Biological Consequences of Global Change

The 10th International Symposium of Integrative Zoology

27–31 Oct 2018, Beijing, China

Full Program • Abstracts • Maps • List of Participants

Society Information • Author Guidelines for *Integrative Zoology*

BCGC Research Program Information • BCGC Summary Report (2008-2018)

Preface

This year is the 10th anniversary of the International Symposium of Integrative Zoology (ISIZ) and the 10th anniversary of the scientific program of Biological Consequence of Global Change (BCGC), which are hosted by the International Society of Zoological Sciences (ISZS). ISZS was created in 2004, to run the four-year International Congress of Zoology (ICZ), which started in 1889 in France. ISIZ is held annually between the four-year ICZ with a aim to promote international exchange of research development of integrative zoology, cooperation among global zoologists, as well as training to students. The theme of this symposium is “Biological Consequences of Global Change”.

It is clear that the creation of the ISZS has made a great contribution to the development of global zoology. During the past 14 years, ISZS has grown rapidly. It currently has 118 Institutional Members (that in turn represent over 30,000 individuals) and 1119 Individual Members. The ISZS has also successfully organized four ICZs, ten ISIZs, an international program of “Biological Consequences of Global Change” (BCGC) and has launched an official journal: *Integrative Zoology* which has become a top 20% SCI-indexed journal in the field of zoology. Through those activities, the ISZS has become an important global platform for the promotion of and the development of integrative zoology, international collaboration, and training of young scientists.

Our society is facing great challenge from the rapid development of global change, including industrialization, urbanization, climate warming etc. Global change has significantly shaped our ecosystem, and causing serious problems, such as species extinction, biological invasion, disease transmission, pest outbreaks, collapse of ecosystem function and services. There is an urgent need to use integrative approaches to solve these challenges. I appeal for more collaborations among global zoologists to deal with challenges imposed by the rapid global change.

The 10th ISIZ is held together with the 2018 World Life Science Conference (2018 WLSC) which is hosted by the China Association of Science and Technology (CAST), for details, visit the website: http://wlsc2018.csi.org.cn. There are two sessions on BCGC organized by ISZS which will be held in the afternoon of Oct. 27 at the China National Convention Center (CNCC) and the whole day of Oct. 30 at the campus of Institute of Zoology, Chinese Academy of Sciences. Besides, we also edited a virtual issue of *Integrative Zoology* entitled “Continuing challenges in the study of the biological consequences of global change”. This virtual issue of *Integrative Zoology* commemorates the 10th year of the BCGC program.

On behalf of ISZS, I thank all speakers and participants for your attendance and input to the 10th ISIZ. Please enjoy your attendance to this symposium and your trip in China.

Dr Zhibin Zhang
Professor, Institute of Zoology, CAS
Chair, the 10th International Symposium of Integrative Zoology
President, International Society of Zoological Sciences
Editor-in Chief, *Integrative Zoology*

Contents

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The International Society of Zoological Sciences (ISZS)
Institute of Zoology (IOZ), Chinese Academy of Sciences (CAS)

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Organizing Committee

Chair

ZHANG, Zhibin, Professor, IOZ, CAS; President, ISZS; Editor-in-Chief, *Integrative Zoology*

Members (in alphabetic order by surname):

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COOPER, Edwin, Professor, Laboratory of Comparative Neuroimmunology, UCLA Los Angeles, USA; AC Member, ISZS
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MAREE, Sarita, Postdoctoral Research Fellow, Department of Genetics, University of Pretoria, South Africa; Vice President, ISZS
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STENSETH, Nils Chr., Professor, Ecological and Evolutionary Synthesis, University of Oslo, Norway; EC Member, ISZS; Immediate President, IUBS
WAKE, Marvalee, Professor, Department of Integrative Biology, University of California, Berkeley, USA; AC Member, ISZS
XIE, Yan, Associate Professor, IOZ, CAS, China; AC Member, ISZS

Secretariat

HAN, Chunxu, Secretary General, ISZS
XIONG, Wenhua, Office Director, ISZS; Executive Editor, *Integrative Zoology* (INZ)
ZHANG, Wei, Membership Manager, ISZS; Editor, INZ
WICKHAM Jacob, Managing Editor, INZ

Program Overview

Fri 26 Oct 2018	
0800–2000	**Registration** **Venue:** Lobby, Gate 3, China National Convention Center (CNCC) **Open Time:** 09:00-22:00, 26 Oct 2018 08:30-12:00; 13:30-17:00 27-29 Oct 2018 **Address:** 7 Tianchen Donglu, Chaoyang District, Beijing 中国国际会议中心大厅 （地址：朝阳区天辰东路 7 号）
Sat 27 Oct 2018	
0900–1700	**2018 World Life Science Conference** **Venue:** China National Convention Center (CNCC)
1330–1700	**Biological Consequences of Global Change Symposium I & The 10th International Symposium of Integrative Zoology, Part A** **Venue:** Room 405, CNCC
Sun 28 Oct 2018	
0900–1700	**2018 World Life Science Conference** (for detailed program, visit http://wlsc2018.csi.org.cn) **Venue:** China National Convention Center
1900–2100	**ISZS Executive & INZ Board Joint Meeting** **Venue: IOZ, CAS**
Mon 29 Oct 2018	
0900–1700	**2018 World Life Science Conference** (for detailed program, visit http://wlsc2018.csi.org.cn) **Venue:** China National Convention Center
Tues 30 Oct 2018	
0900–1800	**The 10th International Symposium of Integrative Zoology, Part B** **Venue:** C101, Institute of Zoology, Chinese Academy of Sciences

Program Schedule

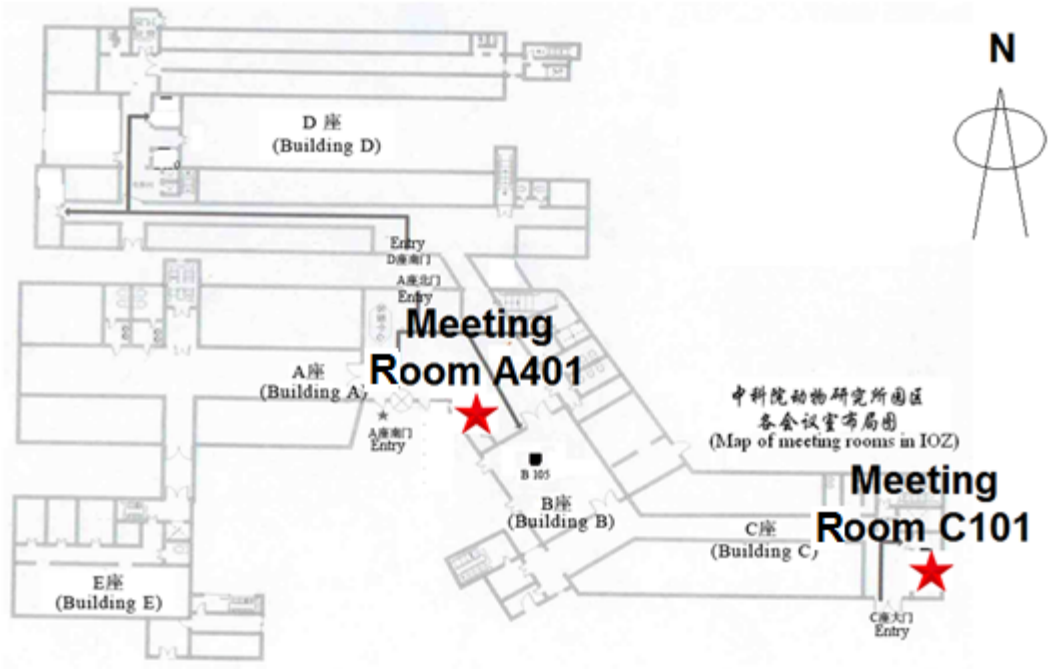
Fri 26 Oct 2018	
0800–2000	**Registration** **Venue:** Lobby at Gate 3, China National Convention Center (CNCC) **Open Time:** **09:00-22:00, 26 Oct 2018** **08:30-12:00; 13:30-17:00 27-29 Oct 2018** Address: 7 Tianchen Donglu, Chaoyang District, Beijing 中国国际会议中心大厅 （地址：朝阳区天辰东路 7 号）
Sat 27 Oct 2018	
0900–1700	**2018 World Life Science Conference** **Venue:** China National Convention Center (CNCC)
1330–1700	**Biological Consequences of Global Change (BCGC) Symposium I & The 10th International Symposium of Integrative Zoology, Part A** **Venue:** Room 405, CNCC **Co-Chairs: Zhibin Zhang & Nils Chr. Stenseth**
1330–1400	**Nils Chr. Stenseth,** *Ecological and Evolutionary dynamics in marine systems under anthropogenic influence*
1400–1430	**Rodolfo Dirzo,** *Human impact on wildlife: A critical global change of the Anthropocene*
1430–1500	**Alan Hastings,** *Dynamics of species in response to movement of suitable habitat*
1500–1530	**Break**
1530–1600	**Weiguo Du,** *Ecological responses of desert lizards to environmental change*
1600–1630	**Qiyong Liu,** *Global vector control response to vector borne diseases in the new era*
1630–1700	**Zhibin Zhang,** *Impacts of global climate change on animals and diseases*
Sun 28 Oct 2018	
0900–1700	**2018 World Life Science Conference** **Venue:** China National Convention Center

1800–2100	**ISZS Executive & INZ Board Joint Meeting** **Venue: IOZ, CAS** **Chair: Zhibin Zhang**
Mon 29 Oct 2018	
0900–1700	**2018 World Life Science Conference** **Venue:** China National Convention Center
Tues 30 Oct 2018	
0900–1700	**The 10th International Symposium of Integrative Zoology, Part B & BCGC Symposium II** **Venue:** Meeting Room C101, Institute of Zoology(IOZ), Chinese Academy of Sciences (CAS) Address: 5-1 Beichen West Road, Chaoyang District, Beijing 地址：朝阳区北辰西路 1 号院 5 号 C101 会议室
0900-1000	**Opening** **Venue:** Meeting Room C101, IOZ, CAS **Chair: Zhibin Zhang**
0900–0930 0930–0945 0945–1000	**Invited remarks & ISZS outstanding contribution award presentation** **Chunxu Han,** *ISZS progress report* **Wenhua Xiong,** Integrative Zoology *2017 report*
1000–1030	**Group photo & Break**
1030–1235	**BCGC Symposium II-1** **Venue:** Meeting Room C101, IOZ, CAS **Chair:** Nils Chr. Stenseth
1030–1055 1055–1120 1020–1145	**Charles J. Krebs,** *Impact of Climate Change on the Small Mammal Community of the Yukon Boreal Forest* **Xinhai Li,** *Impact of climate change on a number of species (snow leopard, Mongolian gazelle, white-naped crane) cross country borders* **Marcel Holyoak,** *Moving from static to dynamic patterns in studying the effects of climate change on ecological communities*

1145–1210	**Luca Bütikofer,** *C-Traps, a form of anthropogenic dispersal barrier threatening climate migrants*
1210–1235	**Lydia Beaudrot,** *Impacts of global change on terrestrial mammals in tropical forest protected areas*
1235–1400	**Lunch**
1400–1800	**BCGC Symposium II-2** **Venue:** Meeting Room A401, IOZ, CAS **Chair: Marcel Holyoak**
1400–1425	**Abraham Haim,** *The loss of ecosystem-services emerging from artificial light at night – Sustainable illumination should be the next stage*
1425–1450	**Sarita Maree,** *Planning for persistence in the face of anthropogenic threats and environmental change: Insights from phylogenetics and phylogeography for conservation of Africa's endemic golden moles* (Chrysochloridae)
1450–1515	**Luca Bütikofer,** *A new method for modelling biological invasions from early spread data accounting for anthropogenic dispersal*
1515–1540	**Alice J Kenney,** *Can camera traps be used to estimate density of unmarked wildlife populations?*
1540–1605	**Guangshun Jiang,** *Land sharing and land sparing reveal social and ecological synergy in big cat conservation*
1605–1630	**Eric I. Ameca,** *Extreme climatic events and the prioritization of conservation planning under uncertainty*
1630–1700	**Break**
1700–1800	**BCGC Program Discussion** **Chair: Zhibin Zhang**
1700–1715	**Chunxu Han,** *BCGC progress report*
1715–1740	Open Discussion
1740–1800	Panel Discussion
Wed 31 Oct 2018	
0900–1700	**Departure**

Map of Surrounding Area

Map of Meeting Rooms, IOZ, CAS



Participant Instructions

Registration
The registration for 2018 WLSC will be started on Oct 26th 2018 at the Lobby at Gate 3, China National Convention Center (CNCC). The open time is 09:00-22:00, 26 Oct 2018 and 08:30-12:00, then 13:30-17:00 from 27 to 29 Oct 2018 during the day. The address is 7 Tianchen Donglu, Chaoyang District, Beijing. If you take a taxi, please show the taxi driver the Chinese characters as: 国家会议中心，朝阳区天辰东路 7 号.

The registration for the 10th International Symposium of Integrative Zoology will be outside Meeting Room C101 at the Institute of Zoology (IOZ), Chinese Academy of Sciences (CAS) on Oct 30th 2018. The address is 1-5 Beichen West Road, Chaoyang District, Beijing. If you take a taxi, please show the taxi driver the Chinese characters as: 中国科学院动物研究所，北辰西路一号院 5 号动物研究所 C 座 101 会议室.

Participant's Badge: The participant's badge may be collected from the Registration Desks. This badge is available only to the invited representatives of ISZS institutional members, EC Members and Officers and those who have paid the registration fee.

Registration Fee: The registration fee is US$300 for ordinary attendees and US$150 for ISZS members, students or accompanying guests. Extra fees will be charged for those who wish to exhibit products or devices during the Symposium. The registration fee does not cover local accommodation or insurance (but does cover the lunch and dinner during the meeting). Registration fees for ISZS EC/AC members, INZ board members, and invited plenary speakers will be waived.

Ordinary Attendee	ISZS Members, Students or Accompanying Guests
US$300	US$150

Payment: You can pay your registration at the Registration Desk or through bank transfer. The information on bank transfer appears as below:

Bank name: BANK OF CHINA BEIJING MIDDLE NORTH FOURTH ROAD SUB-BRANCH
Bank address: 1-2/F, Tower Pangu Building, Middle North Fourth Ring Road, Chaoyang District, Beijing, China
Name of the bank account: International Society of Zoological Sciences
Bank account number: 324656829425
Swift code: BKCH CN BJ 110
Bank telephone number: +86-10-59393301

Note: Your registration becomes valid only after your payment. Please notify the Secretariat after your fund transfer at: iszs@ioz.ac.cn or fax +86-10-6480-7295.

Refund Policy: The Secretariat incurs costs immediately upon the registration of a participant. If no other costs are incurred, there will be a processing fee (20% of the registration fee you paid) for a refund. There will be no refunds after 20 Oct 2018. Questions regarding refunds may be sent to the Secretariat at: iszs@ioz.ac.cn or fax +86-10-6480-7295.

Insurance
All insurance during the meetings and while traveling in China must be self-arranged.

Financial support
ISZS will cover the local costs (including registration fee, hotel and meal) of ISZS EC/AC members, invited speakers and guests, as individually arranged with the Secretariat in advance.

Working Language
The working language of the Symposium is English.

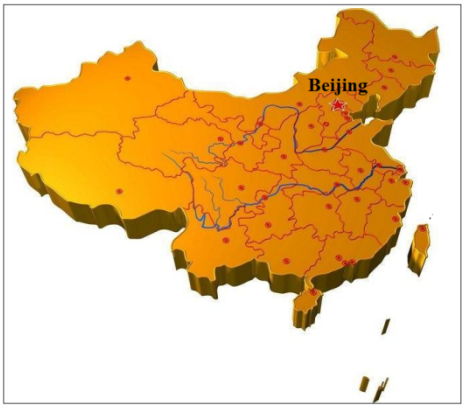
ISZS Membership
Attendees of the Symposium will become the ISZS members and enjoy related (unpaid) membership benefits. For details on ISZS membership benefits, please visit the website at: http://www.globalzoology.org/Membership/MembershipBenefits.aspx.

Note that if an ISZS Member would like to enjoy voting rights at the ISZS General Assembly (GA), an Individual Member is required to pay 40 Euros per 4-year term and an Institutional Member pays 500 Euros per 4-year term. If voting rights are waived, the membership is free.

Accommodation Information
The recommended hotel is listed below:
Best Western OL Stadium Hotel (4-star),
Address: No. 1 Datun Road, Beishatan, Chaoyang, Beijing, 100101;
Tel: +86-10-64874433; Fax: +86-10-64873565.
If you take a taxi, please show the taxi driver the Chinese characters as:
北京亚奥国际酒店 (地址：北京朝阳区大屯路 1 号)

Information on Beijing

Beijing (北京, the first character "bei" means north and "jing" means capital), a world famous city and young metropolis, is the capital city of the People's Republic of China. It is also the center of politics, science, education, culture and art in the country. As one of the largest ancient cities in the world, Beijing is home to a large number of natural and manmade wonders, and unique cultural heritage. Beijing is also a combination of tradition and modern prosperity. The imperial gardens, ancient temples and tombs of the royal family provide a cultural backdrop to modern Beijing.



Geography: Beijing Municipality lies in the northwest of the North China (Huabei) Plain, around 150 kilometers northwest from Tianjin's port and the Bohai Sea. Measuring over 16,800 km^2, the city has a total population of approximately 17.5 million and it is China's second largest city after Shanghai. To the north of the city are the Jundu mountains, to the west the Western hills and to the south and east is the alluvial plain, formed by the Yongding and Chaobai rivers. 39% of the municipality is flat; the city, surrounding plain and the other 61%, to the west and north, where the Great Wall winds along the ridges, is mountainous.

