Summary Report
Biological Consequences of Global Change
An ISZS/IUBS International Research Program (2008-2018)

A contribution to the celebrations of the 100th Anniversary of International Union of Biological Sciences (IUBS), 130th Anniversary of the International Congress of Zoology (ICZ) and 15th Anniversary of the International Society of Zoological Sciences (ISZS)
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. 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 monotonic 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, El Nina and Southern Oscillation (ENSO) and Northern Atlantic Oscillation (NAO) 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 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. The BCGC program was launched by International Society of Zoological Sciences (ISZS) in 2008, and adopted by International Union of Biological Sciences (IUBS) in 2009. During the past 10 years, BCGC has organized over 38 meeting and training courses. Over 350 people delivered invited speeches, and over 1100 people participated in various activities of BCGC (Appendix 1). BCGC has published 1 book, 3 special issues and 1 virtue species issue in Integrative Zoology, and over 20 papers in the other journals (Appendix 2, 3). These activities have significantly deepen our understanding on the biological consequences of global change, 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 supports to the program.

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

Dr. Zhibin Zhang
Professor, Institute of Zoology, Chinese Academy of Sciences
Program Leader, Biological Consequences of Global Change (BCGC)
President, International Society of Zoological Sciences (ISZS)
Editor-in-Chief, Integrative Zoology
Remarks by Prof. Hiroyuki Takeda, President of IUBS

The International Union of Biological Sciences (IUBS), established in 1919, is a non-governmental and non-profit organization consisting of national academies and international scientific associations and societies. IUBS has been providing a global platform for cooperation and interaction among scientists from all disciplines and nationalities to promote research, training, and education in biological sciences. IUBS currently unites more than 110 national, scientific, and institutional members.

The Biological Consequences of Global Change (BCGC) programme is a great example of the scientific programmes supported by IUBS in relation with one of its scientific members, ISZS, the International Society of Zoological Sciences. Climate Change is one of the most significant issues of our times. The BCGC programme, lead by Prof. Zhibin Zhang, aims to address the impact of global change on biological invasion of alien species, on outbreaks of diseases, insects and rodent pests, on community structure and biodiversity of different ecosystems. The BCGC programme was first approved in 2009 at the 30th IUBS General Assembly and then supported and renewed at the following General Assemblies in 2012 and 2015. Currently, over 50 scientists from 15 countries participated in the programme. The programme organized training workshops and symposia, 3 special issues (25 papers) were published in Integrative Zoology, 5 papers in PNAS, PRSB, GCB. I, as the President of IUBS appreciates the great achievement of BCGC and recognizes BCGC as the best honor student.

Finally, IUBS is happy to celebrate the 10 years’ fruitful activities and collaboration with BCGC and IUBS.

Hiroyuki Takeda
The President of International Union of Biological Sciences
Professor and Dean, School of Science, University of Tokyo
Remarks by Dr. Nathalie Fomproix, Executive Director of IUBS

The Biological Consequences of Global Change (BCGC) programme was initiated by ISZS, the International Society of Zoological Sciences, in 2018 and it was presented and approved at the 30th General Assembly of IUBS, the International Union of Biological Sciences, in South Africa in 2009 as a triennial scientific programme of the Union. One of the roles of IUBS is to initiate and facilitate research, education and capacity-building, and other scientific activities that require international and interdisciplinary cooperation.

In this respect, the BCGC programme is a great example on how active partnership between IUBS members can help addressing major environmental problems. The BCGC programme was successfully renewed in 2012 and 2015 at the General Assemblies as a core programme of IUBS.

The climate change problem is complex and requires multi-disciplinary approaches. During the last decade, the objectives of this programme, led by Prof. Zhibin Zhang, were to enhance our understanding of the impacts of climate change on animals and their environments, coordinate collaborative research by studying outbreaks of biological disasters, invasion of alien species, and biodiversity of different ecosystems. The programme has become influential through the organization of the conferences, symposia, international training course and though the publication of many articles, the newsletter and the website.

Thus, it is with great pleasure that we will celebrate in 2019 a productive decade of cooperation and scientific results with the BCGC programme.
Remarks by Prof. John Buckeridge, Past President of IUBS and ISZS

Humans are having a deleterious impact on the Earth’s biosphere. This is not simply because there are too many of us; rather it is because of our unsustainable activities, which are resulting in an ever-increasing environmental footprint. This footprint, which is a measure of the resource use required to sustain our population, now extends beyond what is appropriate for a species in a finite setting.

