damage (e.g., protein carbonylation) were analyzed across treatment groups via immunoblot. Animals injected with neuropeptide F and fed unrestricted diets exhibited disproportional damage relative to sham-injected controls, while neuropeptide F-injected animals on dietary restriction showed a significant reduction in damage relative to sham-injected controls.

related oxidative damage (shown in fat body tissue), the opposite effect was observed when supplementing NPF upon dietary restriction (Fig. 5). While sham-injected animals on dietary restriction still exhibited reductions in fat body protein carbonylation, a much more profound enhancement of maintenance was observed upon the combination of dietary restriction and additional NPF. These results support the idea that many of the beneficial adaptive responses to dietary restriction are not necessarily directly tied to amounts of food intake, but rely upon the activation and reinvigoration of processes tied to nutrient-sensing and signaling. Our lab continues to analyze several aspects of maintenance and gene expression in additional tissues, building an organism-wide analysis of maintenance upon these treatments.

While the simple answer to preventative medicine has always been to eat healthier and be more active, widespread nutritional ignorance and a highly stimulatory industrial environment leaves a much more nuanced problem for current generations of aged adults. Even so, if scientific research (with the help of grasshopper physiology!) can lay the groundwork for understanding how diet and exercise alter regulation and promote maintenance and tissue integrity, a promising bridge to preventative medicine could be constructed by instilling a stronger understanding of nutrition and metabolism in future generations.

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Adaptive behavioral plasticity in the calling song of *Teleogryllus oceanicus*

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Teleogryllus oceanicus (Gryllidae: Gryllinae), the Pacific field cricket, is native to Oceania and introduced to Hawaii, where it co-occurs with an acoustically orienting parasitoid fly, *Ormia ochracea*. Male *T. oceanicus* produce calling song by stridulation, which females use to identify and localize appropriate mates (Gerhardt and Huber 2002). In addition to intended receivers, these signals attract gravid female *O. ochracea*, which infest calling male crickets with larvae (Cade 1975; Zuk et al. 1993). The larval flies burrow into the cricket host and subsist on his tissues until emerging to pupate 7-10 days later, killing him in the process (Wineriter and Walker 1990; Adamo and Hoy 1995). *Ormia ochracea* represents a novel selection pressure against sexual signaling for *T. oceanicus* in Hawaii, the only place in the world where they co-occur. On three islands of Hawaii, populations of *T. oceanicus* have recently acquired single-gene, sex-linked mutations, collectively called "flatwing", that destroy the wing structures males use to produce song (Zuk et al. 2006; Pascoal et al. 2014). The

Figure 1. An adult female *T. oceanicus* photographed in the field on the island of Oahu. Photo by JC Tanner.

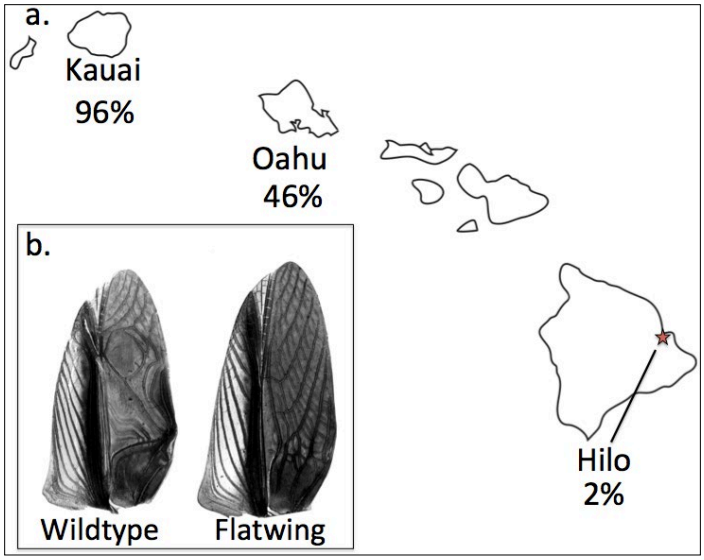

Figure 2. (a) Proportion of flatwing males present on three islands of Hawaii. (b) Examples of normal (left) and flatwing (right) wing venation. Flatwing males lack stridulatory structures and are therefore incapable of producing song. Photo from Bailey and Zuk (2008).

mutant phenotype has attained a different frequency on each island: approximately 96% on Kauai, 46% on Oahu, and 2% in Hilo (Figure 2; Zuk et al. 2006; Tinghitella 2008). Although the flatwing phenotype protects males from the fly, it poses serious problems for mate attraction and courtship. Previous work in the Zuk lab has suggested that plasticity in female behavior has accommodated this new trait. We know that mating behaviors in *T. oceanicus* are plastic because female crickets reared in silent environments that mimic an all-flatwing population are less selective and more responsive (i.e., respond indiscriminately) to calling song than females who are exposed to song during development (Bailey and Zuk 2008; Swanger and Zuk 2015). Moreover, gravid female *Ormia* preferentially infest males with the same trait values females prefer (Wagner 1996). Taken together, these results suggest that 1) there is natural selection in these populations against not just singing, but singing preferred songs in particular; and 2) female selectivity with regard to preferred signal traits, such as the percentage of long chirp in male calling song, may be plastic. Based on these observations, we are investigating the idea that sexual selection on male signaling should be relaxed following the introduction of flatwing. Our central hypothesis is that adaptive plasticity initiates a negative feedback loop between experience of preferred sexual signals and the expression of mating preferences that exert selection in the signaling system.

To test this hypothesis, we collected eggs from wild, mated females in the field in Hawaii and raised two filial generations in the lab to control for maternal effects. We recently began the acoustic experience phase of our experiment, in which we are manipulating the percentage of long chirp in the calling song that *T. oceanicus* experience during development. Individuals will experience one of three percentages of long chirp beginning at the fourth instar when their auditory organs are functional, and continuing through the first few days after eclosion. We will then record the calling song production of males and measure the percentage of long chirp produced. We will use a within-individual design to assess the mating preferences of females with regard to percentage of long chirp using a series of phonotaxis tests.

While it has been shown that phenotypic plasticity is ubiquitous, whether it facilitates or hampers adaptive evolution remains contentious (West-Eberhard 2003). Controversy arises partly because many studies demonstrate seemingly non-adaptive environmentally-induced variation, while few show how plasticity has caused adaptive differentiation in the wild (Ghalambor et al. 2007). When organisms enter new environments, novel selection pressures, including predators, competitors, and biophysical environments, can precipitate rapid evolution (Reznick and Ghalambor 2001); these events create natural experiments, offering an opportunity to observe evolution in action. While most studies of sexual signals investigate trait elaboration, evolution is not inherently directional and traits may also be lost. This work will elucidate the role of adaptive plasticity in the differentiation of wild populations.

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Development and identification of the different post-embryonic nymphal instars of *Eyprepocnemis plorans ibandana* Giglio-Tos, 1907 in southern Cameroon

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Eyprepocnemis plorans (Charpentier 1825) (Acrididae: Eyprepocnemidinae) is a polyphagous pest of crops, including potatoes, beans, beets, radishes, and spinach (Harrat and Moussi 2007). This species is present in agricultural production systems in southern Cameroon (Mestre and Chiffaud 2006), including manioc, groundnut, corn, and other green vegetables. There are limited options for the control of this grasshopper in southern Cameroon. Apart from chemical control, which is heavily criticized today for its multiple adverse effects on the environment, there is no other effective means of treatment for this species in the wild. The development of alternative methods, biological or ecological, therefore becomes a necessity for a better conservation of forest ecosystems in southern Cameroon. However, the implementation of a better control strategy first requires good knowledge on the bio-ecology and population dynamics of this pest. *E. plorans* is a polymorphic species with two sub-species in Cameroon, *Eyprepocnemis plorans ornatipes* (Walker, 1870) in the Sahel regions and *Eyprepocnemis plorans ibandana* Giglio-Tos, 1907 in the forest area (Dirsh 1958). Only a few studies, such as those of Descamps (1953, 1956), have dealt with some biological aspects of this species in the Sahelian regions of northern Cameroon. In rainforest areas, its life cycle has not been studied and needs to be examined. Elsewhere, studies on this subject led to different results, probably related to the specific ecological conditions of each zone and to possible seasonal migrations between complementary zones. In Sahel environments, this species may be encountered throughout the year as nymphs and adults (Lecoq 1988), while in Spain it has either a single generation per year (Hernández and Presa 1984) or two (Olmo-Vidal 1990). In the laboratory, up to four generations can be produced per year (Schmidt et al., 1996). This work on the morphology and development of

Figure 1. *E. plorans Ibandana* habitus.