Climate and Temperature: As Beijing is located in a warm temperate zone, it has a semi-humid monsoon continental climate. Beijing has 4 distinct seasons, dry in spring, hot and rainy in summer, cool in autumn and chilly and dry in winter. The wind has significant seasonal variation, with a prevailing northwest wind in winter and a prevailing southeast wind in summer. Beijing has a relatively short spring and autumn. The annually average temperature of Beijing is about 11.7 °C. The coldest weather falls in Jan with the

temperature ranging from –22.8 to 10.7 °C and the hottest weather falls in Jul with the temperature ranging from 16.1 to 39.6 °C. The annual average precipitation is about 644 mm and most of the rainfall falls in summer.

Month	Sep	Oct	Nov	Dec
Average high °C (°F)	25.8 (78.4)	19.1 (66.4)	10.1 (50.2)	3.7 (38.7)
Average low °C (°F)	14.8 (58.6)	7.9 (46.2)	0.0 (32)	−5.8 (21.6)
Average relative humidity (%)	68	61	57	49

Source: China Meteorological Administration

Transportation System: Beijing has a high-speed transport system. It has a transport hub consisting of two airports, Beijing Capital International and Nanyuan, several train stations, many buses, subway lines, and taxis. These all offer good services to the public and extend in all directions, providing people with convenient ways to get around Beijing.

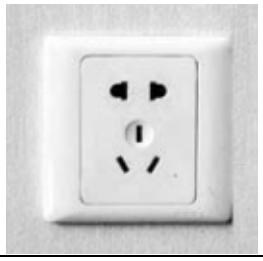
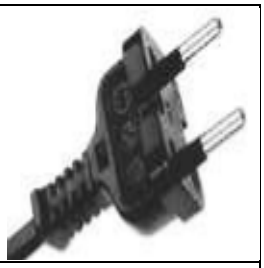
Currency, Credit Cards and ATM: The Chinese currency is the Chinese yuan, known as CNY or RMB. One CNY consists of 10 jiao (dimes) or 100 fen (cents; these are seldom seen nowadays). Denominations available in bank notes are 1, 5, 10, 20, 50 and 100 CNY. Participants can exchange currencies at airports, banks and major hotels in China. The exchange rate is provided daily by the Banks in China. Currently, 1 USD is equivalent to approximately 6.93 CNY. All currency exchange receipts should be saved in order to change RMB back to your own currency as banks may request to see the original exchange receipt. You must have your passport with you when exchanging money.

Visa, MasterCard, American Express, Diners Club, and JCB are accepted in larger department stores and hotels. ATMs are available to obtain RMB with your credit or debit card. The amount deducted from your account will vary due to fluctuations in the exchange rate.

Internet Access: Internet service should be available in your hotel, the airport and some areas around the city.

Water: It is not recommended to drink tap water in China. If you want to drink cold water, it is best to purchase bottled water. It is also recommended that you avoid ice cubes. Hotels usually provide an electric kettle to boil water in your room. Consider using a reusable water bottle.

Voltage, Socket and Plugs: The electrical current in China is 220-volts, 50Hz A/C. Hotels usually provide wall sockets in every room, accommodating both the standard “Flat blade attachment plug (Type A)” and common “Oblique flat blades with ground (inverted V) plug (Type I)”, as well as the not-so-common “Round pin attachment plug (Type C)” as shown in following photographs.

			
Wall socket	Type A	Type I	Type C

Hotline Phone Numbers:
110 Police
114 Local Telephone Number Inquiry
116 Domestic Long Distance Inquiry
117 Time Inquiry
119 Fire
120 Ambulance
121 Weather Forecast
122 Traffic Police

Contacts

ISZS Beijing Office

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Tel: +86-010-6480-7295; Fax: +86-010-6480-7295; iszs@ioz.ac.cn; website: www.globalzoology.org
For symposia: Wenhua Xiong (English and Chinese; iszs@ioz.ac.cn)
For donation and advertisement: Chunxu Han (English and Chinese; iszs2@ioz.ac.cn)

Official Conference Website

For detailed information about **2018 World Life Science Conference, please visit the website at:** http://wlsc2018.csi.org.cn.

For the 10th International Symposium of Integrative Zoology, please visit the website at: http://www.globalzoology.org/dct/page/70057

Abstracts

Biological Consequences of Global Change (BCGC) Symposium I

Ecological and Evolutionary dynamics in marine systems under anthropogenic influence

Nils Chr. Stenseth

Ecology and Evolution at Department of Biosciences, University of Oslo, Norway
Email: n.c.stenseth@ibv.uio.no

Abstract

This talk starts with some general reflections on our dependency on natural resources and that they need to be managed and used in a sustainable manner (so that future generations can use them the same way we use them, if they should want to do so). Much of the talk will use cod as the key example (with reference to the North Sea, the Skagerrak, the Barents/Lofoten coastal and migratory system, and the Baltic Sea), discussing the effect of both harvesting and climate change – both ecological and evolutionary effects. Much of the work reported have long-term time series; towards the end of the talk there will be a plea for saving the long-term monitoring time series.

Human impact on wildlife: A critical global change of the Anthropocen

Rodolfo Dirzo

Department of Biology, Stanford University, Stanford, California 94305, USA
Email: rdirzo@stanford.edu

Abstract

Scientists have rigorously documented that human impact on wildlife is of great magnitude and omnipresent, and is leading to a dramatic decline and loss of animal populations. In addition, such impact shows a prevalent “community downsizing effect”, whereby medium/large animals are rapidly declining, while smaller species are thriving. In this presentation, I will review the research examining i) the patterns of human impact on wildlife; and ii) the ecological consequences of animal community downsizing and the cascading consequences on plant communities, ecological processes and critical services for human wellbeing. I will argue that a collective appreciation of the impacts of the human enterprise on wildlife is needed if we hope to prevent it from eroding biodiversity and its services and from catalyzing Earth’s next mass extinction.

Dynamics of species in response to movement of suitable habitat

Alan Hastings

Department of Environmental Science and Policy, University of California, Davis
Davis, CA 95616, USA
Email: amhastings@ucdavis.edu

Abstract

I will present results based on two modeling approaches for describing the response of species in response to movement of suitable habitat. In one approach integro-difference equations are used. In the other approach the habitat is divided into three discrete habitats: behind the suitable habitat, the suitable habitat, in front of the suitable habitat where in front and behind refer to the direction the suitable habitat is moving. Effects like age structure and habitat modification by ecosystem engineers are included. In both cases, conditions are found that show when persistence is possible.

Ecological responses of desert lizards to environmental change

Weiguo Du

Key Laboratory of Animal Ecology and Conservation Biology, Institute of Zoology, Chinese Academy of Sciences, China
Email: duweiguo@ioz.ac.cn

Abstract

The global decline of reptiles is already evident due to environmental change. The Lizard in arid regions is one of the reptilian lineages that need additional attention and conservation actions. We carried out experiments both in the field and laboratory to demonstrate ecological responses of lizards to climate change and habitat alteration in the desert steppe of Inner Mongolia, China. Here are our results: (1) Despite seasonal variation in ambient temperatures, females selected warm and moist nests that improve the growth and survival of offspring; early eggs produced high-quality offspring, but late eggs only produced high-quality offspring at falling incubation temperatures, a case of temporal adaptation. (2) Low precipitation aggravated the impact of extreme high temperatures on lizard reproduction, and the vulnerability of lizards to climate warming differed between sympatric species. (3) Desertification significantly decreased the abundance and diversity of lizards and simplified invertebrate-lizard food webs; and the change in the lizard community is attributable to physical and predation differences among habitats. Therefore, climate warming and desertification will threaten the survival of desert lizards, although these species have developed some strategies in response to environmental changes.

Global vector control response to vector borne diseases in the new era

Qiyong Liu

State Key Laboratory of Infectious Disease Prevention and Control, WHO Collaborating Center for Vector Surveillance and Management, National Institute for Communicable Disease Control and Prevention,Chinese Center for Disease Control and Prevention, Beijing, China
Email: liuqiyong@icdc.cn

Abstract
Unexpectedly, vector borne diseases are emerging or reemerging in the world. They are exacerbated by various factors, including rapid urbanization, large numbers of travelling, changes in climate, ecology, and policies. So, it really need a sustainable strategy to response the global public health challenge. The talk presents the Global vector control response 2017-2030. The author will try to introduce the Chinese strategy change from Integrated Vector Management (IVM) to Sustainable Vector Management (SVM). The current experiences and lessons from China in managing emerging and re-emerging vector borne diseases may have merits in helping other countries to control and prevent vector borne diseases.

Impacts of global climate change on animals and diseases

Zhibin Zhang

Institute of Zoology, Chinese Academy of Sciences, Beijing, China
Email: zhangzb@ioz.ac.cn

Abstract

The earth is facing rapid climate warming during past century, but its impacts on spatial-temporal dynamics of animals are not well understood. Understanding the macro-process of global climate change is essential in preventing species extinction, outbreaks of pest or diseases, biological invasion and in preserving biodiversity and ecosystem services. Traditional climatic hypothesis emphasizes on the effects of local climate, but recent advances in population biology have greatly expanded the traditional theory from small scale to large scale and from linear or monotonic regime to non-monotonic regime. Accumulating evidences demonstrate that population dynamics of many species have been closely associated with indices of global climate change, such as global temperature, ENSO (El Nina and Southern Oscillation) and NAO (Northern Atlantic Oscillation) and so on. Furthermore, the effects of these global climate factors are often non-monotonic, depending on the spatial-temporal scale, environment gradients and complex pathway or interactions. There is an urgent need to integrate studies of different scales in revealing the response of organism to global climate change.

BCGC Symposium II

Impact of climate change on the small mammal community of the Yukon boreal forest

***Charles J. Krebs*[1] *and Rudy Boonstra*[2]**

[1]Department of Zoology, University of British Columbia, Vancouver, B.C., Canada and [2]Department of Biological Sciences, University of Toronto Scarborough, Toronto, Ontario, Canada

Email: krebs@zoology.ubc.ca

Abstract

We have censused the small mammal community of the Yukon boreal forest by live trapping unmanipulated grids for 46 years since 1973. The study area is an almost completely undisturbed forested valley of more than 350 km^2. Although there are 10 vole and mice species in this community, two dominant species comprise about 80% of the captures. At present red -backed voles *Myodes rutilus* comprise about 68% of the captures, and the deer mouse *Peromyscus maniculatus* about 11%. The 4 *Microtus* species comprise most of the other 21% of the captures. We will discuss how this community has changed over time and the possible causes. The red-backed vole *Myodes* has fluctuated cyclically at 3-4 year intervals throughout this time period. The deer mouse *Peromyscus* has fluctuated irregularly, disappeared for 5 years, and then reappeared. The *Microtus* voles show the most confusing pattern with good 3-4 year population cycles but with the dominant species of *Microtus* changing from cycle to cycle. These changes occur within a forest community that is being affected by a warming climate. Growth of trees and shrubs as well as herbs in this forest community has slowly increased over the 46 years of our study, and this has slowly raised the carrying capacity of the forest for small mammals. We suspect that patch dynamics and metapopulation changes are important for the *Microtus* species and we need to consider a larger landscape view to understand these fluctuations. Predation seems to be a small component explaining these population changes and the species diversity, partly because the density of voles and mice is too low (typically less than 10 per ha) to support predators like weasels. We think than an interaction of social dynamics (territoriality, infanticide), food supplies, and predation are the main drivers of population change. We could detect no effect of severe winters on population fluctuations in *Myodes*. Climate change impacts do not appear to be direct but are working through increased vegetative growth in this northern Yukon forest community.

Impact of climate change on a number of species (snow leopard, Mongolian gazelle, white-naped crane) cross country borders.

Xinhai Li

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Abstract

Species that occur in multiple countries face extra challenge in the changing world, since conservation actions are harder to coordinate cross political boundaries. Snow leopard and Mongolian gazelle are two typical species having wide ranges in a number of countries. A comprehensive analysis of the habitat preference of the two species at the global scale is still absent. Such study is important and it can be used to evaluate the status of this species, to predict its future range shift driven by climate change, and to guide conservation planning. I used the range maps of snow leopard from Snow Leopard Conservancy and Snow Leopard Trust, and range map for Mongolian gazelle from WCS as source information, applied eight species distribution models (SDMs) to quantify the relationship between leopard distribution and 22 environmental variables. I also imported future climate data from WorldClim data layers to predict the future range of the species. Among eight SDMs, random forest and Maxent had the best performance, as their estimated ranges match the observed ranges well. In 2080, the snow leopard was predicted to move to higher areas, since the climate warming on the Qinghai-Tibet Plateau would be severe. The predicted distribution of snow leopard is very close to that of blue sheep, yet far apart from other carnivore species such as grey wolf and Tibetan fox. I believe climate change is a major threat to snow leopard, further long term on-spot monitoring are needed to check the status of the species and the surrounding environment. As to Mongolian gazelle, drier climate would push the species to contract to the east.

Moving from static to dynamic patterns in studying the effects of climate change on ecological communities

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Abstract

For predicting the effects of climate change on plant communities, studies concluded that space-for-time substitutions produced similar predicted directions of change compared to experimental warming and long-term monitoring. Specifically, species that have warmer thermal niches increased due to warmer summer temperatures. Space-for-time substitutions essentially assume a static pattern is predictive, which reaches its limits in plant communities since experimental manipulations and monitoring produced different magnitudes of change. We asked what we can learn about the spatial structure of bird communities (i.e. metacommunities) using either static analyses or analyses of variables that are more inclusive of population and community dynamics over time. Our work gains a relevance to climate change by considering bird assemblages in different seasons and which are either resident or seasonal migrants. We analyzed landbird assemblages from islands in Thousand Island Lake (Zhejiang, southeast China) using either dynamic species colonization, extinction and turnover from year-to-year in relation to island area (and isolation) or more static occurrence patterns in relation to more detailed habitat attributes and bird functional traits. Overall, winter and summer resident birds showed strong associations between composition and habitat structure, and lower extinctions and turnover than winter and summer visitors on large islands. Winter visitor assemblages had high extinction rates and small body sizes. Whereas, local extinction of summer visitors was correlated with local species richness, indicating a likely effect of competition on extinction. These differences in seasonal and migratory vs. resident bird assemblages indicate the vulnerability of migratory visitor assemblages to local extinction. Decreased seasonality under climate change we might expect that such species become a smaller part of year-round landbird communities. Beyond the detailed system-specific findings we found that both the static and dynamic analyses produced complementary information about the spatial dynamics of seasonal bird assemblages.

C-Traps, a form of anthropogenic dispersal barrier threatening climate migrants

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Abstract

Climate change induced range shifts studies have raised widespread interest in the scientific community and concern among conservationists. However, even though studies on range shifts are very abundant, the role played by dispersal barriers is yet to be fully included into any modelling framework. In this presentation I will introduce a novel concept where the interplay of range shifts and dispersal barriers of a particular spatial configuration can threaten the persistence of populations under climate change – my co-authors and I named this concept “C-trap”.

After elaborating on the theoretical features of C-traps, I will present a simple method that combines environmental data and future climate projections to locate them spatially. As an application, we used such method to determine where high C-trap densities can further threaten the conservation of endangered, endemic animals across the world’s terrestrial realm, in a climate change scenario. Our methodology detected potential C-traps for the study system with areas of high density mostly located in east Europe, south Asia and North America.

Dispersal barriers add an additional dimension to range shift studies and can ultimately prevent otherwise successful climate migrants from tracking their shifting climatic niche. Our methodology is simple and flexible enough to be adapted to a wide range of taxa and geographical locations, and to be implemented further to account for the fast development of range shift modelling. We, therefore, encourage researchers to include the effects of anthropogenic dispersal barriers in range shifts modelling and in the planning of effective conservation strategies with reference to climate change.

Impacts of global change on terrestrial mammals in tropical forest protected areas

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Abstract

Using data from the world's largest network of camera traps in tropical forest protected areas, I will present my recent research with the Tropical Ecology Assessment and Monitoring (TEAM) Network. I will begin by describing the standardized data collection protocol established by TEAM that has been used throughout the Neotropics, Afrotropics, Madagascar and Southeast Asia, and I will illustrate its ability to detect declines in tropical wildlife populations. I will then share results from the first pantropical analysis of over 500 wildlife populations, including the relationships between hunting, deforestation and occupancy trends, and how these varied across taxa. Lastly, I will show how we have most recently used TEAM data to assess underlying drivers of species distributions, such as temperature and biotic interactions, and how we have identified rapid elevational shifts in multiple mammal species.

The loss of ecosystem-services emerging from artificial light at night – Sustainable illumination should be the next stage

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Abstract

Natural ecosystems offer us goods and services, by removing the goods from the ecosystem will have a negative impact on the offered ecosystem- services. However, what about services that control temporal organization? Light/Dark cycles are the basis for our as other well as other terrestrial organisms, temporal organization. In regards to light/dark cycles the light period is characterized by high intensity with dominance of short wavelength (SWL) that of blue light. However, the late afternoon dark period are characterized by decreasing light intensities with a dominance of long wavelength in the rage of orange 560nm. Therefore, introducing SWL lighting emerging from LED illumination and from media digital screens is a loss of ecosystem services, as we have no dark nights with no SWL, which are important for the entrainment of our biological clock which is based on light/dark cycles. Moreover, the loss of the dark night is also the loss of melatonin production by the pineal gland, melatonin is involved in many of our life functions including antioxidant activities and an anti-oncogenic agent in regards to breast and prostate cancers as well as the function of the immune system. Therefore when we carry out coast benefit analysis if darkness is an ecosystem service it should be included as an external coast.

