MOLECULAR PHYLOGEOGRAPHY AND MUSEUM SPECIMENS: THE CASE OF THE BLACK FRANCOLIN (*Francolinus francolinus*)

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Thanks to the recent advances in molecular biology, application of archival DNA techniques for the investigation of specimens preserved in museums has come to represent an invaluable tool in conservation and evolutionary studies. The benefits of such an approach are evident with rare and elusive taxa displaying extremely wide distribution ranges. Sampling may be even more challenging with species whose range stretches over remote or politically unstable countries. As case in point, the extent of occurrence of the black francolin (*Francolinus francolinus*, Phasianidae) ranges from Cyprus across the Middle East to the Indian sub-continent, including six morphologically recognized clinal subspecies. Renowned as valuable game bird since the Classical Age, the black francolin has always aroused a considerable fascination, yet investigations on this species are still scarce. The goal of this study is getting a comprehensive insight into the phylogeographic pattern of the black francolin by means of a molecular approach to implement the available ecological data for planning management actions within an adaptive conservation framework. In order to pursue a whole coverage of the species distribution range, a number of tissues were loaned from properly selected specimens (n = 77) hosted at US and European natural history museum collections to implement the sampling of modern representatives (n = 205). All of the samples were investigated at a 185 bp-long fragment of the mitochondrial DNA Control Region. Overall, a well-marked intra-specific genetic structure largely coherent with the identification of traditional subspecies emerged, but the most interesting result was the occurrence of haplotypes ascribed to the Near East and the Indian subcontinent also in historical birds from Italy and Spain, which points to the importation of staple and rare exotic species from faraway places fueled by elite demand during the Medieval times and the Renaissance.

Welcome message

Shin-ichi Nakano
Director
Center for Ecological Research
Kyoto University

It is my great pleasure to welcome all of you to the symposium "Integrative Biology in Asia: biodiversity" at Kyoto University (KU).

In this symposium, we will focus on "macro-biology". As you know, macro-biology researchers all over the world have been tackling with environmental issues not only for local but for global scales. KU has been known that there are many macro-biology researchers in natural ecosystems.

Biodiversity is one of the most important research fields in macro-biology. This time, we are specifically focusing on the Asian biodiversity and invite distinguished Asian scientists. In the present symposium, we have gathered biodiversity researchers in KU and invited world-class researchers who have been conducting biodiversity research in local and/or global levels, under the cooperation by graduate schools, institutions and research centers in KU. We respect all your contributions and broad view on the Asian ecosystem and biodiversity, and we are convinced that all of you will be of a great stimulation for all the community in Asia.

In this symposium, we aim to integrate natural history, ecology and environmental science researchers. Cross disciplinary approach is particularly important when considering the real time issues. Through the symposium, we would like to facilitate information exchange among international macro-biology and/or biodiversity researchers for further development in those fields of research all over the world.

Hope you enjoy the symposium.

Goal of the symposium

Ecology, primatology, mammalogy, behavioral ecology, taxonomy etc…. Biological science has been divided into many disciplinaries, as the science advances. While we have many conversations within each disciplinary, we lack communications across disciplinaries even within a university. The primary goal of this symposium is to gather and help networking among variety of field biologists. Interdisciplinary approach produce interesting and innovative science, and also would help tackling to entangle the complicated natural ecosystems. Kyoto University is proud of the rich group of field biologists. We hope this symposium would initiate more interactions among scientists across disciplinary and across countries.

This time, we have particular emphasis on the topic “Biodiversity in Asia”. Asia region is exceptionally rich in biodiversity due to its geology, geological histories and diverse climatic conditions etc. Yet, Asian region is divided into many countries, and the country borders sometimes limit the exchange of information. The nature expands across the country borders, and many species distribute in multiple countries. Therefore, studies across country borders are particularly important to understand the biodiversity in Asia. We are fortunate to have guest speakers from various countries including Hong Kong, Brunei Darussalam, Korea, China, India, Nepal, Vietnam for this topic. We hope this symposium not only integrates the disciplinaries in macro-biology, but also integrates the biological studies across countries in Asia.

Please enjoy the symposium and make friends across borders!

Hiromi Uno
Executive committee of the symposium
Center for Ecological Research
Kyoto University

Symposium of Integrative Biology
February 21, 2019 <Clock Tower 2F, Kyoto University>

10:00~ Opening Remarks Shinichi Nakano Center for Ecological Research, Kyoto Univ.