Table 1. Duration of the development of each nymphal instar of *E. plorans ibandana* in the laboratory.

Nymphal instars Sexes	1	2	3	4	5	6	7	Kruskal-Wallis test		Total duration
								Valeur H	Valeur p	
♂ with 6 nymphal instars	13.61±2.42 **a** (92) (6-24)	11±3.03 **b** (92) (6-22)	12.10±4.24 **b** (92) (10-28)	14.80±5.31**a** (92) (11-34)	19.78±8.08 **c** (92) (12-49)	21.91±6.69 **c** (92) (10-34)	—	160.6	4.60^{E}-33	86.23±11.53 (92) (66-109)
♀ with 6 nymphal instars	13.71±2.12 **ab** (49) (12-22)	11.63±3.76 **c** (49) (6-22)	10.76±2.46 **c** (49) (6-20)	14.12±3.77 **ad** (49) (10-26)	15.45±5.29 **bd** (49) (8-34)	19.55±7.00 **e** (49) (10-38)	—	98.05	1.35^{E}-19	85.26±7.94 (49) (72-105)
♀ with 7 nymphal instars	14.33±2.79 **a** (24) (10-24)	9.67±2.39 **b** (24) (6-14)	9.42±2.80 **b** (24) (6-12)	12.08±3.31 **c** (24) (8-24)	12.75±3.66 **c** (24) (10-28)	13.58±4.02 **c** (24) (6-26)	16.43±3.23 **d** (24) (10-24)	73.20	9.09^{E}-14	88.35±9.22 (24) (72-105)

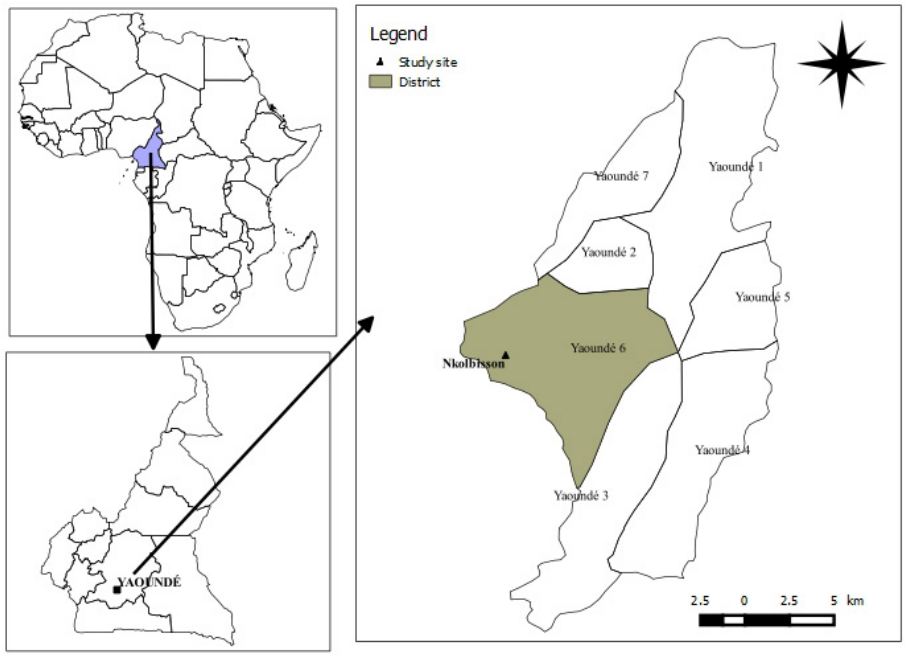

Figure 2. Study site.

E. plorans ibandana is a preliminary work necessary to the study of population dynamics and the life cycle of this sub-species in Cameroon forest areas. The objective of this study was to determine and characterize the various post-embryonic nymphal instars and to precisely determine their development times.

Materials and Methods

The adult specimens of *E. plorans ibandana* (Fig. 1) used in the laboratory were caught in a net in the locality of Nkolbisson (Fig. 2), a district of Yaounde, between July and November 2016. This area is characterized by an alternation of hills and swampy lowlands (Bachelier 1959), located in a semi-deciduous forest zone where the vegetation is degraded because of urbanization. The climate is of the Guinean type, sub-equatorial at four seasons: a short rainy season (April to June), a long rainy season (September to mid-November), a long dry season (mid-November to March), and a short dry season (July to August). Average rainfall is about 1600 mm per year and temperatures are between 19-33°C (Suchel 1987). In the laboratory, the development of *E. plorans ibandana* was carried out at room temperature, with the temperature and humidity controlled using a thermohygrograph. During the study, temperatures and humidity varied respectively between 21-29 °C and 61-95%. Male and female adults of *E. plorans ibandana* captured in the field were paired in type "1" cages: transparent boxes of 24 cm high and 25 cm in diameter with a lid made of a fine mesh of 1 mm, and filled midway with sand sterilized by the wet heat of an autoclave (121°C and 1.5 Pa) for 30 minutes. After adult mating, egg laying in the sand, and incubation and egg hatching, each nymph was placed in type "2" cages: transparent boxes of 9 cm height and 13 cm in diameter with a lid made of a fine mesh of 1 mm, and arranged on shelves in the laboratory. Each cage, of type 1 and 2, contained a dry stem of *Chromolaena odorata* (L.) King & Rob used as support for nymphs. Observations were made every two days to look for exuvia and note whether the nymphs were dead or alive, and the cage was also cleaned and food changed. All individuals were fed with a fresh leaf of *Manihot esculenta* (Crantz 1766). In total, the development of 420 nymphs was monitored. The morphological (pterotheca, external genitalia, antennae) and morphometric studies of the different post-embryonic nymphal instars of *E. plorans ibandana* were