Planning for persistence in the face of anthropogenic threats and environmental change: Insights from phylogenetics and phylogeography for conservation of Africa's endemic golden moles (Chrysochloridae)

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Abstract
Global environmental change can lead to shifts in ecosystem functioning andlineage diversification, altering the geographic distribution of species across the landscape. Against this backdrop of natural change, anthropogenic pressures substantially increase extinction risks. Habitat loss and fragmentation are considered serious threats to the persistence of species across diverse taxonomic groups, and particularly those with very specific habitat requirements. Golden moles (Chrysochloridae), a group of fossorial insectivores exhibiting narrow habitat tolerances, epitomize such a case, as their naturally restricted and very specific sandy soil habitats are heavily impacted by human activities. The family represents one of Africa's most endangered and under-studied mammals with 10 of the 21 recognized species listed as threatened (IUCN 2017), but taxonomic uncertainties hamper current conservation efforts. In this context we present a revised Chrysochloridae classification on the basis of a total evidence phylogeny. The inferred relationships uncovered evolutionarily unique lineages within two genera and three species. We also used four mitochondrial and nuclear genes to investigate intraspecific relationships and gene flow in the severely threatened Juliana's Golden Mole (*Neamblysomus julianae*) at two spatial scales (regional and localized). Allele networks revealed phylogeographic structure that, consistent with compelling morphological evidence, suggest that populations at the western and eastern limits of its geographic range are genetically divergent, and may represent distinct evolutionary lineages. A small sample size from Kruger National Park precludes definitive conclusions regarding taxonomic status, but it is crucial that each population is considered an Evolutionary Significant Unit (ESU) to conserve its evolutionary history. Our study emphasizes that a sound taxonomy based on rigorous phylogenetic inference at different levels and spatial scales and an understanding of variation across species' ranges are essential for effective conservation of threatened chrysochlorid species, and in general. Such insights contribute to a greater comprehension of the effects of human impacts on threatened species, and how these effects could be mitigated.

A new method for modelling biological invasions from early spread data accounting for anthropogenic dispersal

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Abstract

Biological invasions are one of the major causes of biodiversity loss worldwide. In spite of human aided (anthropogenic) dispersal being the key element in the spread of invasive species, no framework published so far accounts for its peculiar characteristics, such as very rapid dispersal and independence from the existing species distribution.

I will present a new method for modelling biological invasions using historical spatio-temporal records. This method first discriminates between data points of anthropogenic origin and those originating from natural dispersal, then estimates the natural dispersal kernel. My co-authors and I use the expectation-maximisation algorithm for the first step; we then use Ripley's K-function as a spatial similarity metric to estimate the dispersal kernel. This is done accounting for habitat suitability and providing estimates of the inference precision.

Tests on simulated data show good accuracy and precision for this method, even in the presence of challenging, but realistic, limitations of data in the invasion time series, such as gaps in the survey times and low number of records. I will also provide a real case application of our method using the case of Litoria frogs in New Zealand.

This method is widely applicable across the field of biological invasions, epidemics and climate change induced range shifts and provides a valuable contribution to the management of such issues. Functions to implement this methodology are made available as the R package Biolinv (https://cran.r-project.org/package=Biolinv).

Can camera traps be used to estimate density of unmarked wildlife populations?

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Abstract

Camera trapping has been used largely to determine presence or absence of large vertebrates, and the question of whether it can be used to estimate absolute abundance of unmarked animals is an open one. We will report on 6 years of research in the southwest Yukon, Canada, to determine if camera images can reflect absolute abundance of unmarked mice, voles, red squirrels and snowshoe hares. For these smaller vertebrates the answer is yes. We have now embarked on a larger question of whether cameras can detect and census larger vertebrates in the boreal forests of the Kluane Lake area, Yukon. We have deployed remote cameras on game trails year-round to capture images of all vertebrates including moose, bears, wolves, wolverine, coyotes and lynx and we report on progress here. A few individuals of moose, bears and wolves have clear identifying features but not enough to use standard mark-recapture estimates. We are testing new methods of determining density of unmarked animals with camera trap photos. Many of the predator species photographed fluctuate in numbers dramatically in response to the 10-year hare cycle, which will provide a unique opportunity to test these new density estimation methods using cameras. The eyes of cameras may be an important technique to provide data 24/7 on the state of this boreal forest ecosystem under rapidly shifting climate in northwestern Canada.

Land sharing and land sparing reveal social and ecological synergy in big cat conservation

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Abstract

Global biodiversity conservation has recently focused on the roles of land management strategies of land sharing vs. land sparing. However, few studies have evaluated the roles of social and ecological interactions in modifying the e□ectiveness of land management for top predator conservation. Using a 65-year dataset from northeastern China, we evaluated the roles of government social policies in resolving human-wildlife conflicts and improving human livelihood. From 1998 to 2015, both big cat populations and their habitats have increased. Concurrently, regional human population density decreased by 59.6%, forest volume logged was reduced by 62.6%. Consequently, increases of key prey species were observed during the same periods. Although populations remained small, the annual finite rate of increase was 1.04 for the Amur tiger population and 1.08 for Amur leopards from 1999 to 2015. Habitat areas occupied by big cats increased significantly. Overexploitation of forest resources and big cat declines under previous unsustainable land use are progressively being reversed under land sparing. Large economic investment and intense human-relocation projects coupled with e□orts to reduce poaching and illegal hunting and trapping demonstrate a complex social and ecological synergy in big cat conservation in China.

Extreme climatic events and the prioritization of conservation planning under uncertainty

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Abstract

Robust evidence indicates that climate change and severe weather will remain moulding the extinction risk of species already bearing the brunt of the Antrophocene. As funding in support of protecting biodiversity is limited, it is imperative to identify areas designated for priority conservation and investment. These areas can also be the battlegrounds to protect vulnerable species and the ecosystems that sustain them from climatic impacts, hence, help maximize the benefit of investment on species and habitat protection. In the first part of this talk I'll provide a brief overview of the consequences that extreme climatic events (ECEs) can exert on biodiversity in the form of species, and how contemporary exposure to these phenomena may contribute species extintion risk. In the second part I'll present the findings of a nation-wide assessment on how well 32 priority areas for biodiversity conservation in China capture areas with a high cummulative incidence of floods and refugia for different taxa. Lastly, I present our findings identifying species-specific vulnerability to tropical cyclones for a subset of mammals flagged at high risk of extinction in Mesoamerica, and a set of recommendations to avert the worsts risks from these phenomena expected to become more frequent and intense in the coming decades. In absence of robust predictive frameworks for risk to ECEs, we stress that more efforts are needed in risk evaluation to inform conservation planning if we are to avert the worst risks.

Posters

Anthropogenic transformation of Palaearctic/Oriental transition zone: case of freshwater fauna

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Abstract

The confinedness of different species to particular geographical regions is a unique phenomenon, noticed by early scholars of evolutionary biology and biogeography. The great empirical material on plants and animals distribution, obtained during many expeditions in the Age of Exploration, allowed to delineate the preliminary biogeographical patterns in the 18th century. However the first global map for vertebrates was developed by A.R. Wallace only at the end of the 19th century. Since that time there were many attempts to carry out a biogeographical zoning based on certain groups of organisms, as well as to regard the distribution patterns of unrelated groups in their combination. The number of biogeographical regions and their boundaries vary in different schemes, but the main approach to draw a precise line between regions based on similarity of their species composition is surprisingly constant from a research to next research. At the same time, transition zones between such biogeographical regions are still insufficiently studied, although they harbor higher biodiversity due to presence of taxa from adjacent regions. Just they may be especially vulnerable to anthropogenic impact. Here we summarize data on transition zone between Palaearctic and Oriental regions based on data on species composition in different freshwater taxa of animals, which are a sensitive indicator of environmental conditions. Although there is a problem of precise definition of biogeographical boundary between Palaearctic and Oriental regions, transition zone between them involves central and northern parts of China and even southern portion of Asian Russia. Here some species of fish, mollusks, insects and (micro-) crustaceans, typically for Palaearctic and Oriental regions, respectively, co-exist together. Dispersal from the southern part of zone to North was already shown for many taxa and may be associated with a global climate warming and with direct anthropogenic transferring. The Amur basin is considered as main way of dispersal for freshwater fauna. Although dispersion from North to South is known for some non-freshwater taxa as well, this phenomenon requires additional investigations. In any case, transition zone between Palaearctic and Oriental regions needs a long-term ecological monitoring. Overview on microcrustaceans for ANN and AAK was funded by the Russian Science Foundation (research project № 18-14-00325). Investigations of fish and some freshwater invertebrates for YYD, AAM and VSA were supported by the Russian Foundation for Basic Reasearch (project № 17-54-53085 GFEN_a).

Morphological adaptations of the Cladocera (Crustacea: Branchiopoda) resting stages to zoochory: analogues with plant seeds and consequences of such similarity for biogeographical patterns similarity

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Abstract

Cladocera (Crustacea: Branchiopoda) is a group of microscopic crustaceans inhabited continental water bodies of different types. Their resting eggs are well-protected from adverse environmental conditions. Resting eggs of Ctenopoda, Onychopoda, Haplopoda are covered by a strong drought-resistant shell, while in Anomopoda they are enclosed by so-called ephippium – a modified moulting exuvium of the female. Transportation of the resting eggs and ephippia by water birds through the gut and on the feathers is the main vector of the cladoceran dispersion. Previously several authors already declared that functionally ephippia are very similar to plant seeds, and the same dispersal mechanisms may operate (Altermatt & Ebert, 2008; Figuerola & Green, 2002; Van Damme & Sinev, 2013). In our report we pay a special attention to the analogues between cladoceran resting eggs and ephippia and plant seeds in their morphological adaptations to zoochory. This phenomenon reflects similarity of biogeographical patterns both for some cladocerans and seed plants across the Earth. In fact, their dispersal via birds occurs mainly in the longitudinal direction, but on short distances. Meanwhile, dispersal speed is relatively small. It may be one of important circumstance by which recent local freshwater faunas and floras are quite stable.

The study was funded by the Russian Science Foundation (project № 18-14-00325).

Role of participatory approach in mitigating large carnivore-human conflict in the trans-Himalaya

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Abstract

Large carnivore-human conflict is a worldwide issue and co-existence rarely exists. Large carnivores often cause serious economic losses by preying on livestock and get persecuted due to retaliation, which at times lead to local extinction. We investigated the grass root factors causing large carnivore-human conflict in Kargil in the west Himalaya. Globally endangered snow leopard and more common wolf were the two main wild predators in Kargil. About 8.3% livestock loss (2009-2012) was due to predation by large carnivores, which resulted in strong negative perception amongst the local communities. A total of 1113 heads of livestock were reportedly killed by wolf (43.6%) followed by unknown predators (31.4%) and snow leopard (21.5%) in the study site, which comes to 2.8% annual livestock losses. Poor livestock husbandry practices and traditional livestock corrals were found to be the major drivers contributing in the large carnivore-human conflict in Kargil. Scat analysis also revealed significant amount of livestock in the diet of snow leopard (47%) and wolf (51.2%). Based on our research findings, we worked with the local communities to sensitize them about wildlife conservation and support for predator proof livestock corrals. Eventually it helped in reducing conflict level and conserving the imperial carnivores in Kargil. We conclude that a participatory approach has been successful to generate a model in reducing large carnivore-human conflict in the west Himalaya.

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To become an ISZS member or subscribe the journal, please contact Dr Wenhua Xiong (xiongwh@ioz.ac.cn). For BCGC and further information, please contact Chunxu Han (iszs2@ioz.ac.cn).

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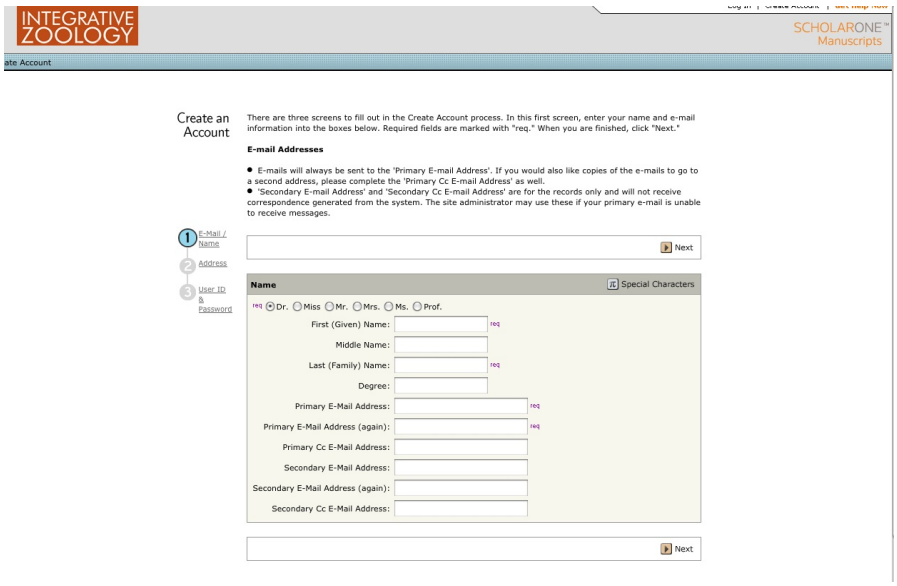

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All articles must have a brief abstract that states in 250 words or fewer the purpose, basic procedures, main findings and principal conclusions of the study. The abstract should not contain abbreviations or references.

Five key words (for the purposes of indexing) should be supplied below the abstract in alphabetical order.

Text
Authors should use the following subheadings to divide the sections of their manuscript: Introduction, Materials and Methods, Results and Discussion.

Acknowledgments
The source of financial grants and other funding must be acknowledged, including a frank declaration of the authors' industrial links and affiliations. The contribution of colleagues or institutions should also be acknowledged. Personal thanks and thanks to anonymous reviewers are not appropriate.

References
The Harvard (author date) system of referencing is used (examples are given below). In the text give the author's name followed by the year in parentheses: Smith (2000). If there are two authors use 'and': Smith and Jones (2001); but if cited within parentheses use '&': (Smith & Jones 2001). When reference is made to a work by three or more authors, the first name followed by et al. should be used: MacDonald et al. (2002). In the reference list, references should be listed in alphabetical order, then chronologically.

In the reference list, cite the names of all authors when there are six or fewer; when seven or more, list the first three followed by et al. Do not use ibid. or op cit. Reference to unpublished data and personal communications should not appear in the list but should be cited in the text only (e.g. Smith A, 2000, unpublished data). All citations mentioned in the text, tables or figures must be listed in the reference list.

Authors are responsible for the accuracy of the references.
Journals
Currie PJ, Chen PJ (2001). Anatomy of Sinosauropteryx prima from Liaoning, northeastern China. Canadian Journal of Earth Science 38, 1705–27.

Books
Ringsven MK, Bond D (1996). Gerontology and Leadership Skills for Nurses, 2nd edn. Delmar Publishers, Albany, NY.

Chapter in a book

Hull DL (1988). Interactors versus vehicles. In: Plotkin HC, ed. The Role of Behavior in Evolution. MIT Press, Boston, pp. 19–50.

Conference proceedings

Kimura J, Shibasaki H, eds (1996). Recent advances in clinical neurophysiology. Proceedings of the 10th International Congress of EMG and Clinical Neurophysiology; 15–19 Oct 1995, Kyoto, Japan. Elsevier, Amsterdam.

Web page

Diabetes Australia. Prevalence of Diabetes in the Australian Population. [Cited 5 Jun 1996.] Available from URL: http://www.diabetes.org.au

Tables

Tables should be self-contained and complement, but not duplicate, information contained in the text. Number tables consecutively in the text in Arabic numerals. Type tables on a separate page with the legend above. Legends should be concise but comprehensive – the table, legend and footnotes must be understandable without reference to the text. Vertical lines should not be used to separate columns. Column headings should be brief, with units of measurement in parentheses; all abbreviations must be defined in footnotes. Footnote symbols: ?, ?, §, ?, should be used (in that order) and *, **, *** should be reserved for P-values. Statistical measures such as SD or SEM should be identified in the headings.

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* Check the title and keywords of your study: Do they attract researchers in your field and more broadly?
* An abstract of 250 words or less that effectively summarizes your study and engages other researchers.
* Check that the manuscript follows the Author Guidelines for Integrative Zoology and that the sections are in the correct order.
* Check you have indicated the ethics approval system under which your study was conducted in the manuscript.
* Cross-checked all referencing and checked the formatting of these both in the text and references section.
* Ensure your manuscript is in DOC (Microsoft Word) format.
* All tables and figures are presented at the end of the text.
* Check that only SI values have been used throughout the manuscript.
* At least one colleague has read through your manuscript.

IUBS/ISZS International Research Program: Biological Consequences of Global Change (BCGC)

Program Co-ordinator :
Zhibin Zhang (zhangzb@ioz.ac.cn)

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Background

Global change is now one of the most discussed topics in the world. Indeed, our earth is facing great challenges of global change, such as global warming and human disturbance. Understanding the impact of global change is extremely important for the sustainable development of our society. Unfortunately, the biological consequences of global change have been largely ignored. There is an urgent need to strengthen researches on BCGC.

It was due to these circumstances that the ISZS initiated a BCGC international research program in 2008, first supported by the CAS. In 2009, ISZS organized a symposium on BCGC in Beijing and about 130 participants attended the symposium. The same year, BCGC was adopted by the International Union of Biological Sciences (IUBS) as a new international research program, led by Zhibin Zhang, Yury Yu Dgebuadze and Hari Sharma. In Jun 2010 and Jul 2012, *INZ* published two special issues on BCGC, edited by Nils Chr. Stenseth and Zhibin Zhang, respectively. Currently, there are over 40 scientists from many countries such as USA, France, United Kingdom, Germany, Norway, Canada, Australia, Chile, Mexico, India, Israel, South Africa, Russia, Armenia, Pakistan and China involved to the program.

The focus of the BCGC program is to organize a diverse group of international experts, with expertise in many scientific disciplines, to develop an understanding of the biological consequences and the mechanisms on biological structures, endangered species and biological disasters under both global climate change and human activities. BCGC has become a core scientific program of IUBS in 2012 and it was extended for another triennium in 2015 for its outstanding performance and achievements.