10:10-11:05 Ferry Slik Universiti Brunei Darussalam
Pantropical tree floristics and diversity patterns

11:05-12:00 Hirokazu Toju Center for Ecological Research, Kyoto Univ.
Designing ecosystems with core microbiomes

12:10-12:30 Ryutaro Goto Field Science Education and Research Center, Kyoto Univ.
Diversity and evolution of spoon worms and their associated fauna

12:30-12:50 Sanjeeta Sharma Pokharel Indian Institute of Science
Lower levels of stress in crop-raiding Asian elephants: diet as a potential 'pacifier

~Lunch Time~

14:00-14:55 David Dudgeon University of Hong Kong
The next great extinction? The challenge of conserving freshwater biodiversity in a rapidly changing world

14:55-15:50 Takakazu Yumoto Primate Research Institute, Kyoto Univ.
Asian tropical forests and plant-animal interactions

~Coffee Break~

16:05-16:25 Fan Pengfei Sun Yat-Sen University, China
Ecology and Conservation of the Skywalker Hoolock Gibbon

16:25-16:45 Satoshi Nakagawa Department of Agriculture, Kyoto Univ.
Deep-sea vent bacteria: who's there, what are they doing, and what's new?

16:45-17:05 Raghavendra Gadagkar Indian Institute of Science
Beyond Species Diversity – Measurement and Apportionment of Behavioural Diversity in the Primitively Eusocial Wasp Ropalidia marginata

17:05-17:15 Invitation to the drone workshop on 2/22

17:15-17:25 DIWPA, CER-NIE MoU introduction

18:00 Group Photos & Room arrangement

18:00-20:00 Posters & Mixers (Fun time!! Light meals will be provided)

Keynotes:
Pantropical tree diversity, biomass and composition patterns

Ferry Slik (Universiti Brunei Darussalam)

Based on a database of more than 1 million trees and 15000 tree species gathered from forest inventories covering more than 500 one degree grid cells across the tropics, we determined tropical tree diversity, biomass patterns and composition. We uncovered several new and interesting patterns that have already changed our understanding of tropical tree ecology and biogeography....

Impact of the 1998 El Nino associated fires on tropical forests of eastern Borneo
abstract: In this talk I give an overview of how the 1998 fires in eastern Borneo, which burned about 3 million hectares of forest and agricultural land, affected the forests. We also monitored the first seven years of forest recovery after fire. The main question that I will try to answer during this talk is whether these burned forests are still valuable enough to preserve.

Dr. Ferry Slik did his PhD and several postdoc studies at Leiden University before moving to China, where he led a research group at the Xishuangbanna Tropical Botanical Garden (Chinese Academy of Sciences). In 2013 he moved to the Environmental and Life Sciences Department of the Universiti Brunei Darussalam. Ferry Slik has studied Asian tropical trees and the forests they live in, especially those of Borneo and China, for the past 20 years. During that period he has set up a large global network of researchers that share tree inventory data from across the tropics, resulting in the largest pan-tropical tree inventory database in the world.

Keynotes:

Designing ecosystems with core microbiomes

Hirokazu Toju (Center for Ecological Research, Kyoto University)

In an era of ecosystem degradation and climate change, maximizing microbial functions in natural and agricultural ecosystems has become a prerequisite for the future of humanity. However, managing species-rich communities of plant-associated microbiomes remains a major challenge. Informatics now allows us to identify members and characteristics of "core microbes" or "core microbiomes", which may be deployed to organize otherwise uncontrollable dynamics of natural and agricultural ecosystems[1,2].

By merging DNA metabarcoding (i.e., biological community profiling with high-throughput DNA sequencers) and network science, my colleagues and I have uncovered the structure of bacterial and fungal communities associated with diverse plant species across forest, grassland, and agricultural ecosystems[3-5]. We then found that diverse taxonomic groups of "endophytic" fungi are ubiquitously associated with plant communities, potentially playing crucial, but often overlooked, roles at the ecosystem level[3,6].

Based on the patterns found in microbe-plant and microbe-microbe networks, we have begun to design optimal core microbiomes for managing agroecosystems with high resource-efficiency and stress-resistance. Moreover, we anticipate that the multidisciplinary research platform of understanding/controlling microbiomes will be applied not only for agricultural but also for medical, pharmacological, and industrial purposes.