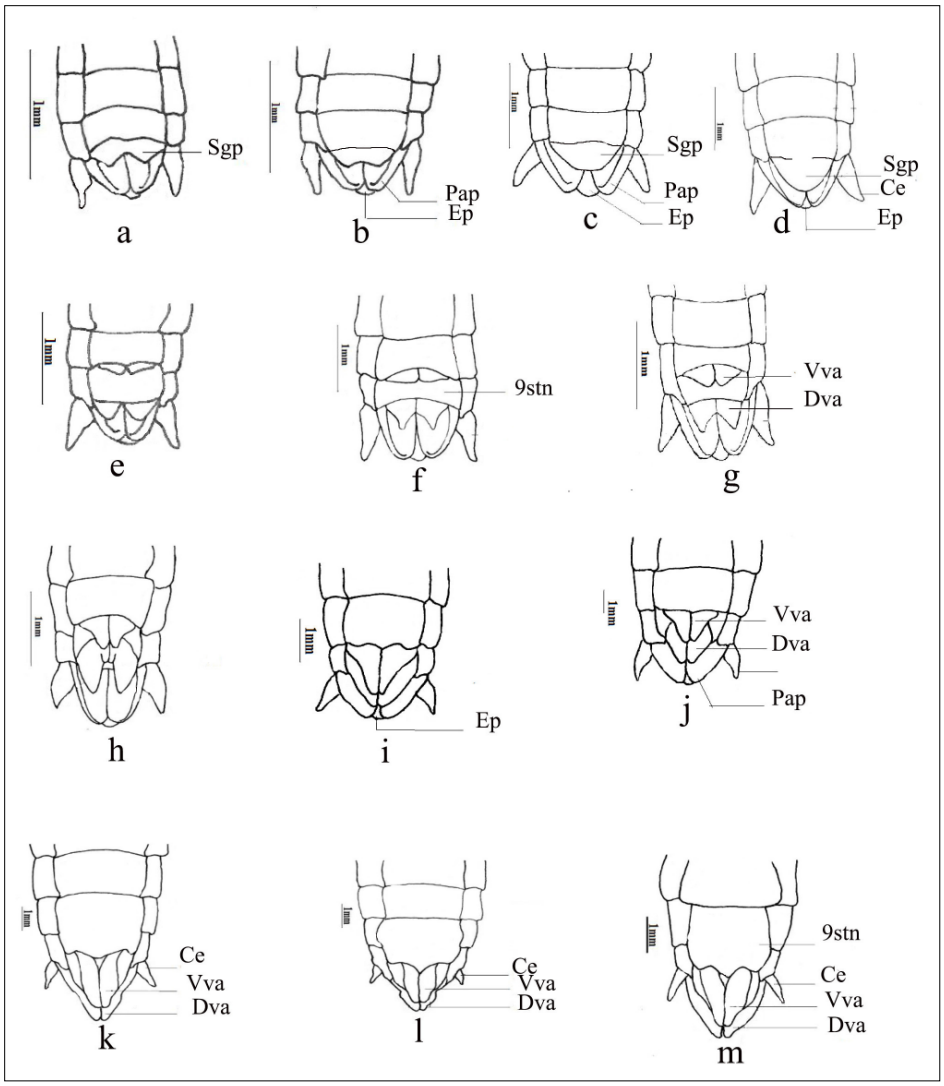

Figure 3. External genitalia of nymphal instars of *E. plorans Ibandana* in ventral view. a : male, 1st instar; b : male, 2nd instar ; c : male, 3rd instar ; d : male, 4th instar; e : female, 1st instar; f : female, 2nd instar; g : female, 3rd instar ; h: female, 4th instar ; i : female, 5th instar (female with 6 nymphal instars); j : female, 5th instar (female with 7 nymphal instars); k : female, 6th instar (female with 6 nymphal instars); l : female, 6th instar (female with 7 nymphal instars); m : female, 7th instar (female with 7 nymphal instars); Ce : cercus; Ep: epiproct; Pap: paraproct; Sgp: sub-genital plate; 9stn : sternite 9; Dva : dorsal ovipositor valve; Vva: ventral ovipositor valve.

made under a binocular lens, on specimens previously fixed with 70% alcohol. Means were compared using the Kruskal-Wallis and Mann Withney tests (PAST 2.17 software). All probabilities were assessed at 5% of error risk.

Results and Discussion

Number and duration of post-embryonic nymphal instars of E. plorans ibandana

The post-embryonic development of *E. plorans ibandana* in the laboratory involves 7 developmental instars in the male (6 nymphal instars and 1 adult) and 7 (6 nymphal instars and 1 adult) or 8 (7 nymphal instars and 1 adult) in the female. Our results corroborate those of Jago (1963) in Ghana on *E. plorans meridionalis* and those of Hernandez and Presa (1984). Nevertheless, the work of Schmidt et al. (1996) in Germany on the same species show 6 development instars in the male and only 7 in the female. All these observations indicate that there is a variation in the number of male and female nymphal instars in subspecies of *E. plorans* according to the environment. The duration of nymphal development was 86.23 ± 11.53 days in the male, and 85.26 ± 7.94 / 88.35 ± 9.22 days, respectively, in the females with 7 and 8 instars (Table 1). Jago (1963), in Ghana, obtained 55.3 and 59.5 days, respectively, for males and females. These differences may be due to differences of the subspecies studied and also differences in temperature and humidity between Cameroon and Ghana (lower temperatures in southern Cameroon).

Identification key of nymphal instars of E. plorans ibandana *in South Cameroon* (Figs. 3 and 4)

1 - Wing buds (pterotheca) very small, nervation absent; male subgenital plate indented …….……2

1'- Wing buds more visible, nervation present; male subgenital plate not indented…….3

2(1) – Antenna with 11 articles and reaching dorsally half of the length of pronotum; eye with one weakly longitudinal stripes; male sub-genital plate conical, not exceeding the half of the paraproct, with a deep indentation in the posterior base; ventral ovipositor valves very small, not reaching the 9th abdominal sternite nor half of the length of the parapro ct..... 1st instar

2'- Antenna with 11 articles and reaching dorsally half of the length of pronotum; eye with two weakly longitudinal stripes; male sub-genital plate with a shallower indentation than that of the 1st stage nymph; ventral ovipositor valves exceeding the 9th abdominal sternite and reaching half of the length of the paraproct .... 2nd instar

3(1') - Antenna with 17 or 19 articles, shorter or reaching dorsally the 3/4 of the length of pronotum…….....…4

3' - Antenna with 21 to 24 articles, exceeding 3/4 of the length pronotum and reaching dorsally almost to the posterior margin of the pronotum …….....5

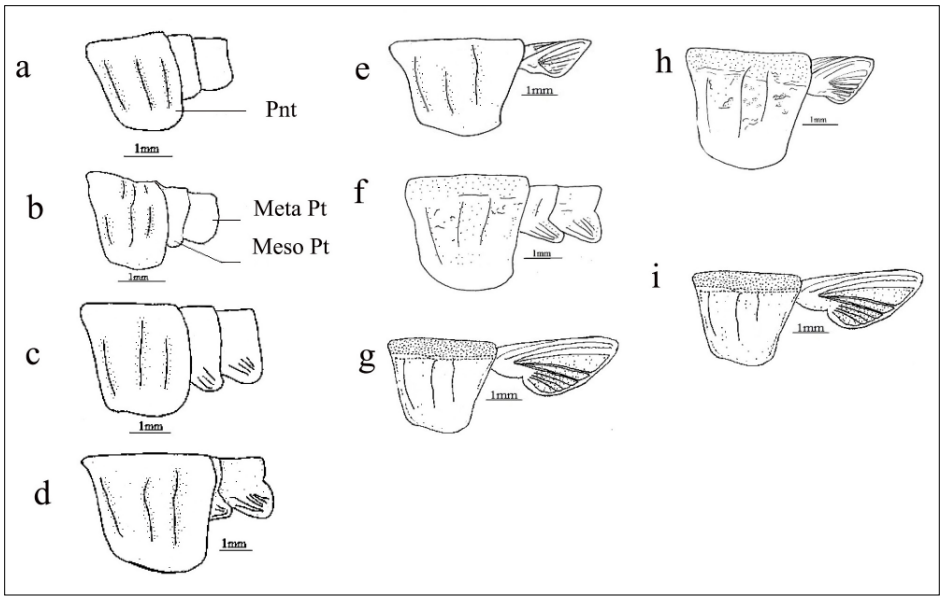

Figure 4. Pterotheca of nymphal instars of *E. plorans Ibandana* in lateral view. a : 1st instar; b : 2nd instar; c : 3rd instar; d : 4th instar; e : 5th instar (female with 6 nymphal instars); f : 5th instar (female with 7 nymphal instars); g : 6th instar (female with 6 nymphal instars) ; h : 6th instar (female with 7 nymphal instars) ; i : 7th instar (female with 7 nymphal instars) ; Pnt : pronotum; Meso Pt : mesothoracic pterotheca; Meta Pt : metathoracic pterotheca.