The IUBS/ISZS sponsored BCGC program provides an excellent platform for scientists around the world to collaborate in exploring the impact of global change on biodiversity, ecological infectious diseases, agricultural pests, invasive species and many other topics of interest. In future, BCGC will expand its research networks to include more sciences from more places and countries in the world. This will help to reveal regional differences in

response to biological aspects of global change. BCGC will continue to improve its website and database quality which will further promote idea exchanges and accurate modeling studies. BCGC will also improve public awareness about its research output, which may help in the policy-making of governments for managing our biological resources.

Questions addressed by the project:

- Outbreaks of biological disasters, such as disease pest outbreaks
- Biological invasion of alien species
- Abundance and range shifts of endangered species
- Community structure and biodiversity of different ecosystems
- Nonlinearity and interactions of biological populations

Goals:

- To promote understanding of BCGC and improve the management of our earth
- To promote international collaborations
- To promote the influence and leadership of the BCGC program and the IUBS

Action plan (2018–2020):

- To collaborate with other programs (e.g. Future Earth) or organizations (e.g. IPCC);
- To expand research network in more countries and attract more scientists to participant in related studies and activities;
- To develop research tools for solving complex impacts of global change;
- To setup BCGC database;
- To provide advisory reports to government or non-government agencies;
- To raise funds to complement those tasks.

Contact the ISZS

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Summary Report

Biological Consequences of Global Change (BCGC)

-- An ISZS/IUBS International Research Program

(2008-2018)

The International Society of Zoological Sciences
2018.10.24

Preface

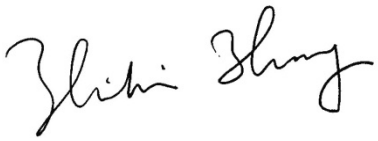
The earth has been facing rapid global change since last century and it is going on even today. Its impacts on spatial-temporal dynamics of animals, however, are still not yet well understood. From studies, researches and investigations on BCGC during last decade, scientists found that global changes do have significant impacts on biological organism. The impacts could be complex, i.e. negative or positive. As a result, understanding the macro-process of global change is somewhat essential not only in preventing species extinction, outbreaks of pest or diseases, biological invasion, but also in preserving biodiversity and ecosystem services on earth.

Traditional ecological hypothesis emphasizes ecological studies of system at small or local scale, but recent advances in global change biology have greatly expanded the traditional theory from small scale to large scale and from linear or monotonic regime to non-monotonic regime. Accumulating evidences demonstrate that population dynamics of many species have been closely associated with indices of global change, such as global temperature, ENSO (El Nina and Southern Oscillation) and NAO (Northern Atlantic Oscillation) and so on. Furthermore, the effects of these global change factors are often non-monotonic, depending on the spatial-temporal scale, environment gradients and complex pathways or interactions.

BCGC requires studies on global and long-term scales. International cooperation and coordination, therefore, become a critical trend in advancing our understanding of global change and its biological consequences. Ten years' ago, ISZS launched the BCGC international research program. It was adopted as an international scientific program by the International Union of Biological Science (IUBS) in 2009. A BCGC working group was established within ISZS to coordinate BCGC. A number of BCGC symposia were organized, and three BCGC special issues were published in *Integrative Zoology,* an official journal of ISZS. More than 100 scientists from the world have been involved in the BCGC program. Significant outputs of the BCGC were produced. These results provide novel insight into BCGC, especially in fields of pest outbreaks, biological invasion, species extinction, disease transmission etc.

Lastly, I would like take this opportunity to express thanks and appreciation to all the BCGC members, scientists, researchers and students for their input to the program. I am grateful to the International Union of Biological Sciences (IUBS); the International Society of Zoological Sciences (ISZS); Bureau of International Cooperation, Chinese Academy of Sciences; Department of International Affairs and Department of Academic and Societies Affairs, China Association for Science and Technology; Division of Life Science, National Natural Science Foundation of China; and John Wiley & Sons, Inc. for their generous financial supports to the program.

Welcome to join and to continue your support to our BCGC program.



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Secretary (Assistant program leader)

HAN, Chunxu (China)

Contents

Background

Global changes, including alterations in climate, land productivity, oceans and other water resources, atmospheric chemistry, and ecological systems, are significantly altering the habitats, reproduction and even survival of countless species on our planet. Evidence shows that industrial, agricultural, and other human activities, coupled with an expanding world population, are contributing to the process of global change that may significantly alter the earth's ecosystems and thus shape our future.

It is well-known that the terrestrial and aquatic ecosystems that make up the planet biosphere provide a range of vital goods and services to our human beings, including food, fiber, fuel, genetic resources, pharmaceuticals, cycling and purification of water and air, regulation of weather and climate, recreation, and natural beauty. However, recent and ongoing global changes—including climatic change, changes in atmospheric composition, land use, habitat fragmentation, pollution, extraction of natural resources, and spread of invasive species—are affecting the structure, composition, and functioning of many ecosystems nowadays. In turn, many biological consequences of global change have potentials to affect atmospheric composition, weather, and climate through both negative and positive feedback mechanisms. Because many global changes are expected to increase in magnitude in the coming decades, the potential also exists for increased BCGC on ecosystems and the goods and services we extract from them.

In the 21st century, our planet is facing a tremendous challenge from global change. Global warming, environmental degradation, and spread of infectious diseases are some of the most pressing issues. The on-going increase in global temperature is widely believed to be the biggest threat to survival of many species around the globe. At the same time, however, some species are benefiting from climatic change. Anyhow, the globalization of the world economy coupled with a rapidly growing human population will continue to place great strains on the health and survival of many species and ecosystems on our planet. The biological invasions of non-native species continue to pose a serious threat to the biodiversity and native ecosystems. Furthermore, while the global transportation system makes it more convenient for human beings to conduct international exchanges and transactions, it also increases the risk of spreading invasive species and infectious diseases.

For the last few decades, a number of scientists and laboratories around the world launched various research programs on global change, mainly aimed at studying global climate change. Their activities include scientific research, data collection and on-site observation. They have made tremendous progresses and achieved valuable research results. They hope that with their hard work and findings they can help prioritize the problems, design and implement strategies to lessen harmful impacts, and identify the most effective approaches in practical management and decision-making.

However, the participants of many of these endeavours have found that it is quite beyond individual agencies or small group of agencies to put together a full picture of the on-going global change. A significant challenge has arisen, namely how to integrate research and findings on global change, so as to develop a comprehensive view of global change and its potential significances. A standout example is the 2009 United Nations Climate Change Conference in Copenhagen. As there is no agreed upon comprehensive scientific view of global climate change, the conference, dissolved into arguments of national interests amongst world politicians and produced practically no concrete results.

BCGC is a long-term global phenomenon and as a result, it requires global and long-term responses. Cooperation and coordination at an international scale have become a critical trend in advancing understanding of global change and related ecosystems. Large regional differences will exist both in the magnitude and rapidity of the changes that will occur. The results from integration of global data and cooperation in an

internationally-oriented BCGC program will by definition be wider in scope than those from national efforts alone.

In the process of understanding the BCGC, historical data will no doubt play an extremely important role. In order to understand the phenomena of global change and devise solutions, many scientists around the world have launched research programs to produce and analyze data to model and predict the likelihood of future impacts from global change. However, most of the existing programs on global change are being conducted by scientists and laboratories scattered around the world without a clear mechanism for data collaboration and information share. Under such circumstances, one of the current priorities for international research on BCGC is establishing a practical working mechanism for international data analysis and information sharing. This mechanism will make it possible for a wider range of international research activities that cover the broad spectrum of global change to be shared and thus increase our understanding of BCGC more precisely and effectively.

It was under such circumstances that the International Society of Zoological Sciences (ISZS) , taking its advance of a nonpartisan, nonprofit membership-based organization of zoological professionals around the globe, initiated an international research program – Biological Consequences of Global Change (BCGC) – in 2008 to promote international scientific research, communication between scientists and information exchange, to unite scientists in different countries and disciplines to set up an international working platform for international BCGC research collaboration, data integration and information exchange so as to improve our understanding and forecasting of those potential BCGC.

The focus of BCGC is to organize a diverse group of international experts with expertise in many scientific disciplines to understand the biological consequences of endangered species, biological invasion and biological disasters, such as diseases, that are a direct result of global change.

The major objectives of BCGC are:
To understand the changes in species population, distribution, behavior and their functions in ecosystems;
To understand the impact of global change on biodiversity structures, patterns and complexity of ecosystems;

- To understand the impact of global change on biological invasion, infectious diseases and biological disasters;
- To set up a mechanism for integrating and exchanging international data and information on BCGC;
- To build up a global network and necessary personnel capability for scientific research and communication on BCGC.

Questions addressed by the BCGC program included but not limited to:

- Outbreaks of biological disasters, such as disease or pest outbreaks;
- Biological invasion of alien species;
- Abundance and range shifts of endangered species;
- Community structure and biodiversity of different ecosystems;
- Nonlinearity and interactions of biological populations.

Major Goals are:

- To promote understanding of BCGC and improve the management of our earth;
- To promote international collaborations;
- To promote the influence and leadership of the BCGC program, ISZS and IUBS.

Shortly after the launch of the program in 2008, BCGC was adopted by the Chinese Academy of Sciences (CAS) as a key international cooperation program. In 2009, BCGC was adopted by the International Union of Biological Sciences (IUBS) as a new

international scientific program. In 2012, BCGC was reviewed as the core program at IUBS, and in 2015, BCGC was granted for an extended third triennium at the 32nd IUBS General Assembly (GA) in Berlin for its outstanding performance and achievements. Currently, there are over 100 scientists involved in the program coming from many countries such as USA, France, United Kingdom, Germany, Norway, Canada, Australia, Chile, Mexico, India, Israel, South Africa, Russia, Armenia, Pakistan and China.

Major activities

1. **Overview**

In the last decade, various academic events were organized under the BCGC, including international congresses, general assemblies, conferences, symposia, workshops, seminars and training courses. Over 1,000 scientists or students from more than 90 countries in the world attended the events, delivering over 1,000 oral presentations and 1,200 posters on their work and research on BCGC with a coverage of almost all branches of biology, such as morphology, anatomy, physiology, neurology, behavior, reproduction, genetics, evolution, geographical distribution; from macro to micro (ecosystem, species, biocoenosis, individual, molecular); and interdisciplines such as industry, agriculture, forestry, urbanization, mutualism, climate change, bio-adaptation, population dynamics, diseases, invasive species, computer, statistics and bioethics, etc.

2. Themes and events

The theme of those events included BCGC; data collection, analysis and share; wildlife monitoring; adaptation under extreme environments; endangered species survival strategies and habitats; wildlife-borne diseases; invasive species, etc. International meetings on BCGC were held in China, Russia, Israel, France, Germany, Poland, Italy, Bulgaria, Mongolia, South Africa, Indonesia and Japan, respectively. Many scientists started or extended their collaboration through various exchange programs or training courses.

3. Participants

Leading scientists from the United States, France, Norway, Belgium, Australia, Russia, Japan and China were invited to attend the events and to deliver key-note speech or plenary lectures. Representatives from the International Council of Science (ICSU), International Union of Biological Sciences (IUBS), European Research Council (ERC), the Norwegian Academy of Science and Letters, Centre National de la Recherche Scientifique (CNRS), Chinese Academy of Sciences, National Natural Sciences Foundation of China, the Zoological Society of Japan, China Zoological Society; International Union for Conservation of Nature and Natural Resources (IUCN), United Nations Educational, Scientific and Cultural Organization (UNESCO), Food and Agriculture Organization (FAO), the Asia-Pacific Forest Invasive Species Network (APFISN), Asia-Pacific Wildlife-borne Disease Network (APWDN), as well as some scientific journals, such *Ecology Letters, Nature and Science* were also invited to the events.

4. Field studies

In addition, the program organized field studies in the cold, middle, warm, subtropical, tropical and plateau-climate zones for scientists on BCGC to collect samples and data for their research. The studied fields included the steppe grassland in Inner Mongolia, China; grassy marshland in Qinghai-Tibetan Plateau, China; Changbaishan Forest, Northeastern China; Xishuangbanna Tropical Rain Forest, China; National Panda Protected Area, Chichuan, China; Cuihu Park, Yunnan, China; Diaoluo Mt. Nature Preserve, Hainan, China; Mojave National Preserve, California, USA; Irkutsk Nature Preserve, Russia; Elat National Park, Israel; National Nature Preserve, Cape Town, South Africa; and Xuan Son National Park, Viet Nam (Han *et al.* 2018).

5. Published special issues and papers

The program organized 3 special issues on BCGC in *Integrative Zoology*, an SCI Q1 journal on zoology. Over 30 original articles were published in those special issues. According to a report released by Wiley-Blackwell, 9 of the top 10 most downloaded articles were from the BCGC special issue in 2010. The published article "*Climate change and invasive species: double jeopardy*" was the top downloaded article from *Integrative Zoology* in that year, receiving 696 full text downloads. The article "*Some biological consequences of environmental change: A study using barnacles (*Cirripedia: Balanomorpha*) and gum trees (*Angiospermae: Myrtaceae*),*" published in the special issue was featured on BBC Earth News. The program also supported scientists on BCGC to publish articles in other scientific journals, including *Nature, PNAS, Ecology and Oecologia,* etc. (Xiong *et al.* 2018; Zhang *at al.* 2018).

6. Assessment on strategic and action plans in China

BCGC scientists helped to assess the vulnerability for 208 endemic or endangered species in China to the effects of climate change, as a part of the project "Research on China's National Biodiversity and Climate Change Strategy and Action Plans."

Based on the China Species Information System (CSIS), they selected comprehensive species as analysis targets, covering taxa including mammals, birds, reptiles, amphibians, and plants. 9 species distribution models in BIOMOD (a package of R software) were applied to estimate the current (1991-2010) ranges and projected the future (2081-2100) ranges of these species, using six climate variables based on Regional Climate Model version 3 (RegCM3) and A1B emission scenario.

Modeling results showed that different taxa might show diverse potential range shifts over time. The range sizes of half of the species (104 species) would decrease, and another half would increase. Of those declines, 135 species would be reduced to more than 50% of their current range size, and species that are both endemic and critically endangered, especially on the Qinghai-Tibetan Plateau, in Hengduan Mountain Range, and Southern China would be the most vulnerable losing species and it is very like that they would lose more if no effective strategic actions were taken (Li *et al.* 2015; Li *et al.* 2016; Zhao *et al. 2018*).

7. Sponsorship to an International Research Network on pine moth

The BGCG program also sponsored the launching and the development of the International Research Network about the Adaptive Response of Processionary Moths and Their Associated Organisms to Global Change since 2012. The network was constituted as a multidisciplinary network, gathering research teams of 23 countries of Europe and the Mediterranean basin working on processionary moths. It was aimed to gather scientists from all of the concerned fields; i.e., entomology, ecology, genetics, mathematical modelling, veterinary and medical epidemiology, immunology and dermatology to work on the climate impact on the moths. As a matter of fact, the pine processionary moth, *Thaumetopoea pityocampa* (Lépidoptère: Notodontidae), constitutes an outstanding model to explore the relationships between global warming and insects because its range expansion observed in recent years towards higher latitudes and altitudes has been definitely related to global warming.

Through collaboration in the network, a number of papers were published in top ISI-reviews (e.g., *TREE, BMC Evol Biol, J. Biog., Ann. Rev. Entomology*). Furthermore, the network succeeded in associating 101 authors in 22 countries in Europe, Middle Asia and North Africa to publish a book *"Processionary moths and climate changes: year update*" at Quae/Springer in November 2014.

This 427-page work synthesizes the current knowledge of all scientific disciplines concerning the responses to the climate change of the model insects, processionary

moths, in a multi-field approach of biology and ecology, genetics, phylogeography, impact on all the organisms (tree, competitors and natural enemies, humans, cattle, pets) of predictive modeling, and the definition of management strategies, especially in urban environments.

This is the first synthesis available that is not only on the pine processionary moths, but on the other processionary moths in Europe and the Mediterranean basin as well. The book also made it possible to carry out a mapping of the northern front edge of expansion of the pine processionary moth from Brittany to Bulgaria on a 16x16-kilometer grid, which specifies the zones recently invaded with climate change.

Through this international research network, a simultaneous survey of the phenological development of the populations of pine processionary moths was conducted in 25 sites distributed out of 10 countries during the winter 2014-2015 (Roques *et al.* 2018).

8. Model tools

In order to clarify the characteristics of the models and suitable situations for their use (in terms of data type and species–environment relationships) and to provide guidelines for model application in BCGC, scientists made a comparison analysis of a few popular models. Those included regression models (the generalized linear model, the generalized additive model, the multivariate adaptive regression splines model and hierarchical modeling), classification models (mixture discriminant analysis, the generalized boosting model, and classification and regression tree analysis) and complex models (artificial neural network, random forest, genetic algorithm for rule set production and maximum entropy approaches) aiming to provide insight into the prevailing statistical models for newcomers on BCGC to do their model selection, formulation and parameter estimation (Li *et al. 2018*).

In addition, mechanistic models have been used increasingly to infer the impacts of climate change. The behavior of these models depends on assumptions about environments, organisms, and the interactions between them. Scientists reviewed the assumptions and predictions of recent models of animal performance in a changing climate. The most sophisticated models incorporate spatiotemporal variation in microclimates, acute responses to warming, and different stages of the life cycle. These models can reveal the potential for animals to avoid costs of climate change through behavioral and physiological plasticity. They can also identify selective pressures and extinction risks throughout the geographic range of a species (Angilletta *et al.* 2017).

9. Assessments on risk of extreme climatic events

Although species risk of negative impacts from extreme climatic events depends not only on its exposure but also its intrinsic sensitivity and adaptive capacity, identifying taxa currently exposed can help to (1) reduce the uncertainty in identifying species least likely to be resilient to future impacts, and (2) complement extinction risk assessments and (3) provide a more informed evaluation of current conservation status, to better guide management.