[1]Toju, H. *et al.* Core microbiomes for sustainable agroecosystems. *Nat. Plants* **4**, 247–257, (2018). [2]Toju, H. *et al.* Species-rich networks and eco-evolutionary synthesis at the metacommunity level. *Nat. Ecol. Evol.* **1**, (2017). [3]Toju, H., Guimarães, P. R., Jr, Olesen, J. M. & Thompson, J. N. Assembly of complex plant–fungus networks. *Nat. Commun.* **5**, 5273, (2014). [4]Toju, H., Guimarães, P. R., Jr, Olesen, J. M. & Thompson, J. N. Below-ground plant–fungus network topology is not congruent with above-ground plant–animal network topology. *Sci. Adv.* **1**, e1500291, (2015). [5]Toju, H., Tanabe, A. S. & Sato, H. Network hubs in root-associated fungal metacommunities. *Microbiome* **6**, 116, (2018). [6]Toju, H., Yamamoto, S., Tanabe, A. S., Hayakawa, T. & Ishii, H. S. Network modules and hubs in plant-root fungal biome. *J. R. Soc. Interface* **13**, 20151097, (2016).

After two-year postdoctoral research in National Institute of Advanced Industrial Science and Technology (AIST), Dr. Hirokazu Toju joined the Hakubi Center for Advanced Research, Kyoto University, as an assistant professor in 2010. Being supported by the Funding Program for Next Generation World-Leading Researchers of Cabinet Office, the Government of Japan (NEXT program), he then launched an interdisciplinary project integrating high-throughput DNA sequencing and network science. He has developed research platforms for uncovering poorly explored interactions among organisms in natural and artificial ecosystems through NEXT and JST PRESTO programs.

Lower levels of stress in crop-raiding Asian elephants: diet as a potential 'pacifier'

Sanjeeta Sharma Pokharel[1], Polani B. Seshagiri[2], Raman Sukumar[1]

[1] Centre for Ecological Sciences and [2] Department of Molecular Reproduction and Developmental Genetics, Indian Institute of Science, Bangalore-560012, India.

Assessing the stress response of wild animals has become one of the promising means of understanding their health status, behaviour and reproductive fitness; aiding in their conservation and welfare. Specifically in large-bodied animals such as elephants, where they face massive human-induced threats and habitat degradation, measuring stress response provides many vital insights about their changing health and behaviour. Particularly in case of elephants, overlapping habitats and sharing of resources with people has led to intense elephant-human conflicts (including crop-depredation by elephants) across elephant-range countries. While raiding agricultural crops, elephants face numerous threats from humans which could enhance the associated energetic costs, ultimately elevating their stress levels. Based on this, we hypothesized that elephants raiding crops (in the human-production habitat) would show higher faecal glucocorticoid metabolite (fGCM) levels, a proxy of stress-response, as compared to them who do not raid crops (in protected forests). To test this, we collected 208 fresh faecal samples from crop-raiding elephants in a human-production habitat and 394 samples from nonraiding elephants in protected forests during 2013 and 2015. Contrary to our hypothesis, fGCM levels were significantly higher in nonraiding than in crop-raiding elephants of both sexes. We further investigated the influence of benefits obtained from foraging as one of the potential factors for lower fGCM in crop-raiding elephants. This was achieved by measuring the difference in the vegetation greenness from remotely-sensed Normalized Differential Vegetation Index (NDVI), and further confirmed by measuring dietary quality (faecal nitrogen (N) content and C:N ratio as proxies for crude protein). Interestingly, higher NDVI values (greater biomass availability), higher N content and lower faecal C:N ratio (indicating higher protein content in the diet) of elephants in the human-production habitat indicated enhanced nutritional levels here as compared to protected forests. Further, there were significant correlations between faecal C:N ratio (positive) or N content (negative) and fGCM levels in crop-raiding elephants. These findings indicate that crop-raiding comes with the benefits of a superior quality diet which may help in reducing human-induced stress-response in elephants inhabiting or foraging within human-production habitats.

(The findings are published in the Animal Conservation: Pokharel, S. S., Singh, B., Seshagiri, P. B., & Sukumar, R. (2018). Lower levels of glucocorticoids in crop-raiders: diet quality as a potential 'pacifier'against stress in free-ranging Asian elephants in a human-production habitat. Animal Conservation.)