4(3) - Antenna with 17 articles and dorsally reaching 1/3 of the length of the pronotum; eye with three weakly visible longitudinal stripes; pterotheca reaching the anterior base of the 1st abdominal segment; male sub-genital plate reaching half of the length of the paraproct; ventral ovipositor valves reaching half of the 9th abdominal sternite ….....…3rd instar

4' - Antenna with 19 articles and dorsally reaching 1/3 of the length of the pronotum; Eye with four weakly visible longitudinal stripes; pterotheca slightly exceeding the anterior base of the first abdominal segment and reaching the anterior margin of the tympanic orifice; male sub-genital plate reaching the 3/4 of the length of the paraproct; ventral ovipositor valves exceeding half of the 9th abdominal sternite …….....…4th instar

5(3') - Pterotheca not returned; mesothoracic pterotheca reaching dorsally almost half of the metathoracic pterotheca; ventral ovipositor valves reaching half of the length of the dorsal valves ….....5th instar (only in female with 7 nymphal instars)

5'- Pterotheca returned; mesothoracic pterotheca reaching or exceeding dorsally half of the metathoracic pterotheca; mesothoracic wing buds covering the metathoracic one; ventral ovipositor valves exceeding clearly the half of the length of the dorsal valves …….....….6

6(5') - Antenna with 21 to 22 articles ….....…7

6' - Antenna with 24 articles and reaching dorsally the posterior margin of pronotum; eye with seven clearly visible longitudinal stripes; ventral ovipositor valves almost as long as the dorsal valves …….....…7th instar (only in female with 7 nymphal instars)

7(6) - Eye with five longitudinal stripes; metathoracic pterotheca reaching dorsally half of the 1st abdominal segment; ventral ovipositor valves exceeding half of the length of the dorsal valves…..……5th instar

7' - Eye with six longitudinal stripes; metathoracic pterotheca reaching or exceeding dorsally half of the 1st abdominal segment; ventral ovipositor valves exceeding 3/4 of the length of the dorsal valves …....8

8(7') Metathoracic pterotheca reaching the posterior margin of 3rd abdominal segment in male and reaching the posterior margin of 2nd abdominal segment in female; ventral ovipositor valves exceeding clearly 3/4 of the length of the dorsal valves …….....…6th instar

8' - Metathoracic pterotheca reaching dorsally half of the first abdominal segment; ventral ovipositor valves exceeding slightly 3/4 of the length of the dorsal valves… ….....6th instar (only in females with 7 nymphal instars)

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Diet nutrient composition affects development and life history traits of a wing-polymorphic cricket, *Gryllus lineaticeps*

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All organisms must acquire nutrients from the environment and invest resources in the physiological processes that define an individual's life history, including growth, reproduction, and maintenance. Limitations in energy acquisition result in trade-offs or negative functional associations between life history traits. As a result, changes in resource acquisition can either exacerbate or ameliorate trade-offs (e.g. increased energy acquisition will reduce limitations on allocation between competing traits) (Zera and Harshman 2001). In conjunction with caloric or total energy intake, macronutrient composition of the diet may be an additional environmental factor mediating life history trade-offs (Clark et al. 2015). Different physiological processes require different macronutrient inputs. For example, both growth and reproduction involve building new tissues, and thus may require a correspondingly protein-rich diet. In contrast, somatic maintenance involves management of long-term energy stores, primarily derived from carbohydrate intake. Consequently, throughout a life cycle, individuals will experience ontogenetic shifts in the energy and macronutrient demands.

Wing-polymorphic crickets in the genus *Gryllus* (Gryllidae: Gryllinae) exhibit divergent life history strategies: morphs of *Gryllus* crickets specialize either in dispersal (long-winged: LW) or reproduction (short-winged: SW) (Roff 1984; Zera and Harshman 2001). A dispersal morph (LW) develops functional flight muscles during its last juvenile instar prior to adulthood. These muscles are maintained in adulthood, which is when lipids are accumulated to fuel flight. In contrast, the reproductive morph (SW) does not develop its flight muscles during its last instar. Instead, during the first five days of adulthood, SW females invest heavily in ovary growth and reach reproductive maturity earlier than LW adults.

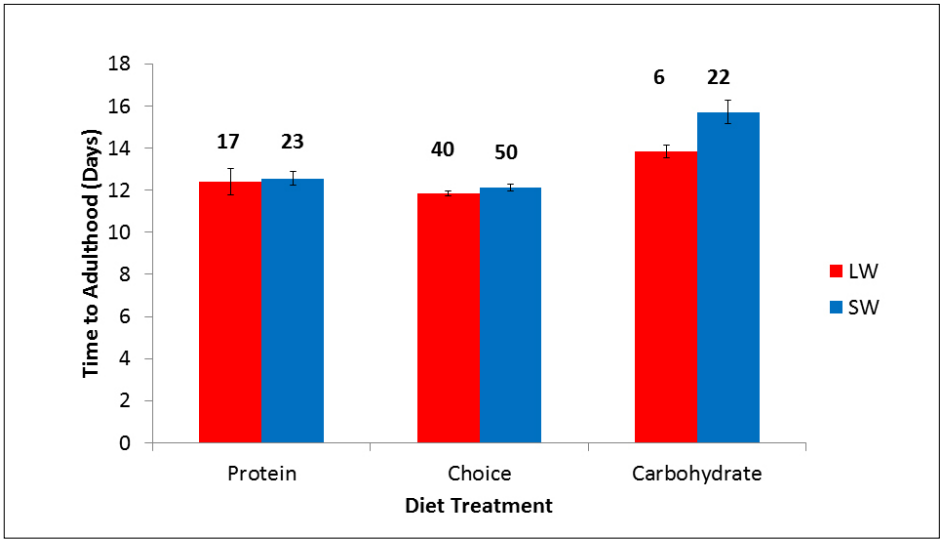

Figure 1. Development time in number days from the start of last juvenile stage to the first day of adulthood. Numers above the bars denote the number of juveniles that molted to the respective morph.

We hypothesized that these alternate life history strategies are associated with specific nutrient requirements across development. We investigated the extent to which morphs adjust dietary macronutrient intake to meet changing developmental demands. We further tested how the morphs cope with diets that do not meet demands. We predicted that the LW morph would modulate nutrient preference between last instar and adult stage from favoring a protein-biased diet to support muscle growth, to a carbohydrate-biased diet to promote production of lipids to fuel flight. We also predicted that LW adult dispersal capability would be negatively impacted by a protein-biased (carbohydrate-limited diet). Meanwhile, we predicted no shift in nutrient intake across life stages in the SW individuals and that, across life stages, a carbohydrate-biased diet would negatively affect performance compared to a balanced or protein-biased diet.

Methods

During either the last juvenile

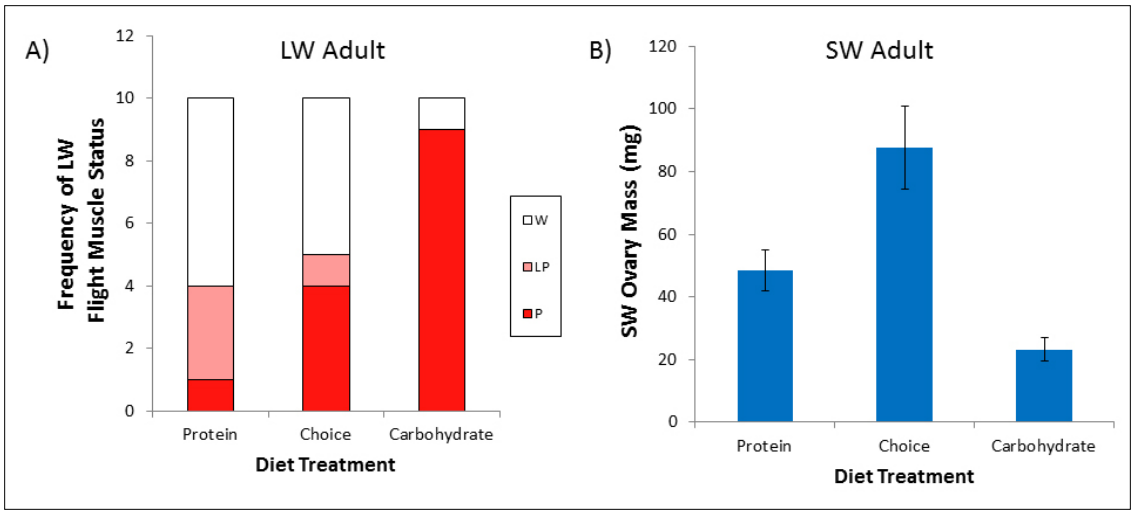

Figure 2. Adult investment in life history traits; A) Flight muscle status frequency of one week old LW adults (W = white and non-functional, LP = light pink, P = pink and functional); B) Ovary mass of one week old SW adults

stage or early adulthood (first 5 days), crickets were randomly assigned to one of three ad libitum artificial diet treatments that were isocaloric (equal energy content) but differed in macronutrient composition: 1) choice between protein- and carbohydrate-biased diets, 2) protein-biased diet (2P:1C), or 3) carbohydrate-biased diet (1P:4C). We monitored food intake and growth (mass gain) of crickets throughout each life stage. When provided a choice, crickets can modulate feeding to optimize nutrient intake, allowing us to quantify dietary preference. To assess differences in performance when fed different diets, we measured key life history traits for individual performance, including development time, morph determination (LW or SW) of juveniles, and adult investment in either dispersal (muscle mass and status) or reproduction (ovary mass).