By using globally distributed data for cyclones and droughts as well as information on the distribution of 5,760 terrestrial mammals (species and subspecies), a study on exposure to extreme climatic events for terrestrial mammals was carried out. The proposition that the severity of impacts depends on (1) the level of exposure to extreme events, (2) the cumulative effects of similar such phenomena experienced in the past, and (3) the intrinsic vulnerability of the systems affected (Ostertag *et al.* 2005; Adger 2006; Murray *et al.* 2012; Seneviratne *et al.* 2012),

With this proposition, scientists (1) define the mammals with significant exposure as those with an overlap of at least 25% of their extant geographic range with areas that have been impacted by either cyclones or droughts; and (2) pinpoint those with ≥75% overlap as

being at the highest exposure.

With this study, it is stressed that incorporating the quantification of exposure to extreme climatic events, combined with information pertaining to species intrinsic sensitivity and adaptability to such events, into existing risk assessments could contribute toward reducing the overall vulnerability of species to potential population losses and hence, ultimately, reducing their risk of extinction (AMECA et al. 2012).

10. Website developments

BCGC scientists developed an AmphibiaWeb (https://amphibiaweb.org) at University of California (Berkeley) out of concern for global change affecting amphibians — frogs, salamanders and caecilians with a mission to provide accurate information on amphibian declines, natural history, conservation, and taxonomy, and make it freely and easily accessible to all. Currently, it has become an international resource, organized with a leadership team that includes personnel and contributors from across the planet (Wake *et al.* 2018).

Major scientific output

1. Overview

From studies, researches and investigations on BCGC, scientists found that global changes do have impact on biological consequences. BCGC, however, could be negative or positive depending on region and species. Furthermore, the effects of global change are often non-monotonic, depending on the spatial-temporal scale, environment gradients and complex pathways or interactions. The following are summaries of some major results from BCGC studies by our member scientists.

2. Impacts on range shift

2.1 Historical data revealed range contraction of mammals

Many species have experienced dramatic declines during past millennia due to accelerated impacts of human activities and climate change, but evidences are usually lacking. However, China has a unique system archiving historical records of important social, meteorological, agricultural and biological events over last three millennia and BCGC scientists derived historical species occurrences (0-2000 AD) based on historical literatures in China.

They used correlation and multiple regressions to quantify the linear association between species range indices and climate variables (five temperature series and three precipitation series), as well as human population size in history, to detect the driving forces of the range contraction. Techniques such as machine learning technique and random forest were used to quantify the nonlinear and interactive effects of the climate variables and human population.

Primary analysis revealed that the southwestward retreat of the Asian elephant (*Elephas maximus*) and Asian rhinoceros (*Rhinoceros unicornis, Dicerorhinus sumatrensis, Rhinoceros sondaicus*) are closely associated with both climate cooling and intensified human impact represented by large population size, and the westward retreat of the giant panda (*Ailuropoda melanoleuca),* however, is associated more closely with the intensified human impact (Li *et al*. 2013).

Further analysis found that though both temperature and population size affected the range shift of elephant and rhinoceros interactively, temperature accounted more when the population size was small and it was opposite when the population size was high. This also implied that when higher temperature caused northward or eastward range shift of Asia elephant, Asia rhinos and giant panda, human activities, however, imposed a greater impact in causing their range contractions than that of climate change (Li *et al*. 2014).

2.2 Impact on range shift on sub-Antarctic island

An observation at the sub-Antarctic island, South Georgia, found that with its position at the northern edge of the Southern Ocean, the island experiences the warmest maximum sea surface temperatures (SST), and the widest annual SST range within the Southern Ocean. The summer SST at the island is above the measured physiological limits of many of the co-occurring species from further south on the Antarctic Peninsula. To cope with the warmer environment at the island, some of these co-occurring species have altered depth distributions to avoid the warmest water masses, and have greater physiological plasticity to cope with the more variable thermal conditions However, further understanding how gene flow and adaptation of species at the island has affected physiological tolerance will further indicate important mechanisms underlying species geographic ranges in the ocean (Morley *et al.* 2012).

2.3 Climate change and range size

A research was carried out to examine the generality of factors among different terrestrial vertebrates (mammals, birds and reptiles) and to evaluate simultaneously the strength of relationships between their range size and factors at a global scale.

Factors, including current climate (for example, climate variability and climate extremes), long-term climate change, evolutionary age, topographic heterogeneity, land area and species traits such as physiological thermal limits, dispersal ability, annual fecundity and body size were used to shown influence on their range size.

Contributions of these factors to range sizes were quantified in the research and it was found that large-ranged species experience greater monthly extremes of maximum or minimum temperature within their ranges, or occur in areas with higher long-term climate velocity and lower topographic heterogeneity or lower precipitation seasonality. Flight ability, body mass and continent width, however, is important only for certain particular taxa.

The results highlight the importance of climate and topographic context in driving range size variation. It was suggested that small-range species might be more vulnerable to climate change and they should be the focus of conservation efforts. The study also provided an important insight into the distribution of biodiversity, which is very crucial for predicting shifts in species ranges, especially in response to climate change (Li *et al.* 2015).

3. Impacts on population change

3.1. Non-monotonic effects of climate changes

Traditional climatic hypothesis emphasizes on the effects of local climate, but recent advances in population biology have greatly expanded the traditional theory from small scale to large scale and from linear or monotonic regime to non-monotonic regime. Accumulating evidences on BCGC study demonstrate that population dynamics of many species have been closely associated with indices of global climate change, such as global temperature, ENSO (El Nina and Southern Oscillation) and NAO (Northern Atlantic Oscillation) and so on. Furthermore, the effects of those global climate factors are often non-monotonic, depending on the spatial-temporal scale, environment gradients and complex pathway or interactions (Zhang *et al* 2018).

3.2. Impacts on human epidemics

In order to disentangling causes and consequences of the prevalence of infectious diseases at historical time scales, scientists on BCGC reconstructed the spatiotemporal occurrence patterns of human epidemics for large parts of China and most of the last two millennia.

It was found that cold and dry climate conditions indirectly increased the prevalence of

epidemics through the influences of locusts and famines, as climate cooling could have resulted in collapsed agricultural production and poor human health conditions due to famine, thereby increasing the prevalence of human epidemic events.

Further analysis revealed that by using long-term data on a scale of centuries to millennia, a cold climate temperature was positively associated with more human epidemic events in ancient China via increased frequencies of drought and locusts, followed by famine. This result is inconsistent with previous research results derived from short-term data (often of only several decades). Even a small time scale (i.e., 100 y) indicated that the associations between human epidemic events and temperature were unstable over time. The results imply that the effects of climate on the prevalence of human epidemic events are much scale dependent (i.e., dependent on data frequency and time scale), and an intertwined, direct, and indirect array of biological, ecological, and societal responses to different aspects of past climatic changes are much dependent on the frequency domain and study period chosen (Tian *et al.* 2017)

3.3. Impacts on hare-lynx cycles

With an endeavor to further reveal the ecological mechanisms that drive the classic 10-year population cycle of snowshoe hares (*Lepus americanus, Erxleben 1777*) and Canada lynx (*Lynx canadensis, Kerr 1792*) in the boreal forests in North America, BCGC scientists constructed a series of generalized additive models to study the effects of density dependence, predation, and climate (both global climate indices of North Atlantic Oscillation index (NAO), Southern Oscillation index (SOI) and northern hemispheric temperature (NHT) and local weather data including temperature, rainfall, and snow). Several key pathways were identified from global and local climate to lynx with various time lags. Rainfall shows a negative, and snow shows a positive effect on lynx. NHT and NAO negatively affect lynx through their positive effect on rainfall and negative effect on snow. SOI positively affects lynx through its negative effect on rainfall. Direct or delayed density dependency effects, the prey effect of hare on lynx and a 2-year delayed negative effect of lynx on hare (defined as asymmetric predation) were also found.

This simulated population dynamics fitted well to the observed long-term fluctuations of hare and lynx populations. It was found that density dependency and asymmetric predation, only producing damped oscillation, are necessary but not sufficient factors in causing the observed 10-year cycles. The extrinsic climate factors are also of a great importance in producing and modifying the sustained cycles. The results provided an alternative explanation to the mechanism of this 10-year cycles (Yan *et al.* 2013).

3.4. Effect of climate warming on mammal populations in Armenia

Field study in Armenia, a country bordering Europe and Asia, found that the patchy nature of mountainous habitats and the high demand of large mammals for space make those landscapes and species in the country particularly vulnerable to climate change.

There are two species, golden jackal (*Canis aureus* L., 1758) and Indian crested porcupine (*Hystrix indica* Kerr, 1792), benefit from warming in Armenia due to their omnivorous diet and tolerance to arid conditions and human activities.

The Armenian mouflon (*Ovis orientalis gmelinii* Blyth, 1841), European roe deer (*Capreolus capreolus* L., 1758), grey wolf (*Canis lupus* L., 1758), bezoar goat (*Capra aegagrus* Erxleben, 1777) and leopard (*Panthera pardus* L., 1758) are tentative losers.

Mouflons use the snow-free areas for wintering and would possibly benefit from warming-driven snowmelt rates, but their life is strongly linked with snow cover which offers soft substrate for basking and ensures moisture for lush alpine vegetation.

Roe deer inhabit gorges in moist broadleaf forests and suffer from dryout and reduction of local dense vegetation.

Wolf distribution is correlated with mountain pastures for domestic livestock and drought-triggered hardship of animal husbandry causes wolves to dwindle or shift to predation on wild boars (*Sus scrofa* L., 1758).

The heat-loving bezoar goat and leopard would likely benefit from accelerated snowmelt, but azonal precipitous cliffs where they live are small, scattered and contain few options to retreat from hunger during drought.

The brown bear (*Ursus arctos* L., 1758), Eurasian lynx (*Lynx lynx* L., 1758) and wild boar inhabit arid sparse and moist broadleaf forests, so their response to climate change would depend on forest-specific pressures of warming (Khorozyan *et al.* 2009).

3.5. Effects of anthropogenic disturbance and climate on hamster populations

A study on population dynamics of the Chinese striped hamster (*Cricetulus barabensis*) showed that an overall climate change might be expected to increase the population level. However, anthropogenic disturbances, such as flood irrigation could help to prevent this population increase in a long run. This is because that though warmer weather increased the population size in non-breeding seasons, this effect, however, was counteracted by the negative effect from the flood irrigation (anthropogenic disturbances) in breeding seasons. This study also showed that anthropogenic disturbance should be considered as another integral component of population responses while studying the effect from climate change. (YAN *et al.* 2012)

3.6. Global change and ant population

Researches on ants were carried out in the context of BCGC mostly included genetic, genomic and behavioral studies on the invasive ant species *Cardiocondyla obscurior* and related species

The ant genus *Cardiocondyla* comprises about 100 species, mostly from tropical Asia, Africa, and Australia, of which several have been distributed worldwide through human activities. One or several *Cardiocondyla* species reliably occur in anthropogenically disturbed habitats around the world, including beaches on Pacific islands, plantations in South America, and parks in Southern Europe. Though the ants have not reached pest status and are relatively inconspicuous, their abundance in these ecosystems raises the question about how they interact with native taxa and if they spread by replacing other ants from their nesting sites.

During the studies on *C. obscurior*, it was found that transposons are concentrated in particular genomic (TE) islands of this ant. A comparison between two introduced populations, one from Okinawa, Japan and the other from Bahia, Brazil, indicated that most genetic differences between the two samples are found in or near these TE islands. They are currently investigating further whether transposons may ease invasion.

In addition, they investigated what happens when ants introduced from two different source populations meet and crossbreed. They found that crossbreeding leads to a decrease of female longevity and fecundity in *C. obscurior* and a second species, *C. itsukii*. These data suggest that multiple introduction may have a negative effect on the success of invasive ant species, as previously also documented for invasive Argentine ants.

They also studied the phylogeography of the clonal ant *Platythyrea punctata*, which occurs widely in anthropogenic habitats throughout the Caribbean. They found that the invasion success depends on the clonality of the species, while in its original habitat colonies are characterized by sexual reproduction and recombination. (Heinze *et al.* 2018).

4. Impacts on community changes

4.1. Anthropocene and defaunation

BCGC scientists found that there are omnipresent evidences that human impact on earth configures a newly recognized era, the Anthropocene. One of the features of the Anthropocene is the decimation of animal life—global extinction, population loss and declines in local abundance of remaining populations, a process increasingly referred to as Defaunation.

Research shows that this defaunation represents not only the loss of animal life, but also leads to a plethora of cascading consequences of global change. Under conditions of intense defaunation, ecosystems (e.g., Neotropical rain forests) undergo changes in understory plant-mammal interactions, including the local extinction of mammalian herbivory and disruptions of seed predation, ultimately affecting plant establishment and forest understory diversity. Decimation of animals that operate as vehicles of resources (e.g., seabird declines in Central Pacific islands) leads to changes in nutrient subsidies, in turn unleashing a cascade of changes, including nutrient dynamics and food chain length. Large mammal defaunation due to context-dependent site productivity, land use change and hunting/poaching (e.g., in African savannahs), brings about thriving of smaller species, such as rodents, and this changes the risks of rodent-borne disease in humans. They collectively indicate that the current pulse of Anthropocene defaunation deserves to be recognized as another major global environmental change (*Dirzo et al 2016)*.

4.2. Effect of climate change on small rodent community

It is widely believed that the current accelerating climate change imposes a great threat to biodiversity. Many published studies also suggest that climate warming may cause a dramatic decline in biodiversity, especially in colder and drier regions. A study based on the 1982–2006 data collected in the semi-arid grassland in Inner Mongolia, China, however, showed that this is not always the case.

In the study, the effects of temperature, precipitation and a normalized difference vegetation index on biodiversity indices of rodent communities in the current or previous year for both detrended and nondetrended data were employed. Statistic analysis showed that temperature produced predominantly positive effects on the biodiversity of small rodents; precipitation, both positive and negative; a normalized difference vegetation index, positive. This could imply that an increase in temperature may benefit plant growth and extend the growing season, and thus supporting coexistence of additional species by increasing herbaceous food resources (Jiang *et al.* 2013).

4.3. Impact on species interactions

A research in montane Arizona, USA showed that climate impacts on a plant–animal interaction can have forceful ramifying effects on plants, birds and ecological interactions (Martin *et al.* 2012). As the effects of climate on plant communities may provide an alternative influence on animal populations because plants provide habitats, the researchers experimentally tested the hypothesis that declining snowfall indirectly influences plants and associated birds by allowing greater over-winter herbivory by elk (*Cervus canadensis*). They excluded elk from one of 2 paired snowmelt drainages (10 ha/drainage), and replicated this paired experiment across 3 distant canyons. Over 6 years, they reversed multi-decade declines in plant and bird populations by experimentally inhibiting heavy winter herbivory associated with declining snowfall. Their results did show the contribution of climate change to declining populations of organisms and it also provided an answer to how changing climate drives phenological mismatches between animals and their food. In addition, the statistics from the research showed that predation rates on songbird nests decreased in exclosures, despite higher abundances of nest predators, which demonstrated the over-riding importance of habitat quality (Martin *et al.* 2012).

4.4. Impacts on lizard community

Experiments both in the field and laboratory demonstrated that despite seasonal variation in ambient temperatures, female lizards in the desert steppe of Inner Mongolia, China selected warm and moist nests to improve the growth and survival of their offspring. Low precipitation aggravated the impact of extreme high temperatures on lizard reproduction, and the vulnerability of lizards to climate warming differed between sympatric species. Desertification significantly decreased the abundance and diversity of lizards and simplified invertebrate-lizard food webs. The change in the lizard community is attributable to physical and predation differences among habitats. Further experiments showed that early eggs produced high-quality offspring, but late eggs only produced high-quality offspring at falling incubation temperatures.

Those results demonstrated that climate warming and desertification will threaten the survival of desert lizards, although some species could develop certain strategies in response to adapt themselves to environmental changes (Du, *et al*. 2018).

5. Impacts on biological invasion

5.1. Impacts on biological invasions of moth

Through a simultaneous survey of the phenological development of the populations of pine processionary moth conducted at 25 sites in 10 countries during the winter 2014-2015, BCGC scientists found that winter warming released the barriers of pine processionary moths, *Thaumetopoea pityocampa* (Lépidoptère: Notodontidae) and allowed them to colonized in new areas northwards and upwards. The processionary moths' larvae develop in winter and their survival is highly sensitive to a certain limited temperature variation. It was until the early 1990s, however, that their distribution range was constrained by thermal barriers in certain areas. This thermal barriers release also caused invasive and sanitary consequences both in large forests and human living areas as the larvae are highly urticating for both forests and human beings.

As a matter of fact, the pine processionary moth constitutes an outstanding model for exploring the relationships between global warming and insects. This Mediterranean species in origin is one of the few insect species selected by IPPC for its range expansion observed towards higher latitudes and altitudes in recent years due to the global climate change, especially temperature increase in winter (Roques *et al.* 2018).

5.2. Biological invasion in biodiversity hotspots

To understand the locations of potential invasion hotspots and the extent to which they overlap with biodiversity hotspots so as to help prioritize efforts to reduce the impacts of alien species on global biodiversity, scientists on BCGC used ensembles of species distribution models based on climate, anthropogenic predictors, vegetation, and water resources to predict global potential invasion hotspots for alien herpetofauna (reptiles and amphibians). The research found that potential richness of alien herpetofauna per grid cell (the minimum unit of spatial variables for modeling and projecting) in biodiversity hotspots is nearly 1.4 times higher than in other regions on average when subjected to current and future climate scenarios. Furthermore, potential invasion hotspots are projected to occupy a large proportion of the total area within the studied biodiversity hotspots. Those results suggest that biodiversity hotspots are at greater risk from alien herpetofaunal invasions than that are in other regions. It was suggested that regions with the greatest environmental suitability for future invasions by alien herpetofauna are concentrated in global biodiversity hotspots, and they may be threatened by future alien herpetofaunal invasions to a greater extent than other less-disturbed regions that host fewer threatened but endemic species. The results also provide key information for targeting globally early detection and rapid-response programs to help prevent or mitigate future impacts of alien herpetofauna on biodiversity (Li *et al.* 2016).