Humans are unique amongst the species that inhabit this planet because unlike others, we have the ability to consciously plan for the distant future. This ability to plan is not simply “gathering nuts” as a squirrel may do, but it is an ability to effectively model environmental and resource-use patterns that can have both positive and deleterious impacts upon the planet. Humans are thus bio-stewards, whether we wish this imprimatur or not. Further, we are the only species on Earth that can consciously do something about the environment.

Over the few last decades, there has been increasing public awareness of the impact of human activities. Unfortunately, much of this has been simplified by politicians and well-meaning activists as there being simply too much carbon dioxide in the atmosphere. This reduction ad absurdum has been promoted by many as the sole solution to halting environmental change. However, carbon dioxide levels (at least at the current and immediate projections) are not the biggest threat to the environment. Rather it is the waste we produce and ultimately dump in the oceans. Environments do change, and we have testament to this in the Earth’s geological record. In many instances in the planet’s geological past, change has been very rapid indeed (e.g. when a medium sized meteorite strikes), but human-derived pollution is now so ubiquitous and so insidious that we must act with great urgency. We have all seen the effects of plastics on the charismatic megafauna of our oceans (e.g. seas, fish turtles) but these animals are at the top of the food pyramid, and are sustained by smaller organisms that are perhaps not so charismatic, but nonetheless pivotal for the survival of life on Earth. These “hidden” organisms are now very much under threat.

In 2013, Watts & Buckeridge proposed the Biological Imperative in which humans are seen as a part of (rather than apart from) Nature. Humans clearly have obligations to future generations, and it follows that we have an obligation to not irreversibly compromise their environment. Thus, any working model for resource management must be that in Nature, justice is inter-temporal and must embrace all life found in the Earth’s biosphere.

This holistic approach to environmental management must underpin all human activities, for without it, we will no longer have a biosphere to protect. It is thus
most heartening to see the progress that has been made within IUBS’s Biological Consequences of Global Change programme, where through good science and effective international communication, we can, and are, making a difference. It has been an honour to be part of this programme; long may it continue.

Dr. John St J. S. Buckeridge PhD, FGS
Professor Emeritus, RMIT University, Melbourne
Research Associate, Museums Victoria, Melbourne
President Emeritus, International Society of Zoological Sciences, Beijing
Past President, International Union of Biological Sciences, Paris
Member of the Hungarian Academy of Sciences, Budapest
Honorary Editor-in-Chief, Integrative Zoology

Reference

Remarks by Prof. Nils Chr. Stenseth, Past President of IUBS

Biological Consequences of Global Change: this century’s greatest challenge

The major objectives of the Biological Consequences of Global Change (BCGC) IUBS program – having run for 10 years (2008-2018) – have been:

- To understand the changes in species populations, 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 invasions, 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.

This IUBS-funded program has been a very successful one. I would like to make a few comments on each of the five major objectives.

Understanding ecological changes at several levels of organization, resulting from global changes, has been one of the objectives. To understand how both individuals and populations respond to climate and other alterations is a key to understanding the ecological effects of the ongoing global changes. These effects might be direct and indirect – typically non-linear. The BCGC program has contributed profoundly to an improved understanding of these ecological changes.

Such direct and indirect effects of global changes are difficult to understand, especially in their dynamics – how the ecological system might change with respect to its temporal and spatial dynamics? This is particularly challenging as ecological systems are inherently complex. Again, the BCGC program has contributed profoundly to an improved understanding of dynamics in complex ecological systems.

One of the major ecological effects of changing global climate is that species are invading regions they have not inhabited recently. Such spatial changes will, in general, lead to altered ecological interactions – and hence changing ecological dynamics. Species extinctions are often one of the ecological consequences of such spatial changes. Infectious diseases with wildlife...
reservoirs are important systems in need of improved understanding. Again, the BCGC program has contributed profoundly to an improved understanding of global change on biological invasions, infectious diseases and biological disasters.

Among the objectives of BCGC is to set up mechanisms for integrating and exchanging data and information internationally – an objective which has been very successful, exemplified by how plague scientists throughout the world have contributed to a better understanding of its transmission ecology and history. This is highly linked to the final objective of the BCGC program, namely setting up a global network of scientists – an objective which to a large extent has been facilitated through a series of meetings.