Results and Conclusions

Preliminary results from this experiment indicate that both the quantity and quality of what an individual eats are important components of life history specialization. In contrast to our predictions, there was no evidence of switches in the selected dietary nutrient balance between juvenile and adult life stages for either morph. In fact, when given a choice, both morphs preferred a slightly carbohydrate-biased diet regardless of age. However, juvenile LW individuals ingested a larger total amount of food than juvenile SW individuals (MANCOVA: $F_{2,73}= 7.45$, $p= 0.001$). This higher consumption may be necessary for LWs to meet both energy and protein demands of flight muscle building. During adulthood, no morph differences in total food consumption were evident (MANCOVA: $F_{2,73}= 1.06$, $p= 0.35$).

Second, based on performance measures of individuals fed imbalanced diets, diet composition does differentially affect individuals that possess different nutrient demands. For instance, when fed a carbohydrate-biased (protein-limited) diet, juveniles took longer to develop into adults (Figure 1, Log-rank $\chi2=55.9$, $df=2$, $p=<0.001$), and approximately 80% of juveniles fed a carbohydrate-biased diet emerged as SW adults (Figure 1, $X2=7.13$, $df=2$, $p=0.028$). Thus, dietary protein consumption prior to adulthood is important for development, especially for LW.

Finally, in early adulthood, life history traits were maximized for each morph on different diets. LW adults fed a carbohydrate-biased diet invested in maintenance of flight muscles, as reflected by both larger muscle masses and a higher frequency of healthy and functional pink muscles compared to white, non-functional muscles at adult day five (Figure 2a, $\chi2=14$, $df=4$, $P = 0.0073$). In contrast, SW adults provided with a choice of diets had larger ovaries than adults given either the protein-biased or carbohydrate-biased diets (Figure 2b). This suggests that they effectively selected a diet to optimize reproduction. Additionally, ovary size was significantly reduced when SW were fed a carbohydrate-biased (protein-limited) diet, supporting the importance of protein acquisition for reproductive maturation (Figure 2b, ANCOVA: $F_{2,26}=17.588$, $P= <0.001$). Taken together, this experiment demonstrates that bulk nutrient intake influences physiological performance in a manner specific to particular life history strategies.

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Embarking on a new career: a brief history of rangeland grasshopper management in the U.S. from the perspective of a new member of the United States Department of Agriculture

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In January of this year I embarked on a new career as an Entomologist with the United States Department of Agriculture (USDA) as part of the Rangeland Grasshopper/Mormon Cricket Management Team (Fig. 1) within the Phoenix Lab (part of the USDA's division of Science and Technology) in Arizona. This is my first federal position and I am excited to utilize my knowledge in a helpful, public-oriented capacity. The position is a successional one, which means I am currently in the role as an "apprentice" learning all I can from the current team leader, Larry E. Jech (Supervisory Entomologist: field operations organizer and data analysis), who plans to retire within two years. I thought a brief history of the grasshopper issues in the U.S. and our team might be of interest.

Figure 1. The members of the USDA Rangeland Grasshopper/Mormon Cricket Management Team outside their Science and Technology lab in Phoenix, Arizona, U.S.A.

As we all know, grasshoppers have been flying thorns in the sides of farmers and ranchers worldwide for as long as human civilization has existed. In the U.S., though, their recorded history is much shorter with an outbreak in New England in 1797 being one of the earliest mentions of crop destruction by grasshoppers. As many of you also probably know (perhaps from Jeffrey A. Lockwood's interesting book from 2005 on the subject, Locust), the Rocky Mountain locust (Melanoplus spretus Walsh, 1866 - currently thought to be extinct) was one of the worst plague species in the world and caused significant agricultural woes in the western U.S.. From 1874-1877, this grasshopper was the most abundant it ever had been, resulting in mile-long swarms that would blot out the sky, with the devastation of every edible thing within visual range. For these reasons, in 1877, the U.S. established the Entomological Commission to study the locust in-depth at the urging of Charles V. Riley. Riley was an enterprising entomologist from Missouri who made his name nationally-known due to his great interest in assisting rangeland states with their locust issues. In fact, Riley became so well-known nationally that he was invited to become Federal Entomologist (the second one ever) in 1878, but resigned in 1879 to continue doing field work with the Commission until 1881. Then, he joined the Division of Entomology of the USDA as chief until 1894. Coincidentally, this is also around the time that entomologists began noticing sharp declines in population levels of M. spretus with almost none found at the turn of the century. Amazingly, 1902 was the last reported collection of this species in the wild and occurred in southern Canada.

The incredible decline of this locust species, however, was not the last of the grasshopper problems in the U.S. In the 1930's, 17 western states had infestations by a number of species taking over millions of acres of both federal and private land, and control efforts at the local level were consistently failing. A regional approach was determined to be the solution, so, in 1934, the U.S. Congress mandated the USDA with rangeland grasshopper management under the auspices of the division now known as the Animal and Plant

Health Inspection Service (APHIS). Despite several agency shifts in organization over the years, this is still the same mandate and division that our team is operating under today and, over the years, it became what we now call the Rangeland Grasshopper and Mormon Cricket Suppression Program. After 1934, grasshopper management was largely undertaken by the APHIS divisions placed in each state known as Plant Protection Quarantine (PPQ). Additional support came from the USDA's Agricultural Research Service (ARS) (particularly the lab that used to be in Bozeman, Montana) whose primary responsibility was developing and testing chemical applications for adequate control.

Despite these great strides in grasshopper management, problems continued to persist at undesirable levels, which led to the establishment of a new USDA unit to combat the threat in a different way. The Phoenix Lab's pink bollworm unit has had much success in reducing the presence of this cotton pest in the field. This is why, in 1976, this same lab was chosen to be the home base of another unit that would also have a specific focus: the team to which I now belong. R. Nelson Foster (retired Supervisory Entomologist), who was working for the pink bollworm unit at the time, was assigned the task of building the unit and leading the team to many victories over their saltatorial adversaries until his retirement in 2014. Some of you may be aware of Foster's efforts because our Society awarded him the Sir Boris Uvarov's Award in Applied Acridology during the 2013 Congress of Orthopterology in China. Since Foster's retirement, Jech has been in charge after first working for the team from 1989-1994 and then re-joining in 2008. The other two team members are K. Chris Reuter (Biological Science Technician: grasshopper identifier and data management) who has been with the USDA since 1979 and with the team almost since its inception, and Lonnie Black (Biological Science Technician: equipment specialist and problem solver) who joined in 1991 and swiftly became an integral member.

The primary reason our team were established was to fill in the field-based gap between pesticide testing at the lab level and implementation at the state level. In other words, we spend over two months in the field in various rangeland locations every summer undertaking a variety of field experiments to test applications developed by ARS and others. In fact, we often play a critical role in methods development as well as in the improvement and innovation of equipment and techniques. Our results are then compiled and distributed to our state cooperators and federal partners, so they can, in turn, use this new knowledge to better control local and regional outbreaks. In addition to refining the use of known chemical technologies, we are always on the look-out for new things to try (e.g. biopesticides like fungal pathogens) in order to manage grasshoppers more efficiently, effectively, and inexpensively.