5.3. Impacts on spread rates of alien species

In order to study the ability of species to disperse in response to climate change, BCGC scientists used a global sample of alien reptile and amphibian introductions to try to figure out the effects of human activities, species traits and characteristics of the invaded range on spread rates. Research results show that spread rates vary remarkably among invaded locations within a species, and differ across biogeographical realms. Their spread rates are positively related to the richness of native congeneric species and human-assisted dispersal in the invaded range, but negatively correlated with topographic heterogeneity. This finding helps greatly highlight the importance of environmental characteristics and human-assisted dispersal in developing robust frameworks for predicting species range shifts, especially in light of global change (Liu *et al.* 2014).

6. Impacts on wildlife conservation

6.1. Flood exposure and conservation priority

Studies on taxa exposure to floods, one of extreme climatic events that likely to increase in the coming decades and to have severe consequences on biodiversity, might help identify priority areas for conservation of species prone to climatic impacts and improve the benefit of conservation investments. To carry out those studies, scientists investigated contemporary flood exposure and species internal refugia for amphibians, birds, and mammals within the 32 terrestrial Priority Areas for Biodiversity Conservation (PABC) in China.

Research results found that amphibians comprised the greatest number of species at significant flood exposure followed by mammals and birds (~90%, ~81%, ~52% of the total species richness in the country, respectively). However, availability of flood-free internal refugia N10% and ≤25% was found for ~15% mammals, ~29% birds and ~1% amphibians. Further analysis found that species in these areas possessing traits that contribute sensitivity and low adaptability to flood disturbance are the ones expected to face negative delayed effects from past exposure, or to possess less resilience to future impacts, including human activities.

In face of those multiple threats, it is suggested that conservation actions in flood-prone areas and refugia (e.g., landscape connectivity, habitat restoration, afforestation) should be strengthened to better assist in the allocation of limited resources for protecting vulnerable species (AMECA *et al.* 2016).

6.2. Land sharing and sparing for conservation

On the roles of land management strategies of land sharing vs. land sparing, BCGC scientists used a 65-year dataset from northeastern China to evaluate the roles of government social policies in resolving human-wildlife conflicts and improving human livelihood.

Research statistic analysis showed that under such policies from 1998 to 2015, regional human population density decreased by 59.6% and forest volume logged was reduced by 62.6%. As a result, both big cat populations and their habitats have increased. The annual increase rate for the Amur tiger is 1.04 and for Amur leopards, 1.08, though their population remained small.

The numbers also demonstrate that the over exploitation of forest resources and big cat declines under previous unsustainable land use in the region are progressively being reversed under the land sparing policy. However, the research also indicated that large economic investment and intense human-relocation projects coupled with efforts to reduce poaching and illegal hunting or trapping could be a complex social and ecological synergy, especially in big cat conservation (Jiang *et al.* 2017).

6.3. Impacts on species losses

A quantitative study by scientists on BCGC demonstrated that the estimated proportion of species loss of 252 key protected vertebrate species at the county level in China during

the past half century was 27.2% for all taxa, 47.7% for mammals, 28.8% for amphibians and reptiles, and 19.8% for birds. Further study showed that both human population increase and species richness correlated significantly positive with species loss of all taxa combined, mammals, birds, and amphibians and reptiles. The increase of temperature was also positively correlated with all-taxa and bird species loss. Precipitation increase, however, was correlated negatively with species loss of birds. Consequently, it is very likely that the current ongoing human environmental and climate changes are expected to perpetuate more negative effects on the survival of key vertebrate species, particularly in species richness and high-biodiversity regions (He *at el.* 2018).

6.4. Impacts on amphibians

Starting in the 1980s, BCGC scientists have drawn attention to amphibian declines across the world, not uniformly but affecting some areas and some taxa more than others. Researchers find that over 40% of amphibian species are at some risk of extinction, and the number may be higher because of lack of knowledge of many species, especially those that have been recently discovered. It is believed that amphibians are the most imperiled vertebrate group and may be an indicator that we have entered the period of a sixth mass extinction.

They also discover amphibians are particularly vulnerable to global change, both directly due to their sensitive physiology and indirectly from synergistic effects leading to new diseases and other unanticipated factors.

A dramatic discovery was that new fungal diseases are highly significant factors in amphibian decline. These are among the most potent wildlife diseases ever recorded. Spread and intensity of disease is accentuated by global climate change.

The most widespread is caused by the fungus known as *Bd*, which is thought to have originated in Eastern Asia near the middle of the 20th century and to have spread worldwide since. Recent evidence suggests that human-mediated spread, both incidental and accidental, such as through the pet trade, may be to blame for the global reach of the pathogens.

A second deadly chytrid fungus, known as *Bsal*, especially affects salamanders, and is especially troubling for its potential to spread. So far, the epizootic is isolated to a small region in northwestern Europe, but the potency is great and it is known to affect many species (Wake *et al.* 2018).

7. Others

7.1. Impacts of light pollution

The most significant environmental global change that our plant faces is Artificial Light at Night (ALAN). No doubt, ALAN changed our human lifestyle and brought with it blessing to humans as working hours were extended, health services and social economic activities, such as power station operation and transportation can go on for 24h a day. Furthermore, ALAN also used for ornamental and decoration purposes as well as for advertisement on billboards. However, research by scientists on BCGC found that ALAN also has negative effects both on natural ecosystems as well as on human health.

The human eye as that of other mammals has a dual function in picking signal. The classic cons and rods pick signals that are connected with images and colours known today as Image Forming Photoreceptors (IFP). For the clear function of IFP, daylight is very imported as darkness limits the ability of these photoreceptors to pick up signals of images due to the lack of blue light. In this case, ALAN with high intensity of blue light has a great advantage as we can see the images at night.

However, as being exposed more and more to ALAN, especially the Light Emitting Diodes (LED) bulbs based on short wave length (SWL) emission and that considered more

efficient than traditional incandescent bulbs, the blue light signal produced by LED suppresses the production and secretion of the pineal neuro-hormone melatonin whose plasma levels increase when the blue light disappearances at night.

Melatonin, known as a "Jack of all traits" hormone, is involved in sleep cycles, in function of different physiological systems and immune system. Apart of those, melatonin is a very important antioxidant and anti-aging agent as well as an anti-oncogenic agent in regards to breast and prostate cancers. Nowadays, more and more information obtained from various studies supports more and more the major claim that ALAN is more and more becoming a new source of pollution or known today as a source of toxicity.

As the world worries about global climate change, emerging from increase in CO_2 from power stations and the use of more inefficient illumination to reduce CO_2 level, it is urged that a reasonable and sustainable solution should be found to avoid this unnecessary global light pollution, ALAN, which is proved to be a great risk to both human health and ecological system (Haim *at el.* 2018).

7.2. Early Cretaceous evolution under climate change

The Early Cretaceous represents a geological time from 145 to 100 million years ago. It records some of the most significant geological and paleoenvironmental events across the earth, such as sea floor spreading, volcanic eruptions, and the occurrence of the paleogeomagnetic Cretaceous Normal Superchron. This period is also characterized by an increase of atmospheric CO_2 and a greenhouse climate that reached a peak in the middle Cretaceous with a global annual mean temperature 3-10ºC higher than today.

However, paleontologists discovered from their research that during this geological interval occurred the first flowering plants, the greatest diversification of insects, the first radiation of birds and the first appearance of powerful bird flight, the earliest appearance of eutherian and metatherian mammals, and the appearance of feathers and arboreal adaptation in various theropod dinosaurs. The Early Cretaceous Jehol Biota from Northeast China, about 131-120 millions years old, is characteristic of exceptional preservation and a rare diversity and abundance of fossils, comprising the best evidence for understanding biological evolution at this critical geological time.

Paleontologists found that in the Early Cretaceous, there was also a general body size increase among major vertebrate groups, i.e. birds, dinosaurs, pterosaurs and mammals, possibly as a response to global temperature increase. Furthermore, study found that the Early Cretaceous also marks the emergence of the modern terrestrial ecosystem, providing the first example of pollinating insects, specialized seed-eating birds and pterosaurs, diverse herbivorous theropod dinosaurs and scansorial mammals, suggesting that floral evolution had played a key role in the evolution of these animals (Zhou *et al.* 2009).

Conclusion

To conclude, our earth has been facing rapid global change since the last century and these changes remain unabated. Our planet together with its environment is in a state of flux, and has been so throughout its history. In light of this, BCGC will be a permanent topic as long as there are organisms on our planet. Furthermore, when we use data from past, the objectives will be to try to model conditions in the future. This has been one of the fundamental objectives of BCGC over the last decade.

The studies, researches and investigations that have been made through BCGC scientists have highlighted many of the taxonomic relationships and challenges that humanity has to face. These include insights into the diversity and evolution of organisms in the geological past; the global distribution and phylogenetic relationships of both fossil and extant taxa; how environmental change has contributed to the demise of some taxa – but sometimes

to the advantage of others; what the ways are that we should apply to our resource management; and what sustainable approaches we should take to preserve our biosphere.

It is encouraging to see than BCGC has successfully realized its major goals the last decade. It has already constructed an international platform to attract scientists of different countries and disciplines to work together, and it has carried out several fruitful projects, and produce significant outputs which provided novel insights into the impacts and mechanism of global change on many organisms.

However, given that our earth's biota is evolving, our detailed knowledge is still limited to a very small percentage of the living and fossil organisms on this planet. We still have a long way to go to further understand the mechanism of BCGC, but we must continue improve our international co-operation mechanisms, as it is only through the development of useful inventories of the species within the biosphere and effective international collaboration, that we will have the capacity to mitigate our environmental degradation, and thus, be widely cognizant that humanity is "*a part of nature, not apart from it* (Buckeridge 2018)."

In order to continue endeavors to complement those tasks above, BCGC will further deepen its international cooperation with more scientists from more fields and disciplines worldwide to work together in revealing the biological mechanism and consequences of climate change, and in providing practical measures in coping with challenges and problems that in front of us under the accelerated global change.

The near future priorities are set out as below:

1. To collaborate with other programs (e.g. Future Earth) or organizations (e.g. IPCC);
2. To expand research network in more countries and attract more scientists to participant in related studies and activities;
3. To develop research tools for solving complex impacts of global change;
4. To setup BCGC database;
5. To provide advisory reports to government or non-government agencies;
6. To raise funds to complement those tasks.

Appendixes

Progress Updates

December 2017: Some oral presentations make by BCGC scientists in the year:

- Stenseth, N. C., "*A unified biology during the 21st century and its impact on our lives and our environment."* The 9th International Symposium of Integrative Zoology, 27-37 Aug 2017, Xining China
- Maho, Y. L., "*How to get undisturbed control animals in field investigations."* The 9th International Symposium of Integrative Zoology, 27-37 Aug 2017, Xining China
- Buckeridge, J., "*Conservation and the status of non-endemic taxa."* The 9th International Symposium of Integrative Zoology, 27-37 Aug 2017, Xining China
- Buckeridge, J., *"Responding to climate change. How austral Megabalaninae (Cirripedia: Thoracica) fared during the Pleistocene.*" Monash University, Melbourne, VIC. Australia, 13th Sept, 2017
- Heinze, J., *"The queens, the workers, and the grim reaper."* Uniwersytet Jagielloński w Krakowie, Krakow, Poland, 22 Apr 2017
- Heinze, J., *"Aging and reproduction in social insects."* Università degli Studi di Parma, Parma, Italy, 27 Mar 2017
- Li, X., "*Spatiotemporal dynamics of a recovering population of the crested ibis (*Nipponia nippon*) in central China."* The 9th International Symposium of Integrative Zoology, 27-37 Aug 2017, Xining China
- Jiang, G. "*Ecological thresholds for tiger conservation."* The 9th International Symposium of Integrative Zoology, 27-37 Aug 2017, Xining China
- Xie, Y. "*Promote protected area friendly development with a focus on Russian Mongolian and Chinese bordering areas."* 20-21 November 2017, International Symposium on China-Mongolia Cross-border Wildlife Conservation and Management, Beijing, China
- K S Anoop Das, *"The climate change's effect on the changing avian fauna in the Tropics."* Workshop on the Development of an Integrative Ocean Research Network-Germany, Cruise Terminal Ostseekai in Kiel, Germany, 4-5 Dec 2017
- K S Anoop Das, *"The effect of climate change on birds – a case study."* Conference on Marine Biosphere Research for A Sustainable Ocean, Woods Hole Oceanographic Institute, Woods Hole, MS, USA, 2-6 Oct 2017
- K S Anoop Das, *"Costal biodiversity and the people- a discourse on the perspectives."* Annual conference of the Centre for Oceans Law and Policy Conference on Marine Environment & UN Sustainable Development Goal, Hyatt Regency Yogyakarta, Indonesia, 16-19 May 2017
- Juarez, E. I. A., *"Identifying sensitivity traits for the world's Primates."* XXVIII Congress of the Primatological Society of Brasil. Pirenopolis, Brasil, 21 Aug 2017
- Roques, A., "Global change is triggering a much faster expansion of non-native insects established in Europe during the last decades." 3rd international congress on biological invasions (ICBI), Hangzhou, China, 19-23 November 2017
- Roques, A., "Are non-native forest insects recently established in Europe spreading faster than before?" IUFRO 125th Anniversary Congress, Freiburg, Germany, 18-22 September 2017
- Roques, A., "How human activities and climate change interact to trigger Arthropod invasions and their further spread after establishment? " *Keynote invited speaker*. ESENIAS (East and South European Network for Invasive Alien Species) Training Course, Sofia, Bulgaria, 3-4 April 2017

Articles published by BCGC scientists:

- *Scale-dependent climatic drivers of human epidemics in ancient China* by Huidong Tian, Chuan Yan, Lei Xu, Ulf Büntgen Nils C. Stenseth, and Zhibin Zhang, www.pnas.org/cgi/doi/10.1073/pnas.1706470114, 2018
- *Climate warming and humans played different roles in triggering Late Quaternary extinctions in east and west Eurasia* by Xinru Wan and Zhibin Zhang, Downloaded

from http://rspb.royalsocietypublishing.org/ on March 22, 2017

September 2017: The Fifth International Symposium INVASION OF ALIEN SPECIES IN HOLARCTIC (Borok - V) was held in the ancient Russian city of Uglich, September 25-30, 2017, within the framework of the BCGC program supported by both IUBS and ISZS. Over 100 scientists from 18 countries attended the meeting. Prof. Yury Dgebuadze, a member of the BCGC program Committee, was one of the main organizers of the meeting.

August 2017: BCGC organized a session during the 9th International Symposium of Integrative Zoology in Xining, the capital city of Qinghai province in China 27-31 August 2017. Over 150 scientists from over 20 countries attended the Symposium. Yaping Zhang, Academician and Vice President, CAS; Nils Stenseth, Professor of University of Oslo, Norway, Academician, the Norwegian Academy of Science and Letters, and the Immediate Past President, IUBS; Jiansheng Jia, Deputy Director, Department of Wildlife Conservation and Nature Resource Management, State Forestry Administration, China; Huaigang Zhang, Director of NWIPB, CAS delivered remarks at the opening ceremony, which was chaired by Zhibin Zhang, the leader of the program and a professor at IOZ, CAS.

11 speakers delivered oral presentation under the topic - Biological Buffers and the Impacts of Climate Change.

- *Thermal Sensitivity of Terrestrial Ectotherms in a Warming World* by Raymond B. Huey from Department of Biology, University of Washington, USA;
- *How biologists model ecological and evolutionary impacts of climate change,* Michael Angilletta, Arizona State University, USA;
- *Buffers and amplifiers: behavioural thermoregulation as a key moderator of climate change impacts,* Susana Clusella Trullas, Stellenbosch University, South Africa;
- *A high temperature-induced egg diapause in a morabine grasshopper results in a univoltine life cycle and buffers thermal extremes,* Michael R. Kearney, School of BioSciences, The University of Melbourne, Australia;
- *Predicting survival in a changing climate: unexpected consequences of Individual variation in body temperature and thermal physiology,* Mark Denny, Stanford University, USA;
- *Buffering extreme climate through ontogeny variation in thermal tolerance,* Chun-Sen Ma, Climate Change Biology Research Group, State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, China;
- *Importance and limitations of genetic adaptation as a buffer to climate change,* Luc De Meester, University of Leuven, Belgium;
- *Buffering climate change effects through evolutionary adaptation: can gene pool mixing help?* Ary Anthony Hoffmann, University of Melbourne, Australia;
- *Energetic and life history consequences of cold adaptation in Drosophila melanogaster,* Caroline Williams, University of California, Berkeley, USA;
- *A global test of the cold-climate hypothesis for the evolution of viviparity*, Liang Ma, Key Laboratory of Animal Ecology and Conservation Biology, Institute of Zoology, Chinese Academy of Sciences, China;
- *Extinction of Phrynocephalus lizards due to climate change: from the hottest to the coldest places in the world,* Barry Sinervo & Qi Yi, University of California, Santa Cruz, USA & Chinese Academy of Sciences, China.

November 2016: BCGC organized 3 symposia during the 22nd International Congress of Zoology in Okinawa, Japan 14-19 November 2016. Over 1,100 participants from 31 countries and regions around the world attended the Congress. The 3 symposia were 1) Biological Consequences of Global Change (BCGC), 2) Physiological Responses to Global (or Climate) Change: Patterns and Process, and 3) Plant-animal interaction. 25 scientists from 10 countries delivered oral presentations during the symposia.