I am pleased to congratulate BCGC – and its leaders – with a very successful 10-year program. It has been a great pleasure to be part of this development.

It is very important that this work is continued.

Nils Chr. Stenseth
Professor of ecology and evolution, the Centre for Ecological and Evolutionary Synthesis (CEES) at the University of Oslo, Norway
Past President, International Union of Biological Sciences
BCGC structure

Program leader
ZHANG, Zhibin (China)

Advisory committee members (in alphabetical order of family name)
BUCKERIDGE John St J. S. (Australia); CHARLES, Krebs (Canada); DGBUADZE, Yury Yu. (Russia); DIRZO, Rodolfo (USA); FOMPROIX Nathalie (France); HEINZE, Jürgen (Germany); HOLYOAK, Marcel (USA); LE MAHO, Yvon (France); ROQUES, Alain (France); SHARMA; Hari C. (India); STENSETH, Nils Chr. (Norway); WAKE, David B. (USA); WEI, Fuwen (China).

Team members (in alphabetical order of family name)
ANGILLETA, Michael (Australia); AMECA, Eric (Mexico); AWAN, Muhammad Naeem (Pakistan); BARNOSKY, Anthony (USA); BUCKERIDGE, John St J. S. (Australia); CAZELLES, Bernard (France); CHAN, Kung-Sik (Canada); DAS, K.S Anoop (India); DGBUADZE, Yury Yu. (Russia); DIRZO, Rodolfo (USA); DU, Wei-guo (China); HAN, Chunxu (China); HAIM, Abraham (Israel); HE, Jinxing (China); HEINZE, Jürgen (Germany); HOLYOAK, Marcel (USA); JIANG, Guangshun (China); KHOROZIAN, Igor (Armenia); KLYAP, Liudmila A. (Russia); KOTENKOVA, Elena (Russia); LE MAHO, Yvon (France); LI, Xianping (China); LI, Xinhai (China); LI, Yiming (China); LIMA, Mauricio (Chile); LIU, Xuan (China); MARTIN, Thomas E (US); MASWANGANYE, Kgaogelo Amanda (South Africa); MAREE, Sarita (South Africa); MØLLER, Anders Pape (France); MORLEY, Simon (UK); ROQUES, Alain (France); SASIKALA, G. (South Africa); SHEFTEL, Boris I. (Russia); SHARMA, Hari C. (India); SUN, Jianghua (China); STENSETH, Nils Chr. (Norway); TIAN, Huidong (China); XIE, Yan (China); XIONG, Wenhua (China); YAN, Chuan (China); WEI, Fuwen (China); WAKE, David B. (USA); ZHANG, Wei (China); ZHANG, Zhibin (China); ZHOU, Zhonghe (China)

Secretary (Assistant program leader)
HAN, Chunxu (China)
Background

In the 21st century, the earth is facing great challenge of accelerated global change such as biodiversity loss, pest outbreaks and disease transmission. Intensified human disturbances and climate warming have greatly shaped our ecosystems. There is an urgent need to reveal the impacts of global change on our ecosystems in order to take effective measures to manage these challenges.

To study the biological consequences of global change needs international cooperation of global zoologists. Therefore, the International Society of Zoological Sciences (ISZS) launched an international research program – Biological Consequences of Global Change (BCGC) – in 2008 to promote international scientific research, communication between scientists and information exchange so as to improve our understanding and forecasting of potential agents of BCGC. BCGC was adopted by International Union of Biological Sciences (IUBS) in 2009.

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 pest animals;
- Disease transmission;
- Biological invasion of alien species;
- Range shifts of endangered species;
- Species extinction and biodiversity loss;
- Ecological non-monotonicity.

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 the USA, France, United Kingdom, Germany, Norway, Canada, Australia, Chile, Mexico, India, Israel, South Africa, Russia, Armenia, Pakistan and China.