Since 1976, our team has conducted 157 intensive and encompassing field trials across a majority of the 17 western states, resulting in great advances in how chemical applications should be applied to increase efficacy. Foster would be the first to point out that these successes have only been achieved through the assistance of a plethora of cooperating federal, state, tribal, university, and private entities. A short list of these allies includes the National Grasshopper Management Board (a group that includes members of many different backgrounds interested in the management of U.S. rangeland grasshoppers), the University of Wyoming (e.g. Lockwood and the lab of our very own Society President, Alexandre Latchininsky), Utah State University (the lab of Donald W. Roberts), New Mexico State University (e.g. Ellis Huddleston and many more), South Dakota State University (e.g. David Walgenbach and many more), Stefan Jaronski's ARS lab, PPQ's many State Plant Health Directors and Field Operations personnel who have been invaluable local resources and field partners, and the many Native American tribes that have allowed us access onto their lands.

I have joined the team at an especially exciting time because we are trying many new things while also continuing the legacy of good field science that Foster began. For instance, we recently spearheaded an initiative to place a portion of our many thousands of grasshopper specimens (currently residing unpinned in frostless freezers), collected during field experiment sweeps, into insect collections, such as Arizona State University's Hasbrouck Insect Collection and Colorado State University's C.P. Gillette Museum of Arthropod Diversity. These specimens represent dozens of rangeland species (mainly Gomphocerinae, Melanoplinae, and Oedopodinae) from many U.S. states, span more than 30 years of field collection, and contain a wealth of ecological and geographical information. If your collection or research could benefit from the acquisition of some of these specimens, please write. Another thing we are exploring is the use of Unmanned Aerial Systems (UAS) to assist with remote sensing, an especially helpful tool for areas that are difficult to access. Our search also continues for reliable ways to forecast outbreaks to better prescribe pesticide application regimes and better prepare ranchers. So far, I'm enjoying the position quite a bit, I'm enthused about the opportunity to continue to contribute to a successful legacy of grasshopper management by the USDA, and I'm excited about this upcoming field season!

Visit to China to Discuss Furthering the Use of Biopesticides against Locusts and Grasshoppers

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Between 25 March and 5 April, I had the privilege of visiting Dr. Zhang of the China Agricultural University, Beijing and taking part in a training course on locust control in Tai'an in Shandong province. There were more than 100 participants in this pre-season training course where preparations were made for the coming locust season. I gave a talk on the Integrated Pest Management of Locusts with emphasis on Management programs in Australia and China. This talk included the latest techniques in ensuring locusts are found in a timely manner, so that resources can be allocated such that most locusts are treated before they can reach crops. Various aspects of treatment were outlined, including the use of biopesticides, which in China include both the fungus *Metarhizium acridum* and the microsporidian *Paranosema locustae*. In the past few years, more than 100,000 ha per year have been treated with these biopesticides in China, which account for more than 30% of locust and grasshopper treatments. Long Zhang, who has been instrumental in the introduction and use of these biopesticides, discussed aspects of the locust problem and outlined some of his latest research on the subject.

The next morning, Long Zhang and I climbed the famous Tai Shan (Mount Tai), which is the most sacred mountain in China. In the afternoon, Long and I gave seminars at Shandong University. After returning to Beijing, I gave a seminar on the use of biological pesticides against locusts and grasshoppers in various countries in the world. Overall, a most fruitful trip as China plans to use non-chemical control methods for over half of its treatments of locusts and grasshoppers by the year 2020.

Figure 1. Long Zhang (top) and David Hunter (bottom) discussing about locust control at Tai'an, China.

Edible Orthoptera from Africa: preservation and promotion of traditional knowledge

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In response to population growth, limited natural resources, and food security problems in many low-income regions of the world (particularly in the least-developed countries), insects (often considered as nuisances or pests) have emerged in recent years as a possible response to malnutrition, protein shortages, and micronutrient deficiencies. Entomophagia - the practice of eating insects - is already widely-practiced. For a long time, and in many countries of the world, insects have been traditionally eaten by humans for their food. Currently, over 2 billion people worldwide are consuming them traditionally (van Huis et al., 2013, Niassy & Ekessi, 2016). Some 2,140 edible species have been recorded (Mitsuhashi, 2016), mainly Coleoptera, Lepidoptera, Hymenoptera, Isoptera, Hemiptera, Odonata,

Table 1. The main species of Orthoptera consumed in Africa for human food.

	Algeria	Benin	Burkina Faso	Cameroon	Central african rep.	Congo	DR Congo	Côte d'Ivoire	Gabon	Guinea	Madagascar	Mali	Maroc	Niger	Senegal	Tchad	Togo	Tunisia
Acrididae																		
Acanthacris ruficornis citrina (Audinet-Serville, 1838)		■	■				■			■		■		■				
Acridoderes strenuus (Walker, 1870)														■				
Aiolopus thalassinus thalassinus (Fabricius, 1781)		■	■														■	
Anacridium melanorhodon (Walker, 1870)														■	■			
Acrida sp.			■							■							■	
Acrida bicolor (Thunberg, 1815)							■											
Acrida sulphuripennis (Gerstaecker, 1869)							■											
Anacridium burri Dirsh & Uvarov, 1953							■											
Cataloipus cymbiferus (Krauss, 1877)							■					■						
Acorypha nigrovariegata (Bolivar, 1889)																		
Coryphosima stenoptera Schaum, 1853						■			■									
Cyrtacanthacris aeruginosa (Stoll, 1813)							■			■								
Cyrtacanthacris tatarica (Linnaeus, 1758)							■											
Eurysternacris brevipes Chopard, 1947			■															
Hieroglyphus africanus Uvarov, 1922		■	■															
Homoxyrrhepes punctipennis Walker, 1870						■	■		■								■	
Kraussaria angulifera (Krauss, 1877)												■		■		■		
Locusta migratoria (Linnaeus, 1758)	■	■	■				■				■				■			
Morphacris fasciata Thunberg, 1815																	■	
Nomadacris septemfasciata (Serville, 1838)				■			■											
Oedaleus nigrofasciatus (De Geer, 1773)							■											
Oedaleus senegalensis (Krauss, 1877)														■			■	
Occidentosphena uvarovi (Rehn, 1942)						■			■									
Ornithacris cyanea (Stoll, 1813)							■											
Ornithacris pictula magnifica (Bolivar, 1882)							■											
Ornithacris turbida cavroisi (Finot, 1907)		■	■									■		■			■	
Orthacanthacris humilicrus (Karsch, 1896)														■				
Oxycatantops spissus (Walker, 1870)				■														
Parapropacris notatus (Karsch, 1891)						■			■									
Phymateus viridipes Stål, 1873							■											
Schistocerca gregaria (Forskål, 1775)	■						■					■	■		■			
Spathosternum pygmaeum Karsch, 1893		■																
Stenocrobylus festivus Karsch, 1891										■								
Tristia sp.						■			■									
Truxalis sp.		■																
Zonocerus elegans (Thunberg, 1815)							■											
Zonocerus variegatus (Linnaeus, 1758)		■	■	■			■	■		■							■	
Tettigoniidae																		
Conocephalus sp.		■																
Pseudorhynchus sp.		■																
Ruspolia sp.		■			■	■	■		■	■								
Ruspolia differens (Serville, 1838)							■											
Ruspolia nitidula (Scopoli, 1786)							■											
Tettigonia viridissima (Linnaeus, 1758)							■											
Zabalius sp.		■																
Grillidae																		
Acheta sp.							■											
Brachytrupes membranaceus (Drury, 1770)		■	■		■	■	■	■	■	■	■	■				■	■	
Brachytrupes sp.		■		■	■			■			■	■						
Gryllus sp.		■		■														
Gryllus bimaculatus De Geer, 1773							■											
Gryllotalpa africana (Palisot de Beauvois, 1805)							■											
Orthoptera spp.																		■
Total	2	15	9	5	3	7	25	3	7	7	3	7	1	7	3	2	8	x

Figure 1. Sale of dried grasshoppers on the Niamey market in Niger (a, b) and fresh grasshoppers on a Congolese market (c).