- Yiming Li (Institute of Zoology, CAS, China): *Determinants of range sizes of terrestrail vertebrates*
- Jacob Jens (Julius Kühn-Institut, Germany): *Climate change increases human risk of hantavirus infection by driving bank vole population dynamics via seed mast*
- Fumin Lei (Institute of Zoology, CAS, China): *Phylogeographical process of birds in response to the climate change*
- Alain Roques (INRA- Zoologie Forestiere Centre de echerche d'Orléans, France): *PCLIM, an international research network about the adaptive response of processionnary moths and their associated organisms to global change*
- Hongxuan He (Institute of Zoology, CAS, China): *Emerging infectious diseases and global change*
- Dgebuadze Yury Yu (A.N. Severtsov Institute of Ecology and Evolution, RAS, Russia): *The impact of global change on the biological invasion of alien species and biodiversity of Russia and adjacent territories*
- Xinhai Li ((Institute of Zoology, CAS, China): *The effects of global change on the spatial distribution patterns of the* Galliformes *in the world*
- Xinru Wan (Institute of Zoology, CAS, China): *Both climate warming and humans attributed to late Quaternary extinctions in east and west Eurasia*
- Eric Isaí Ameca y Juárez (University of Veracruz, Mexico): *Vulnerability assessment to hurricane-driven population declines: An implementation for terrestrial mammals in Mexico*
- William Karasov (University of Wisconsin, USA): *Temperature effects on Northern leopard frogs chronically exposed to persistent organic pollutants*
- Noga Kronfeld –Schor（Tel Aviv University, Israel）: *The effects of light pollution on daily rhythms and seasonal acclimation in different rodent species*
- Weiguo Du (Institute of Zoology, CAS, China): *Phenotypic plasticity facilitates lizards to cope with increased variability in ambient temperature*
- Nina Vasilyeva (A.N.Severtzov Institute of Ecology & Evolution, Russia): *Torpor in Campbell's hamster (*Phodopus campbelli*)*
- Dehua Wang (Institute of Zoology, CAS, China): *Physiological adaptations to changing environments in small mammals*
- Denies Dearing (Molecular Biology Program, University of Utah, US): *Temperature-dependent toxicity*
- John R Speakman (University of Aberdeen, UK): *Heat dissipation and climate change effects*
- Xueying Zhang (Institute of Zoology, CAS, China): *Food hoarding and nueroendocrinological mechanism in Mongolian gerbils*
- Vander Wall (Nevada University, USA): *Geographical variation in North American seed-dispersal mutualisms*
- Michael Steele, (Wilkes University, USA): *How Interacting Strategies of Resistance, Tolerance, and Attraction Drive the Oak Dispersal Syndrome*
- Youbing Zhou (Institute of Botany, CAS, China): *Nonsynchronous recovery of obligate seed dispersal mutualism after a catastrophic storm*
- Takuya Shimada, (Forestry & Forest Products Research Institute FFPRI, Japan): *Within-plant variability in seed characteristics and its effects on foraging behaviors of seed consumers*
- Bo Wang (Xishuangbanna Botanical Garden, CAS, China): *Tree-to-tree variation in seed size and its consequences for seed dispersal versus predation by rodent mutualists*
- Hongmao Zhang (Huagzhong Normal University, China): *Effects of burying on nutritional contents of seeds and seed discovery ability of rodents: a testing of nutritional attenuation hypothesis*
- Xianfeng Yi (Jiangxi University, China)：*Long-term chronic nitrogen deposition alter interactions between seeds and food hoarding animals*
- Sarita Maree (Department of Zoology, University of Pretoria, South Africa): *The endangered Juliana's golden mole: Planning for protection in the face of dire anthropogenic threats and environment change*

July 2016: A symposium on BCGC was held at the 8th International Symposium of Integrative Zoology: 25-29 July 2016, Xilinhaote, Inner Mongolia, China with the theme as "Response and Adaptation of Animals to Rapid Global Change." Over 100 scientists from countries, such as Russia, Mongolia, India, Pakistan, Israel, Myanmar, Thailand, the Philippines, Iran, Malaysia, Bangladesh, USA, UK, France, German, Australia and China attended the Symposium. Over 60 scientists and scholars delivered oral presentations on their scientific work and research and 4 sessions with particular topics were organized at during the symposium. Of those oral presentations included "Climate change and sustainable development" by Dahe Qin; "A unified biology: six blind scientists and the elephant in the room, a parable for environmentally mediated diseases (with a focus on plague)" by Nils Chr. Stenseth; "How emperor penguins cope with climate change" by Yvon LE MAHO; "Using beta diversity metrics to detect global change" by Marcel Holyoak; "Global dramatic decrease in the range and synurbization phenomenon of the Common hamster (Cricetus cricetus)" by Alexey Surov; "The multi-faceted consequences of defaunation in the Anthropocene" by Rodolfo Dirzo; "Impacts of climate-driven beech masts on irruption of invasive species and conservation of indigenous birds and invertebrates in New Zealand" by Roger Pech, "Ants in a Globalized World" by Jürgen Heinze; "The fate of an endangered species in the Yangtze River：Challenges and Conservation Opportunities" by Ding Wang; and "A novel global change emerging from chasing darkness away – its possible impact on mammals and humans health" by Abraham Haim, as plenary lectures. Of the 4 sessions with particular topics included Rodent Biology and Management, Wildlife Disease and Climate Change, Eco-physiology and Conservation Biology, and Long-term Monitoring at the Joint Research Station of Animal Ecology.

May 2016: Workshop Global Change Impact on Diseases and Alien Species was held in Cape Town, South Africa, May 2-6 2016. The Workshop was supported by both IUBS and ISZS. Over 60 scientists attended the meeting. Prof. Yury Dgebuadze, a member of the BCGC program Committee, was one of the main organizers of the meeting, and he delivered a lecture on "Global Changes and Biological Invasion of Alien species."

December 2015: A symposium on BCGC was held at the 32nd IUBS General Assembly14-16 December 2015 in Berlin, Germany. 12 speakers delivered speeches on BCGC:

- Chunxu Han, Secretary General, International Society of Zoological Sciences (ISZS): *The IUBS/ISZS's program, Biological Consequences of Global Change (BCGC)*
- Yury Dgebuadze, Academician of Russian Academy of Sciences (RAS); Deputy Director, A. N. Severtsov Institute of Problems of Ecology and Evolution RAS: *Global Change and Fish Diversity in Central Asia*
- Jürgen Heinze, Professor, LS Zoologie, Evolutionsbiologie, Universität Regensburg, Germany: *Ants in a Globalized World*
- Fuwen Wei, Professor, Institute of Zoology, Chinese Academy of Sciences, China: *Global climate shifts drive the population fluctuation of giant pandas*
- Christelle Robinet, INRA- Zoologie Forestiere, France: *A model insect for global change, the pine processionary moth*
- Xianfeng Yi, Professor, College of Life Science, Jiangxi Normal University, Nanchang, Jiangxi, China: *Temperature-directed seed masting and its influences on population fluctuations of small rodents*
- Hongxuan He, Professor, Institute of Zoology, Chinese Academy of Sciences, China: *Wildlife Borne Diseases Surveillance and Prevention in China*
- Abraham Haim, Professor, Faculty of Science and Science Education, University of Haifa, Israel: *Biological Consequence of Global Change – The Disappearance of Dark Nights*
- Xinhai Li, Associate Professor, Institute of Zoology, Chinese Academy of Sciences: *Historical declines of 11 mammals in China and associated driving forces*
- Hiroyuki Takeda, Professor, Department of Biological Sciences, Graduate School of

Science, University of Tokyo, Japan: *Epigenetic and environment in fish*

- Wenhua Xiong, Senior Engineer and Executive Editor, Integrative Zoology (INZ): *Introduction on INZ's efforts for BCGC*
- Nils Chr. Stenseth, President of the International Union of Biological Sciences; Past President of the Norwegian Academy of Science and Letters; Research professor of Ecology and Evolution at Department of Biosciences, University of Oslo, Norway: *Concluding Remarks*

Dr Zhibin Zhang delivered summary report on the BCGC program to the IUBS GA and the IUBS passed a resolution to extend the BCGC program for another triennium.

September 2015: Dr Zhibin Zhang delivered presentation on BCGC at the International Conference on Central Asian Ecosystems 8-10 September 2015 in Ulaanbaatar, Mongolia.

August 2015: A symposium on BCGC was held at the 7th International Symposium of Integrative Zoology (ISIZ) 25-28 Aug 2015, Xi'an, China. Over 160 scientists from 16 countries attended the Symposium. The theme of the Symposium was "Wildlife Monitoring and Data Collection under Global Change." 9 plenary lectures and 8 sessions were organized. The 9 plenary lectures were "New technology to monitor wild animals at population scale while reducing human disturbance" by Yvon LE MAHO; "Approaches to studying the effects of climate change on species interactions" by Marcel Holyoak; "Re-thinking about our ecosystems in a non-monotonic way" by Zhibin Zhang; "Adaptive evolution to the specialized bamboo diet by giant pandas" by Fuwen Wei; "Long-term CMR studies in Mastomys natalensis in Tanzania" by Herwig Leirs; "Fossil first appearances of animal phyla: the Cambrian explosion" by Xingliang Zhang; "A clash of cultures: conservation vs. development in a 21st century urban setting" by John St J S Buckeridge; "Chemical communication in free-living and parasitic nematodes" by Rebecca A. Butcher; "Medaka fish (Japanese killifish) as a vertebrate genome model" by Hiroyuki Takeda; and "Epigenetic modifications in response to environmental changes a new approach to environmental studies" by Abraham Haim. The 8 sessions were Wildlife Disease and Climate Change, Animal-plant Interaction, Bird Evolution, Biological Invasion, Herptile Biology and Conservation, Wildlife Camera Trapping Monitoring, Eco-physiology, and Biodiversity and Conservation.

December 2014: Alain Roques, a member scientist in the BCGC program edited a book entitled "Processionary moths and climate change: An update". The book is published by Springer and it contains 427 pages written by 101 authors from 22 different countries.

November 2014: A symposium on BCGC was held at the 6th International Symposium of Integrative Zoology (ISIZ) 24–25 November 2014 in Beijing. 10 scientists from China, Norway and Netherlands delivered oral presentations on animal population and wildlife borne diseases under global change. The ISIZ was co-organized by ISZS, IOZ, CAS and China National Committee for International Union of Biological Sciences (CCIUBS). The Sponsors and Supporters were Bureau of International Cooperation, CAS; Department of International Affairs, China Association of Science and Technology (CAST); Department of Society Affairs and Academic Activities, CAST; Department of Life Science, National Natural Science Foundation of China (NSFC); Department of Forest Management, State Forest Administration of China (SFA); China Zoological Society; International Union of Biological Sciences (IUBS); and John Wiley & Sons, Inc.

August 2014: A symposium on BCGC was held during the 5th International Conference on Rodent Biology and Management (ICRBM) on 25 August 2014 in Zhengzhou, China. 13 scientists from 7 countries (Canada, Israel, New Zealand, Tanzania, China, South Africa and Norway) delivered oral presentations on BCGC at the symposium. Professor Zhibin Zhang, leader of the BCGC program, delivered a plenary lecture on "Large-scale manipulative experiments reveal accumulative effects of livestock grazing on Brandt's

vole populations in stepped grassland" right after the opening of the Conference. The 5th ICRBM was organized by the Institute of Zoology (IOZ), Chinese academy of Sciences (CAS); China National Committee for International Union of Biological Sciences (CCIUBC) and Zhengzhou University, and it was supported by the International Union of Biological Sciences (IUBS); Bureau of International Cooperation, CAS; Department of International Affairs and Department of Society Affairs and Academic Activities, China Association for Science and Technology; Department of Life Science, National Natural Science Foundation of China.

October 2013: Dr Zhibin Zhang delivered presentation on BCGC at the Annual Meeting of the Ecological Society of China 17-19 October 2013, Nanchang, Jiangxi province, China.

September 2013: The 4th International Symposium Borok-IV with the theme of Invasion of Alien Species was held in Borok, Russia 22-28 September 2013 within the framework of the BCGC program supported by both IUBS and ISZS. Over 100 scientists from 16 countries attended the meeting. Dr. Zhibin Zhang, the BCGC program leader, Vice-President, IUBS and President, ISZS, and Prof. Yury Dgebuadze, a member of the BCGC program Committee, Vice-President, IUBS, were at the meeting. Both of them delivered oral speeches at the symposium on their scientific research on alien species and the BCGC program.

June 2013: The program organized a BCGC Workshop at the Grassland Ecosystem Research Base of IOZ, CAS in Xilinhot, Inner Mongolia, China, 29–30th June 2013. 15 scientists from 6 countries attended the Workshop. Haiqing Chen, Secretary General of the Xilingol Government; Fusheng Li, Head of Xilingol Forestry Department; Xiang Bao, Head of Xinlingol Grassland Station; and Liguo Hong, Head of Xinlinhot Pastures attended the Workshop. Participants of the Workshop also visited the Xilinhot Field Research Station of Plant Protection Institute, the Agricultural Academy of Sciences, China.

June 2013: An ISZS Institutional Member meeting was held on 29th June 2013, Beijing, China. Chunxu Han, the ISZS Secretary General delivered a special presentation on the BCGC program.

June 2013: The ISZS had its 5th International Symposium of Integrative Zoology was held 25–28th June 2013 in Beijing, China. The theme of the symposium is "Biological Consequences of Global Change (BCGC)." Chunxu Han, the ISZS Secretary General delivered a special presentation on the program. Nearly 100 scientists from 13 countries attended the Symposium and over 50 people reported their research on BCGC. Yaping Zhang, Vice President and Academician at CAS, Yingnan Liang, Deputy Director, Department of International Relations at China Association for Science and Technology (CAST), Le Kang, Director of IOZ and Academician at CAS, and Nathalie Fomproix, Executive Director of the International Union of Biological Sciences (IUBS) spoke at the Opening Ceremony, chaired by Zhibin Zhang, Professor at IOZ, CAS, President of ISZS and Vice President of IUBS. Other honourable guests at the ceremony included John Buckeridge, President Emeritus of ISZS and honorary Editor-in-Chief of Integrative Zoology (INZ), the official journal of ISZS; Jean-Marc Jallon, Immediate Past President of ISZS; Abrahan Haim, Vice President of ISZS; Yoshitaka Nagahama, Vice President of ISZS; Ronghui Su, Deputy Director General of Bureau of Major Research and Development Programs, CAS; Jinghua Cao, Deputy Director General of Bureau of International Cooperation, CAS; Jianhui Jin, Bureau of Planning, CAS; Xiaobo Ren, Bureau of Major Research and Development Programs, CAS; Zhenliang Yu and Ling Chen, Life Science Division, China National Natural Science Foundation, and many others.

June 2013: The program organized and published another special issue on BCGC in journal, *Integrative Zoology* (8.2), edited by Zhibin Zhang. The published articles are:

- *Biological Consequences of Global Change: past and future* (page 123); Zhibin ZHANG; Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12043
- *Applying various algorithms for species distribution modeling* (pages 124–135); Xinhai LI and Yuan WANG; Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12000
- *Biological consequences of global change for birds* (pages 136–144); Anders Pape MØLLER; Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12006
- *Review and synthesis of the effects of climate change on amphibians* (pages 145–161); Yiming LI, Jeremy M. COHEN and Jason R. ROHR; Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12001
- *Climate warming increases biodiversity of small rodents by favoring rare or less abundant species in a grassland ecosystem* (pages 162–174); Guangshun JIANG, Jun LIU, Lei XU, Guirui YU, Honglin HE and Zhibin ZHANG; Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12027
- *Experimental evaluation of reproductive response to climate warming in an oviparous skink* (pages 175–183); Hongliang LU, Yong WANG, Wenqi TANG and Weiguo DU; Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12025
- *Influence of geography and climate on patterns of cell size and body size in the lizard Anolis carolinensis* (pages 184–196); Rachel M. GOODMAN, Arthur C. ECHTERNACHT, Jim C. HALL, Lihan D. DENG and Jessica N. WELCH; Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12041
- *Extreme developmental temperatures result in morphological abnormalities in painted turtles* (Chrysemys picta): a climate change perspective (pages 197–208); Rory S. TELEMECO, Daniel A. WARNER, Molly K. REIDA and Fredric J. JANZEN; Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12019
- *Artificial nesting habitats as a conservation strategy for turtle populations experiencing global change* (pages 209–221); John P. WNEK, Walter F. BIEN and Harold W. AVERY; Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12042

21 September 2012: Zhibin Zhang, leader of the program, delivered a plenary speech on BCGC at the Annual Meeting of Mammal Sub-Society of China Society of Zoology held at Shenyang Normal University, Liaoning province, China.

3 September 2012: At the 21st International Congress of Zoology held at the University of Haifa, Israel, the program organized a section on BCGC. Chunxu Han, assistant leader of the program, presented an introduction and progress on the program. Zhibin Zhang, leader of the program, delivered a research presentation on “Agricultural irrigation mediates climatic effects and density dependence in population dynamics of Chinese striped hamster in North China Plain.” Xinhai Li, another assistant leader of the program, presented his research on “*Climate change and human impact caused retreat on large mammals in ancient China.”*

July 2012: At the 31st IUBS General Assembly at the Taihu Lake International Conference Center in Wuzhong, Suzhou, Jiangsu, China. Zhibin Zhang, Leader of the program, did a presentation on the program and proposed to the GA to renew the program for another 3 years, i.e. next triennium. In the end, also based on the recommendations of the IUBS "Scientific Program Committee," the General Assembly adopted the proposal and proved unanimously to implement the BCGC program for the next triennium (2013-2015).