**Major activities**

Currently, there are over 100 worldwide scientists involved in the program. In the last decade, various academic events were organized under the flagship of BCGC, including international congresses, general assemblies, conferences, symposia, workshops, seminars and training courses. BCGC has organized over 38 conference/symposia/workshop/training courses. Over 350 people delivered invited speeches, and over 1100 people participated in various activities of BCGC. BCGC has published 1 book, 3 special issues and 1 virtue species issue in Integrative Zoology, and over 20 papers in the other journals including PNAS and Climate Change Biology. BCGC’s activities cover almost all branches of biology, such as morphology, anatomy, physiology, neurology, behavior, reproduction, genetics, evolution, geographical distribution; from macro to micro systems (ecosystem, species, biocoenosis, individual, molecular); and is inter-disciplinary covering diverse areas such as industry, agriculture, forestry, urbanization, mutualism, climate change, bio-adaptation, population dynamics, diseases, invasive species, computer, statistics and bioethics.

The theme of those BCGC included data collection, analysis and sharing; wildlife monitoring; adaptation under extreme environments; endangered species survival strategies and habitats; wildlife-borne diseases; invasive species. Various events 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.
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 editors from scientific journals, such as Ecology Letters, Nature and Science were also invited to the events.

In addition, the BCGC program organized several field trips 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).

The program organized 3 special issues on BCGC in Integrative Zoology, a 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 (Xiong et al. 2018; Zhang at al. 2018). For details, see Appendix 1 and 2.

During the past decade, with the support of IUBS and ISZS, BCGC team scientists have made significant progress in revealing the biological consequences of global change. In general, the recent rapid global warming has greatly shaped our ecosystems at various levels from physiological,
molecular, behavioral, to the ecological level. Global change will bring increasing risk of species extinction, biological invasion, disease transmissions and pest outbreaks for some regions and taxa, but the impacts are complex, and often non-monotonic, highly depending upon the systems, scales and taxa, due to complicate interactions between biotic and abiotic factors. Besides, our current 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 in order to further understand the mechanism of BCGC. Thus, we must continue to improve our international co-operation mechanisms under the flagship of BCGC.

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 global change, and in providing practical measures in coping with challenges and problems that are in front of us under 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 networks 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 a BCGC database;
5) To provide advisory reports to government or non-government agencies;
6) To raise funds to complement those tasks.
Appendix 1. Outlines of BCGC activities (2008-2018)

Jan-Dec, 2018. Meetings/conferences/ workshops organized

1. The 3rd Training Course on Wildlife Monitoring and Camera Trapping; Date: 22-29 April 2018; Place: Xishuangbannan, China; Number of participants: 150
2. The Exhibition on Coordination Man and Biosphere to Protect Life Community; Date: 30-31 July 2018; Place: Beijing, China; Number of participants: 400
3. The 6th International Conference on Rodent Biology and Management and the 16th Rodent et Spatium; Date: 3-7 Sept 2018; Place: Potsdam, Germany; Number of participants: 300
4. The 2018 Annual Meeting of the International Alliance of Protected Areas; Date: 13-14 Sept 2018; Place: Changbaishan, China; Number of participants: 450
5. The 10th International Symposium of Integrative Zoology; Date: 27–31 Oct 2018; Place: Beijing, China; Number of participants: 150
6. The Asia-Pacific Forest Invasive Species Network Training Workshop – Developing Skills in Forest Protection: an Integrative Approach; Date: 23-27 Oct 2018; Place: Beijing, China; Number of participants: 40
7. The Symposium on the Pan-Third Pole Environment Study for a Green Silk Road (Pan-TPE) ; Date: 4 Nov 2018; Place: Beijing, China; Number of participants: 700
8. The World Forum on Integrative Zoology; Date: 13 Dec 2018; Place: Beijing, China; Number of participants: 100

October 2018. Oral presentations at BCGC session in Beijing

1. **Jiang, Guangshun**, Land Sharing and Land Sparring Reveal Social and Ecological Synergy in Big Bat Conservation, the 10th International Symposium of Integrative Zoology, the Institute of Zoology (IOZ), Chinese Academy of Sciences, 27–30 Oct 2018, Beijing, China,
2. **Stenseth, Nils Chr.**, Evolution and ecology of plague: A disease of today which changed our history, 2018 World Life Science Conference, 27-29 Oct 2018, Beijing, China,
3. **Zhang, Zhibin**, Impacts of global climate change on animals and diseases, 2018 World Life Science Conference, 27-29 Oct 2018, Beijing, China,
5. **Krebs, Charles J.** and **Boonstra, Rudy**, Impact of Climate Change on the Small Mammal Community of the Yukon Boreal Forest, 29 Oct 2018, 10th International Symposium of Integrative Zoology, Beijing, China
6. **Li, Xinhai**, Impact of climate change on a number of species (snow leopard, Mongolian gazelle, and white-naped crane) cross country borders, 30 Oct
2018, the 10th International Symposium of Integrative Zoology, Beijing, China