Diptera and…278 species of Orthoptera (Jongema, 2017).

Work on the use of insects in human and animal foods is increasing and a scientific journal is now devoted to the subject: the *Journal of Insects as Food and Feed* (http://www.wageningenacademic.com/loi/jiff), The University of Wageningen also maintains a site with the World's Edible Insects List (http://www.wur.nl/en/Expertise-Services/Chair-groups/Plant-Sciences/Laboratory-of-Entomology/Edible-insects/Worldwide-species-list.htm), and FAO has maintained a website on edible insects since 2010 (http://www.fao.org/edible-insects/en/).

In Africa, where malnutrition problems are probably more acute than elsewhere, insects often occupy a prominent place in human nutrition, as in the myths of various ethnic groups (Seignobos, 2016). Insects are not only consumed in times of scarcity, but often because of their taste and their established place in the local food culture (van Huis, 2003). They are a highly nutritious food source, rich in protein, iron, and vitamin A.

However, there is a significant risk that cultural and ecological knowledge about entomophagy will be lost because in a globalized world newer Western dietary patterns are gradually being adopted (van Huis et al., 2013). Therefore, it is necessary to safeguard and enhance this traditional knowledge at a time when humanity is increasingly in need of it. In Francophone Africa, this was the objective of the international project LINCAOCNET (funded by the International Organization of La Francophonie and the Belgian development agency), a multidisciplinary project launched in 2009 by the Biodiversity Management Research Center, an NGO based in Benin (http://www.crgbbj.org/). The aim was to collect the knowledge on edible insects of French-speaking West and Central Africa and disseminate it as widely as possible. A participatory website was created (http://gbif.africamuseum.be/lincaocnet/) through a collaboration with the Royal Museum for Central Africa in Belgium, and data has been gathered regularly since then. This site constitutes a source of information allowing for the gradual improvement of the scientific knowledge for a better alimentary use of insects. In this inventory, Orthoptera occupy a special place.

Methodology

The collection of field data, from the local populations who consume insects, was carried out by one of the authors (ST) with the support of a network of partners in each visited country. The countries visited were: Algeria, Benin, Burkina Faso, Cameroon, Central African Republic, Congo, Democratic Republic of Congo, Gabon, Guinea Conakry, Madagascar, Mali, Morocco, Niger, Senegal, and Togo.

Initially, through a literature search and information from local partners, a list of major areas of insect consumption was established as well as, for each country, the periods of presence and abundance of the various species. Field missions were then carried out to collect data on these edible insects. Local communities were asked to obtain information on the various insects used in their diets. Specimens were collected, photographed, and identified. For each observation, a record has been created that includes a photograph of the insect, its common name and scientific name, pronunciation in the local language (recording of the name given by local volunteers), habitat, locality, information on

the method of harvesting, culinary recipes, conservation techniques, and certain therapeutic uses. The insects' host plants have also been collected and placed in an herbarium. Finally, inventories of marketed Orthoptera, and their selling price, were made from visiting the markets, in collaboration with local sellers.

Results

Table 1 provides a country summary of the various species used for human consumption in Africa. Up to fifteen species of Orthoptera are consumed in Benin (but obviously it is the country of the first author and it was therefore better prospected), and 25 in DR Congo. But, quantitatively, Niger is probably the country where the most grasshoppers are consumed, even if the diversity of species is more important elsewhere.

The local names are, of course, multiple according to the ethnic groups. For some, a name exists for each species consumed. For others, the Orthoptera are simply designated by one or a few generic names. Thus, the Bambaras in Mali have only one name, Nton, for various species of locusts, including *Kraussaria angulifera*, *Cataloipus cymbiferus*, and others. The Hausa in Niger designate all locusts as Maï-Akoyé. The Sipyeres in Mali use the term Kanpeinthian. Conversely, the variegated grasshopper *Zonocerus variegatus* L., has a distinct name in many ethnic groups: in Cameroon, Nadoisc in the Baya-Dokai language and Babati in Fulfulbe language; in Burkina Faso, Sabinnin in the Bobo language; in Togo: Agboblomi in the Ewe language; etc.

Capture techniques are simple. Orthoptera are collected or captured with bare hands, sometimes by shaking vegetation, very early in the morning or at nightfall when temperatures are low and insects are not very mobile. Some small Tettigoniidae are sometimes picked up on the dry palms of the coconut

Figure 2. Grasshoppers fried and spiced (1), scalded and dried (2), bulk or in individual sachets (3) are frequently marketed in African markets for human consumption. Grasshopper flour (4) (here prepared at CRGB but not yet marketed) may be incorporated into feed composition for poultry, livestock, etc.

tree, *Coco nucifera*, pre-cut from the trunk. In the Democratic Republic of the Congo, in the peri-urban areas, some species of the genus *Ruspolia* are caught under neon public lighting (Malaisse, 1997). Unfortunately, some populations sometimes take advantage of insecticide treatments to collect dead insects that are then found in markets. Analyses carried out on locusts bought on the market of Niamey some twenty years ago revealed some traces of insecticide (ML). It may be hoped, without being certain, that these practices have now disappeared.

There are many recipes. Frequently, once collected, grasshoppers are scalded, dried in the sun until well-dehydrated, or fried and eaten directly, or seasoned with chili powder. Sometimes the wings are removed and the grasshoppers are skewered and grilled before immediate consumption. This is the case for the variegated grasshopper, which, despite its a priori repulsive name in french ("stinking grasshopper"), is highly appreciated by the local communities of Togo and Cameroon. In Mali, the Bambara remove the head and wings of grasshoppers and crickets, fry or grill them, and eat them directly without storing them. There, the grasshoppers are eaten almost in all the villages, especially by the children. In Senegal and Niger, various species of grasshoppers are eaten like biscuits as an aperitif.

Grasshoppers can be eaten immediately after preparation or kept for sale on the markets, sometimes in bulk and exposed to the open air, sometimes packaged in small sachets containing only a few insects. As an anecdote, one of the authors (ML) one day received a trainee from the Congo who had brought with him to France, in a plastic bag, some dozens of grasshoppers prepared by his family and which he consumed with de-

Figure 3. Some edible locust and grashopper species from Africa. From top to bottom and from left to right: (1) *Zonocerus variegatus*, (2) *Schistocerca gregaria*, (3) *Hieroglyphus africanus*, (4) *Ornithacris turbida cavroisi*, (5) *Kraussaria angulifera*, (6) *Nomadacris septemfasciata*, (7) *Cyrtacanthacris aeruginosa*, (8) *Locusta migratoria* (photos: S. Tchibozo, except M. Lecoq 2 and 8).

light during his stay. Niger seems to be the only country in French-speaking Africa where you can buy and eat scalded and dried grasshoppers all year round. In Benin, a Nigerian woman who has lived for several years in Cotonou imports grasshoppers from Niger and sells them fried and seasoned with chili pepper. The majority of her clients are obviously from Benin's Nigerian community.

Some crickets are also widely-consumed. This is the case of the cricket *Brachytrupes membranaceus* Drury, which is consumed almost all over Africa and is highly-appreciated by children. Arboreal species appear to be the most consumed, mainly for their taste qualities. The nutritional intake is obvious and a chemical analysis of scalded and dried grasshoppers revealed that it contains about 32% total crude protein. Regular consumption could help reduce child malnutrition in Africa (Tchibozo et al., 2016a). The consumption of these orthopterans obviously depends on the life cycle of the various species and their abundance in the field. Species of locusts, such as the migratory locust and the desert locust, are mostly consumed in times of invasion when swarms offer a large amount of available insects. These crop pests can then be both a source of food for the family and a source of income that is not negligible.