5 July 2012: The program organised a symposium of Biological Consequences of Global Change (BCGC) + Integrative Climate Change Biology (iCCB) on 6 July 2012 during the 31st IUBS General Assembly and Conference on Biological Sciences and Bioindustry at the Taihu Lake International Conference Center in Wuzhong, Suzhou, Jiangsu, China. The symposium organizers are Zhibin Zhang and Nils Chr. Stenseth. The speakers, as well as the titles of their speeches, are set out as below:

- John Buckeridge: Barnacles (Cirripedia: Thoracica) - tenacious opportunists who

have demonstrated extraordinary adaptive resilience to environmental change
- David B. Wake: Direct and Indirect Effects of Anticipated Climate Change on Amphibians
- Thomas E Martin: Climate change influences on trophic interactions that affect breeding bird and plant communities
- Jussi Eronen: Mammal traits and environment: Molar tooth crown height and precipitation
- David Nogués-Bravo: Why we do not have mammoths in our backyard? Species extinctions under climate change
- Chuan Yan: Climate and irrigation affect the population dynamics of Chinese striped hamster in North China Plain
- Hari Sharma: Biological consequences of climate change on arthropod diversity, pest management, and food security
- Klara Lokos Toth: The climate as a natural resource on the yield stability of wheat
- David Polly: Traits, habitats, and changing climates: ecometrics and vertebrate locomotion
- Simon Morley: Using regions where biodiversity and ocean warming hotspots overlap to predict physiological responses to climate change
- Brian Helmuth and Mackenzie Zippay: Forecasting sublethal impacts of climate change in marine ecosystems: sometimes the details make all the difference
- Mikael Forteilus: Retrospective on the iCCB Programme: how it came to be and why
- Raimundo Real: The pure effect of climate on species distribution
- Xinhai Li: Applying species distribution models in climate change studies
- Tom Oliver: Promoting resilience or accommodating change? Aims for site and landscape management under a changing climate.

June 2012: The program organized and published another special issue on BCGC in journal, *Integrative Zoology* (7.2), edited by Zhibin Zhang. The published articles are:
- Biological consequences of global change: opportunities and challenges, *Zhibin ZHANG*
- Adélie penguins and temperature changes in Antarctica: a long-term view, Craig D. MILLAR, Sankar SUBRAMANIAN, Tim H. HEUPINK, Siva SWAMINATHAN, Carlo BARONI and David M. LAMBERT
- Direct impacts of climatic warming on heat stress in endothermic species: seabirds as bioindicators of changing thermoregulatory constraints, *Stephen A. OSWALD and Jennifer M. ARNOLD*
- Opportunism and the resilience of barnacles (Cirripedia: Thoracica) to environmental change, *John S. BUCKERIDGE*
- Is the expansion of the pine processionary moth, due to global warming, impacting the endangered Spanish moon moth through an induced change in food quality? *Charles-Edouard IMBERT, Francis GOUSSARD and Alain ROQUES*
- Global climate change is confounding species conservation strategies, *Harold KOOPOWITZ and Bradford A. HAWKINS*

June 2012: SUMMARY OF THE PROGRAM REVIEW RESULT BY H. TAKEDA: BCGC (Biological Consequences of Global Change): The scientific merit and outcome of the programme (2 workshops and 9 publications) have been well appreciated by the reviews. The theme is highly topical and strategic for the community and IUBS. The programme has become influential through the international training course organized and broad communication with EC members and scientists from China, Russia, India and so on, and further expansion can be expected in the near future. Furthermore, there are some suggestions made as to the collaboration with UNESCO and think-tank function together with iCCB. Financially the programme has been well supported by other organizations, which is an ideal situation of the IUBS scientific program in that the IUBS grant should be a seed. Overall this programme is considered as the core of IUBS scientific programmes.

October 2011: The program had a Sino-Russian Symposium on Amur Tiger Conservation

in Hunchun, Jilin Province, China, 19-21 October 2011. 21 scientists from Russia and 45 from China attended the meeting. 29 scientists and specialists delivered speeches about their work and research concerning the Amur tiger, an endangered species, in this cross-border region, including the tiger's ecology, behaviour, genomics and diseases. Prof. Fuwen Wei, Prof. Jianghua Sun and Dr Yan Xie the program were at the symposium.

August 2011: An International Training Course on New Trends and Methodology on Animal Ecology and Conservation Biology was held by the program with an aim to promote new theories, changes, and developments in methodology of animal ecology along with new technologies in the field. Over one hundred young scientists from more than thirty developing counties attended the training. Over 10 professors from the world, including Prof. Fuwen Wei and Dr Yan Xie in the program, delivered lectures at the course.

August 2011: The program organised a Workshop on wildlife –borne Diseases Control and Management in Asia-Pacific Region in cooperation with the Bureau of Life Sciences and Biotechnology, Chinese Academy of Sciences (CAS); Department of Wildlife Conservation and natural Reserve Management, State Forestry Administration (SFA), China; and Wildlife Services, Animal and Plant Health Inspection Service, United States Department of Agriculture (USDA). Over 50 scientists and mangers from 13 countries and region around the Asia-Pacific rim, including the program leader, Zhibin Zhang, came and attended.

March 2011: In 2010 *Integrative Zoology* (SCI-Medline-indexed; ISZS' official journal) published a special issue on BCGC. According to Wiley-Blackwell's (journal publishers) annual report, 9 of the top 10 most downloaded articles were from the BCGC special issue. The article 'Climate change and invasive species: double jeopardy' was the top downloaded article from *Integrative Zoology* in 2010, receiving 696 full text downloads. The article 'Some biological consequences of environmental change: A study using barnacles (*Cirripedia: Balanomorpha*) and gum trees (Angiospermae: Myrtaceae)', also published in the special issue, was featured on BBC Earth News.

March 2011: In cooperation with the Chinese National Committee for MAB Programme, the program organized a training workshop on "Climate Change and Biosphere Reserves in China" on March 30-31, 2011 at North China Electrical Power University. 17 representatives from 12 biosphere reserves in China and 6 experts from the International Society of Zoological Sciences (ISZS), the Chinese National Committee for the International Union of Biological Sciences (CCIUBS), Ms. Sarah Quig from Canadian Biosphere Reserves Association, and more than 30 graduate students participated in the training workshop.

December 2010: A special workshop on the BCGC program was held over the 4th International Symposium of Integrative Zoology in Kunming, the capital city of Yunnan province, southwestern China. Over 20 scientists attended and Dr Yan Xie delivered a presentation on the progress of the program mad in the last 3 years. Discussions were followed and consensuses were reached in the end. It is widely accepted that in the last three years, considerable progresses were made within the framework of the program. To follow up in the program, a scientific committee has to be formed and different working groups are to be set up. At the same time, specific research proposals are to be called for, a mechanism of information exchange and sharing is to be established, and a special database is consolidated. It is agreed that the qualified research proposals have to be funded with seed funds and a program paper is to be composed and released to the authorities and public concerned.

December 2010: The ISZS had its 4th International Symposium of Integrative Zoology 4-6 in Kunming, China. The theme of the symposium is "Biological Consequences of Global Change (BCGC) – Data Analysis and Sharing" and the focus of the symposium was on

how to collect and analyze data for global change research so that the scientists from around the world can work together to plot out a practical approach to establish a working mechanism for international data analysis and information sharing. Dr. Yan Xie, the ISZS Secretary General and also a scientist in the program, delivered a special presentation on the program. Over 120 researchers from 16 countries attended the symposium and the scientists in the program, Dr. Yury Dgebuadz, Dr Elena Kotenkova, Dr Liudmila Khlyap,Dr Alian Roques, Dr Hari Sharma, James Spotila, Dr Yiming Li and Dr Xinhai Li, delivered oral speeches on their scientific research in the program.

October 2010: An international symposium with the theme of Invasion of Alien Species was held in Myshkin, Russia 5-9 October 2010 within the framework of the BCGC program. About 100 scientists from 13 countries attended the meeting. Dr. Zhibin Zhang, a BCGC program leader, was a Co-President of the symposium and Dr. Yury Dgebuadz, also a BCGC program leader, was Vice President of the Scientific Committee of the symposium. Dr. Nathalie Fomproix, Executive Director, IUBS, also attended the symposium. Mr. Chunxu Han, coordinator of the BCGC program, delivered a presentation on the BCGC program. Scientists in the program, Dr. Yury Dgebuadz, Dr Jianghua Sun, Dr Yiming Li and Dr Xinhai Li, delivered oral speeches at the symposium on their scientific research in the program.

June 2010: Dr. Fuwen Wei, a leading scientist in the Program, presented a progress report to the Chinese Academy of Sciences (CAS). The presentation included a synopsis of recent BCGC work on the impact of climate change on biodiversity and endangered species as well as bio-disasters in Asia, Europe, Australia and America. The CAS is satisfied with the progresses made in the Program and has guaranteed its continued support. In addition, the IUBS has approved a €15,000 grant for the implementation of the BCGC Program in 2010.

June 2010: The program organized and published a special issue on BCGC in journal, *Integrative Zoology* (5.2), edited by Nils Chr. Stenseth. The published articles are:

- *The Biological Consequences of Global Change.* Nils Chr. STENSETH
- *Ecometrics: the traits that bind the past and present together.* Jussi T. ERONEN, David P. POLLY, M FRED, J DAMUTH, DC FRANK, V MOSBRUGGER, Christoph SCHEIDEGGER, Nils Chr. STENSETH and Mikael FORTILEUS
- *Climate change and invasive species: double jeopardy*. *Susan A. MAINKA and Geoffrey HOWARD*
- *Climate Optimum rejuvenates the Mediterranean marine world*. Francis Dov POR
- *Some biological consequences of environmental change: a study using barnacles (Cirripedia: Balanomorpha) and gum trees (Angiospermae: Myrtaceae)*. *John BUCKERIDGE*
- *Direct impacts of recent climate warming on insect populations*. Christelle ROBINET and Alan ROQUES
- *Effects of Temperature and Hydric Environment on Survival of the Panamanian Golden Frog Infected with a Pathogenic Chytrid Fungus*. Heidi M. BUSTAMANTE, Lauren J. LIVO and Cynthia CAREY
- *Climate change induced range shifts of Galliformes in China.* Renqiang LI, Huidong TIAN, and Xinhai LI
- *A multi-scale approach to understanding climate effects on offspring size at birth and date of birth in a reptile.* Chloé D. CADBY, Geoffrey M. WHILE, Alistair HOBDAY, Tobias ULLER and Erik WAPSTRA

March 2010: The ISZS submitted an application to the National Natural Science Foundation of China (NNSFC) to raise more funds to support the BCGC program. At the same time, the number of researchers in the program increased from 7 to 15. The new researchers are David B. Wake at the Graduate School at the University of California, Berkeley, USA; Yury Yu. Dgebuadze at the Institute of Ecology and Evolution, the Russian Academy of Sciences; Alain Roques at the French National Institute for Agricultural

Research, France; Hari C. Sharma at the International Crops Research Institute for the Semi-Arid Tropics, India; Bernard Cazelles at the Université Pierre et Marie Curie in Paris, France; Boris I. Sheftel, Senior Scientist, the A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences; Jianghua Sun, Yiming Li and Xinhai Li at the Institute of Zoology, the Chinese Academy of Sciences, China. (For details, please refer to the Researcher Profiles at the end of this update).

January 2010: The ISZS completed a concept plan for constructing an online working platform and database for scientists in the BCGC program to communicate and share research.

October 2009: Representatives from the ISZS made a presentation on the ISZS international research program – Biological Consequences of Global Change - at the Workshop on Integrated Climate Change Biology (an IUBS scientific research program granted in 2006) before the 30th General Assembly of the International Union of Biological Sciences (IUBS) in Cape Town, South Africa. Afterwards, Dr. Zhibin Zhang submitted a proposal to integrate the ISZS international research program – Biological Consequences of Global Change – into the IUBS programs. In the end, also based on the recommendations of the IUBS "Scientific Program Committee," the General Assembly adopted Dr. Zhang's proposal and named the Biological Consequences of Global Change (BCGC) program a new IUBS International Scientific Program with Drs. Zhibin Zhang (China), Yury Yu. Dgebuadze (Russia) and Hari Sharma (India) appointed as leaders. Resolutions also passed that the IUBS would provide some seed funds to support the program.

12 July 2009: Dr. Yan Xie, the ISZS Secretary General, delivered a speech at a workshop on climate change at the 2009 International Congress for Conservation Biology in Beijing, introducing the ISZS international research program – Biological Consequences of Global Change.

9 July 2009: The ISZS had a special workshop on the ISZS international research program – Biological Consequences of Global Change. Jean-Marc Jallon, Vice-President, International Union of Biological Sciences (IUBS); Rosa Polymeni, Professor, Section of Zoology and Marine Biology, Professor, Department of Biology, University of Athens, Greece; Nils Chr. Stenseth, Professor, Centre for Ecological & Evolutionary Synthesis (CEES), Department of Biology University of Oslo, Norway; Alain Roques, Director, Zoology Forestry, French National Institute for Agricultural Research; Jeffrey A. McNeely, Chief Scientist, IUCN (International Union for Conservation of Nature); Abraham Haim, Professor, Biology and Geography, University of Haifa, Israel; Yan Xie, Associate Professor, Institute of Zoology, Chinese Academy of Sciences, China; Zhibin Zhang, Professor, Institute of Zoology, Chinese Academy of Sciences, China; and John Spotila, President, The Global Cause Foundation, were at the workshop. Consensuses were reached that climate change is happening and effecting biological species around us and biological consequences of global change are important to our future. However, these scientists concluded that current research on biological consequences of global change is insufficient. As a result, international research programs, such as ISZS program for biological consequences of global change, are necessary and timely.

8 July 2009: The ISZS had its 3rd International Symposium of Integrative Zoology (ISIZ) in Beijing with the theme "Biological Consequences of Global Change." Over 130 scientists and researchers from over 25 countries in the world attended the symposium. Eighty-three attendees delivered academic speeches and presentations on biological consequences of global change and related scientific topics. The ISZS Secretary General, Dr. Yan Xie, delivered a special presentation on the ISZS international research program – Biological Consequences of Global Change at the opening session of the symposium.

7 July 2009: The ISZS had an online visual conference with the United States National

Science Foundation (NSF) on the ISZS international research program – Biological Consequences of Global Change. The NSF is interested in the program and expressed its strong intent to support the program.

June 2009: John Buckeridge presented an overview of how marine conditions in Australasia are reflected in changes to barnacle fauna. He also expressed that he would very much like scientists in Asia to complement this research with data from their region. In particular, he is interested in marine systems. The objectives are to use the past to model the likely future marine conditions.

March 2009: The ISZS worked with the IUBS and integrated the international symposium of biological consequence of climate change with the IUBS program Darwin 200 Symposium, with the theme of biological consequence of climate change.

February 2009: In order to put the program into action, the ISZS planned an international symposium with a focus on the biological consequence of climate change to be held from 8 to 10 July 2009 in Beijing.

January 2009: The ISZS had a meeting at the IOZ China to introduce and promote the program. Dr. John Buckeridge and Dr. Mauricio Lima Arce sent over research progress on the program to the ISZS Secretariat. Dr. Yan Xie, Secretary General, ISZS, delivered a presentation on the progress of the program at the meeting. Representatives from CAS, CAST, TNC, CI, IFAW and Peking University were at the meeting. They all expressed their support for the program and would like to integrate their work in the program where possible.

December 2008: The ISZS produced a Call for Expressions of Interest to participate in the program and disseminated it to potential researchers and co-sponsors. Dr. Anwar Tumur, College of Life Sciences and Technology, Xinjiang University, China, and Dr. Igor Khorozyan from Armenia, wrote to the ISZS to confirm their willingness to participate in the program. The Earth and Oceanic Systems Research Group, at RMIT University, Australia, expressed their interest to integrate their research into the program.

October 2008: The Chinese Academy of Sciences set the ISZS research program as a Key International Cooperation Program and granted RMB900,000 (USD130,000) in seed funding.

August 2008: The 20th International Congress of Zoology (ICZ) was held in Paris, France. Dr. Zhibin Zhang delivered a speech on the BCGC program at the General Assembly of the ISZS. A resolution was passed that “the ISZS will be the coordinating body and all are invited to participate.”

June 2008: The Biological Consequences of Global Change research program was established. Seven leading scientists from five countries across five continents indicated their interest to participate in the program. They are Nils Chr. Stenseth from the University of Oslo, Norway; Kung-sik Chan from the University of Iowa, USA; Mauricicio Lima Arce from Pontificia University, Chile; John Buckeridge from RMIT University, Australia; and Zhibin Zhang, Fuwen Wei and Yan Xie from Chinese Academy of Sciences, China.

Integrative Zoology Special Issues

5.2 Content

7.2 Content

8.2 Content

List of selected publications by BCGC member scientists

1. Kelly, M.; Edwards, A. R.; Wilkinson, M. R.; Alvarez, B.; Cook, S. de C.; Bergquist, P. R.; **Buckeridge, J. S.**; Campbell, H.; Reiswig, H. M.; Valentine, C. and J. Vacelet, 2009. Phylum Porifera Sponges. *In* Gordon, D.P. (*Ed.*): *The New Zealand Inventory of Biodiversity* Volume 1: 23-46. Kingdom Animalia: Radiata, Lophotrochozoa, and Deuterostomia. Canterbury University Press, Christchurch, New Zealand.
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49. **Xinhai LI** and Yuan WANG: *Applying various algorithms for species distribution modeling* (pages 124–135); Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12000
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51. **Yiming LI,** Jeremy M. COHEN and Jason R. ROHR: *Review and synthesis of the effects of climate change on amphibians* (pages 145–161); Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12001
52. **Guangshun JIANG**, Jun LIU, Lei XU, Guirui YU, Honglin HE and **Zhibin ZHANG**: *Climate warming increases biodiversity of small rodents by favoring rare or less abundant species in a grassland ecosystem* (pages 162–174); Article first published online: 4 JUN 2013 | DOI: 10.1111/1749-4877.12027
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