Jan-Dec, 2018. Articles published:


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

- 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., “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
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


- 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. ESENIA (East and South European Network for Invasive Alien Species) Training Course, Sofia, Bulgaria, 3-4 April 2017

**Articles published by BCGC scientists:**


- *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 terrestrial 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 recherche d’Orléans, France): *PCLIM, an international research network about the adaptive response of processionary 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 Amecay 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. Severtsov 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 neuroendocrinological mechanism in Mongolian gerbils*
- Stephen 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 (Huazhong 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 MÖLLER; 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 XIU, 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.
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: 10.1111/1749-4877.12041

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: 10.1111/1749-4877.12019

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. Chuxu 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 managers 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
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 made 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 Alain 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. *Chloë 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.
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 (BCGC) 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 Polimeni, 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; Mauricio 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.
Appendix 2: List of selected publications by BCGC member scientists

- Dgebuadze YY. 2016. Fishery and freshwater ecosystems of Russia: status,
trends, research, management and priorities //In: Freshwater Fisheries Ecology” Wiley Blackwell. p. 120-133.


Scale-dependent climatic drivers of human epidemics in ancient China; www.pnas.org/cgi/doi/10.1073/pnas.1706470114


- Wan X and Zhang Z. 2017. Climate warming and humans played different roles in triggering Late Quaternary extinctions in east and west Eurasia. Proceedings of the Royal Society B: Biological Sciences 284(1851):20162438


Appendix 3: BCGC special issues

Special issue 1:
Volume 13, Issue 4
Special Issue: Biological buffers alleviate negative impacts of climate change
Pages: 348-493
July 2018

Editorial

Biological buffers and the impacts of climate change
Raymond B. HUEY Lauren B. BUCKLEY Weiguo DU
Pages: 349-354 First Published: 03 May 2018

Reviews

Comparative studies of critical physiological limits and vulnerability to environmental extremes in small ectotherms: How much environmental control is needed?
Ary A. HOFFMANN Carla M. SGRÒ
Pages: 355-371 First Published: 23 November 2017

Genetic adaptation as a biological buffer against climate change: Potential and limitations
Luc De MEESTER Robby STOKS Kristien I. BRANS
Pages: 372-391 First Published: 23 November 2017

Original Articles

Survival in spatially variable thermal environments: Consequences of induced thermal defense
Mark W. DENNY
Pages: 392-410 First Published: 09 January 2018

Adjusting to climate: Acclimation, adaptation and developmental plasticity in physiological traits of a tropical rainforest lizard
John LLEWELYN Stewart L. MACDONALD Craig MORITZ Felipe MARTINS Amberlee HATCHER Ben L. PHILLIPS
Pages: 411-427 First Published: 09 January 2018

Oxygen supply did not affect how lizards responded to thermal stress
Agustín CAMACHO John M. VANDENBROOKS Angela RILEY Rory S. TELEMECO Michael J. ANGILLETTA Jr
Summer egg diapause in a matchstick grasshopper synchronizes the life cycle and buffers thermal extremes
Michael R. KEARNEY John DEUTSCHER Jacinta D. KONG Ary A. HOFFMANN
Pages: 437-449 First Published: 13 February 2018

Climate change, thermal niches, extinction risk and maternal - effect rescue of toad - headed lizards, Phrynocephalus, in thermal extremes of the Arabian Peninsula to the Qinghai—Tibetan Plateau
Barry SINERVO Donald B. MILES Yayong WU Fausto R. MÉNDEZ - DE LA CRUZ Sebastian KIRCHHOF Yin QI
Pages: 450-470 First Published: 13 February 2018

Cold adaptation does not alter ATP homeostasis during cold exposure in Drosophila melanogaster
Caroline M. WILLIAMS James R. ROCCA Arthur S. EDISON David B. ALLISON Theodore J. MORGAN Daniel A. HAHN
Pages: 471-481 First Published: 03 May 2018

Behavioral thermoregulation is highly repeatable and unaffected by digestive status in Agama atra
Jenna Van BERKEL Susana CLUSELLA - TRULLAS
Pages: 482-493 First Published: 03 May 2018