Finally, public awareness was also an important part of the LINCA-OCNET project. Information days (seminars) have been organized in different places, such as in Europe, in the United States, in China, and also locally in the African countries. The most popular events were those associated with insect tasting, attracting many schoolchildren, but also many curious adults.

Conclusion

The information collected, which here complements previous inventories of Tchibozo (2015) and Tchibozo et al. (2005, 2016b), are available for free online at the LINCAOCNET project website. This project ended in 2011, but activities are continuing, both for the collection of new information (which can be added to the site), for public awareness, and for mounting new projects. Sustainable use of edible insects, while taking care not to endanger their wild populations and habitats, is undoubtedly a significant part of a long-term strategy to overcome food security problems in Africa and elsewhere in the world. However, the obstacles to the development of sustainable entomophagy are still numerous, and they are particularly cultural and related to eating habits, especially in western countries (Riggi et al., 2013). Knowledge about indigenous practices, though, can help to refine current research activities and stimulate the development of appropriate technologies to guide research and policy for the development of entomophagia in Africa and around the world (Niassy et al. 2016). The Orthoptera will undoubtedly have a place of choice in this adventure.

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Book Review: Acridofagia y otros insectos / Acridophagy and other insects

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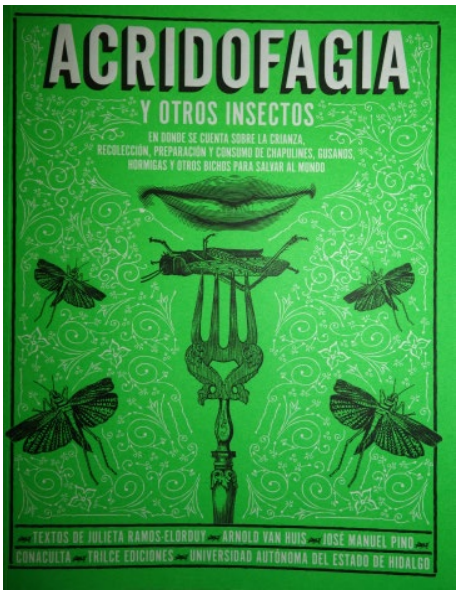
It was a pleasure to receive this book as a gift some months ago. For more than forty years, the first author, Dr. Julieta Ramos-Elorduy has been studying edible insects in Mexico and this book is a culmination and compilation of several of the studies that have been published together with the book's other two authors, Pino and Van Huis. After the introduction to the topic, the authors define entomophagy and provide examples from different parts of the world. Currently, there are 1,900 species recorded that are consumed by humans. They are mainly from Africa, China, Laos, Myanmar, Thailand, Vietnam, Brazil, and Mexico. The latter is considered to be the most entomophagous country in the world with 549 species reported so far. In the case of Orthoptera, 60 species of the genera *Sphenarium, Melanoplus, Schistocerca, Boopedon, Rhammatocerus, Abracris, Taeniopoda*, and *Xyleus* (among others) are reported to be consumed in Mexico. Across the world, Orthoptera species represent 13% of the insects consumed, surpassed by Hymenoptera (14%), Lepidoptera (18%), and Coleoptera (31%). Following this overview, the authors focus on the history of entomophagy in Mexico and provide several statistics. Among them, one Orthoptera genus (*Sphenarium* spp.) is in the top ten species of insects consumed in Mexico. Due to historical reasons (heritage of several indigenous groups living in those regions before the Spanish Conquest), the States of Hidalgo, Mexico, Chiapas, Oaxaca, and Veracruz in the Central and Southern parts of Mexico are the



Acridofagia y otros insectos / Acridophagy and other insects. Julieta Ramos-Elordy, Arnold Van Huis & José Manuel Pino. Conaculta, Trilce ediciones & Universidad Autónoma del Estado de Hidalgo. 2015. 319 pp. Paperback. ISBN 978-607-7663-98-0. In Spanish. $25 USD.

areas where the most insects are consumed. In another chapter, the topic of entomophobia is covered with a special emphasis on the role that movies have played. Later in the book, a chapter about the insects in the arts covers the history since the first honey extraction was recorded at Spider Caves, Spain (17,000 years ago) through the present day, with special emphasis on the last two centuries. In the chapter "Acridophagy", a detailed explanation of grasshopper harvesting is provided, together with instructions on how to breed them, cook them, store them, etc. Interestingly, a section on pairing insects with wine is also provided. For example, apart from the very well-known pairing of mezcal with *Sphenarium* spp., other pairings are suggested, such as crickets with Albariño, locusts with Moscatel, and grasshoppers with Champagne Brut. Finally, a section on recipes using different insects closes out the book. Regarding Orthoptera, several recipes are provided, like grasshopper quesadilla without tortilla, risotto with escamoles (edible larva and pupae of the ant *Atta mexicana*) with *Sphenarium* spp., garlic grasshoppers, grasshopper flour, scrambled eggs with grasshoppers, grasshopper orange cake, Cantonese-style fried locusts, etc. Despite the fact that the book is written in Spanish, it is profusely illustrated and full of images and graphics that can be enjoyed and understood without the knowledge of Spanish. To purchase the book you can visit: https://www.educal.com.mx/0500-ciencias-puras/096214-acridofagia-y-otros-insectos.html

I want to thank Isabel C. Velásquez de la Cruz for giving me this book as a present.

Miniature Melanoplinae

By DEREK A. WOLLER
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This miniature adult acridid is *Melanoplus forcipatus* Hubbell, 1932, a Florida-based member of the southeastern U.S.'s Puer Group. As you can see, it's not much bigger than a European honeybee, *Apis mellifera* L., 1758, and, in fact, I did not even notice it when I first started shooting photos of these scrub flowers at the Archbold Biological Station. *M. forcipatus* is one of the many brachypterous species found in scrub habitats that are associated with ridge systems, which were once ancient islands in Florida. (Photo credit: Derek A. Woller using a Pentax WG-3 GPS.)

Editorial

By HOJUN SONG
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There are more than 27,700 species of Orthoptera that are currently described. This figure is probably an underestimate of the true diversity, considering the fact that there are still many places that have not been explored thoroughly. Understanding biodiversity is the cornerstone of understanding biology, but, presently, we are suffering from major taxonomic impediments in Orthoptera. I would like to highlight two groups in particular, which are in a direr situation than other groups. The first group is the superfamily Eumastacoidea. Commonly known as monkey grasshoppers, this superfamily includes 7 families and more than 1,000 described species mainly distributed in the tropics. They are never abundant like acridids, but they can be locally numerous. In the Neotropics, many species are brightly colored, and collecting them is like picking up little pieces of jewelry. They also have incredibly complicated male genitalia, often quite enlarged. Some species of Chorotypidae in Asia are even remarkable mimics of dead leaves. The second group is what I call the basal ensiferans, including Rhaphidophoridae, Gryllacrididae, Anostostomatidae, and Stenopelmatidae. These families collectively include more than 1,600 species and show amazing diversity in life history traits and mating biology. I recently learned that cave crickets are critical components of small karst fauna without bats because they roost in the cave during the day and their guano basically sustains the obligate cave dwelling arthropods. Isn't that amazing? The Eumastacoidea and the basal ensiferans are biologically and evolutionarily fascinating groups and it really escapes me why there are no students working on these groups. Perhaps, because there is no specific lab focusing on the systematics of these orthopterans, it may be difficult for budding orthopterists to figure out where to start even if they might be interested in these insects. Sure, grasshoppers, katydids, and crickets are really interesting and I recognize why many research programs focus on these groups. But, if we are serious about understanding the biodiversity of Orthoptera, we will need to pay more attention to less familiar, yet, interesting groups. I don't know anything about gryllacridids or chorotypids, but what I do know is that they are incredibly awesome and if there are students willing to invest time and effort to learn these groups, I'd be very interested in working with them as well.

I would like to thank all those who have contributed to this issue as well as our Associate Editor, Derek A. Woller, for his continued assistance in the editorial process.

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 September of 2017, so please send me content promptly. I look forward to hearing from you soon!

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