Special issue 2:

Volume 8, Issue 2
Special Issue: Biological Consequences of Global Change
Pages: i, 123-221
June 2013

Editorial

Biological Consequences of Global Change: past and future
Zhibin ZHANG
Pages: 123 First Published: 08 April 2013

Reviews

Applying various algorithms for species distribution modelling
Xinhai LI Yuan WANG
Pages: 124-135 First Published: 24 September 2012
Biological consequences of global change for birds
Anders Pape MØLLER
Pages: 136-144 First Published: 24 September 2012

Review and synthesis of the effects of climate change on amphibians
Yiming LI Jeremy M. COHEN Jason R. ROHR
Pages: 145-161 First Published: 19 October 2012
Abstract Full text PDF References Request permissions

**Original Articles**

Climate warming increases biodiversity of small rodents by favoring rare or less abundant species in a grassland ecosystem
Guangshun JIANG Jun LIU Lei XU Guirui YU Honglin HE Zhibin ZHANG
Pages: 162-174 First Published: 12 December 2012

Experimental evaluation of reproductive response to climate warming in an oviparous skink
Hongliang LU Yong WANG Wenqi TANG Weiguo DU
Pages: 175-183 First Published: 12 December 2012

Influence of geography and climate on patterns of cell size and body size in the lizard Anolis carolinensis
Rachel M. GOODMAN Arthur C. ECHTERNACHT Jim C. HALL Lihan D. DENG Jessica N. WELCH
Pages: 184-196 First Published: 13 March 2013

Extreme developmental temperatures result in morphological abnormalities in painted turtles (Chrysemys picta): a climate change perspective
Rory S. TELEMECO Daniel A. WARNER Molly K. REIDA Fredric J. JANZEN
Pages: 197-208 First Published: 23 November 2012

Artificial nesting habitats as a conservation strategy for turtle populations experiencing global change
John P. WNEK Walter F. BIEN Harold W. AVERY
Pages: 209-221 First Published: 13 March 2013

**Special issue 3:**

Volume 5, Issue 2
**Special Issue: Biological Consequences of Global Change**
Pages: 85-185
June 2010

Editorials

The Biological Consequences of Global Change
Nils Chr. STENSETH
Pages: 85-86 First Published: 02 June 2010

Integrative Zoology is proud to honor Darwin's legacy by supporting the study of biological and zoological sciences
John BUCKERIDGE Zhibin ZHANG
Pages: 87 First Published: 02 June 2010

Reviews

Ecometrics: The traits that bind the past and present together
Jussi T. ERONEN P. David POLLY Marianne FRED John DAMUTH David C. FRANK Volker MOSBRUGGER Christoph SCHEIDEgger Nils Chr. STENSETH Mikael FORTELIUS
Pages: 88-101 First Published: 02 June 2010

Climate change and invasive species: double jeopardy
Susan A. MAINKA Geoffrey W. HOWARD
Pages: 102-111 First Published: 02 June 2010

Climate Optimum rejuvenates the Mediterranean marine world
Francis D. POR
Pages: 112-121 First Published: 02 June 2010

Some biological consequences of environmental change: A study using barnacles (Cirripedia: Balanomorpha) and gum trees (Angiospermae: Myrtaceae)
John S. BUCKERIDGE
Pages: 122-131 First Published: 02 June 2010

Direct impacts of recent climate warming on insect populations
Christelle ROBINET Alain ROQUES
Pages: 132-142 First Published: 02 June 2010

Original Articles

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 Cynthia CAREY
Pages: 143-153 First Published: 02 June 2010
Climate change induced range shifts of Galliformes in China
Renqiang LI Huidong TIAN Xinhai LI
Pages: 154-163 First Published: 02 June 2010

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 J. HOBDAY Tobias ULLER Erik WAPSTRA
Pages: 164-175 First Published: 02 June 2010

Effect of ENSO-driven precipitation on population irruptions of the Yangtze vole Microtus fortis calamorum in the Dongting Lake region of China
Zhibin ZHANG Lei XU Cong GUO Yong WANG Yongwang GUO
Pages: 176-184 First Published: 02 June 2010

Biological Consequences of Global Change

Biological Consequences of Global Change: 4th International Symposium of Integrative Zoology Kunming, China, 4–6 December 2010
Pages: 185 First Published: 02 June 2010