Dr. Sharma is an elephant biologist. Her PhD was on assessing the influences of various ecological and anthropogenic stressors on the stress-response of the Asian elephant. She was awarded the Nepal Vidya Bhushan A category from the President of Nepal, Government of Nepal for her PhD work. Currently, she is a post-doctoral researcher at the Centre for Ecological Sciences, Indian Institute of Science, working on how different intensity of human-threats affects stress-physiology of wild Asian elephants.

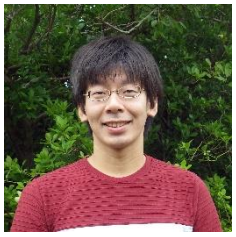
Diversity and evolution of spoon worms and their associated fauna

Ryutaro Goto (Seto Marine Biological Laboratory, Field Science Education and Research Center, Kyoto University)

About 70% of the earth surface is covered by oceans, and most ocean bottom is covered by sediments. Thus, marine sedimentary bottoms are the most widespread habitat on the Earth. A variety of taxa, including crustaceans, fishes, mollusks and annelids, reside within the marine sediments by burrowing, and their burrows often provide a novel niche for smaller symbiotic organisms. Although such benthic infaunal communities are major components of the biodiversity in marine sedimentary habitats, we still know little about how their diversity is generated.

Spoon worms (Echiura) are derived annelids that have secondarily lost segmentation. They have a sausage-shaped coelomate body with an elongate spoon-shaped proboscis. Most of them live in deep burrows in soft sediment bottom, although some inhabit crevices of hard substrata (e.g. rocks). They are known from various shallow-water habitats, including mud flats, coral reefs, and mangroves, and also from the deep sea (max depth ca. 10,210 m). Echiurans are morphologically diverse taxa. Especially, the probosces are various in size and shape as an adaptation to each feeding mode. For example, *Listriolobus* and *Ikeda* have a > 1 m long proboscis to collect organic particles on the bottom sediments, whereas *Urechis* has a very short proboscis as an adaptation to its peculiar filter feeding with a mucus net trap. Their reproductive system is also various: some echiurans exhibit a remarkable sexual dimorphism with tiny dwarf males and perform internal fertilization, whereas others are sexually monomorphic and perform external fertilization. In the present study, we investigate the evolutionary patterns of habitat shift, feeding mode, and reproductive system in spoon worms by performing a molecular phylogenetic analysis based on the combined dataset of five genes (18S + 28S + 16S + COI + H3).

Furthermore, spoon worms are known to harbor smaller symbiotic animals in their burrow. Echiuran symbionts are mostly commensals and comprise diverse taxa, including snapping shrimps, crabs, bivalves, gastropods, polychaetes and gobies. Our field surveys of echiuran symbionts in temperate and subtropical regions of Japan suggest that some groups of galeommatid bivalves are highly specialized, obligate commensals with spoon worms and that microhabitat preference and competitive exclusion of symbionts play an important role in shaping the community structure of commensal complex associated with spoon worms.



Dr. Ryutaro Goto is an Assistant Professor at Seto Marine Biological Station, Kyoto University. He has been workin on evolutionary biology, ecology and taxonomy of marine invertebrates (especially Mollusca and Annelida). His main interest is how marine organisms morphologically and ecologically diversify through adaptation to novel habitats or symbioses with other animals.

Keynotes:

The next great extinction? The challenge of conserving freshwater biodiversity in a rapidly changing world

David Dudgeon (University of Hong Kong)

Tropical East Asia is one of the most densely populated areas of the planet, and its biodiverse ecosystems are being – or have already been – profoundly altered by humans. Fresh waters are especially at risk, and widespread challenges to human water security are accompanied by declines in aquatic animals and faunal impoverishment largely characterized by reductions in populations (the 'great thinning') and mean body size (the 'great shrinking'), and widespread introduction of non-native species (the 'great mixing'). Planned and on-going water-engineering schemes, which are intended to boost economic development and decarbonize industrial output, will further degrade freshwater ecosystems. While giving rise to undeniable benefits for some human stakeholders, these schemes will also put livelihoods at risk in parts of Asia where people are heavily dependent on provision of services from freshwater ecosystems. In this presentation, I will describe the status of - and main threats to - freshwater biodiversity in tropical East Asia, a part of the Earth where the Anthropocene (human) footprint is intense and pervasive. I will then ask whether the contribution of biodiversity to ecosystem functioning and service provision provides a sufficient basis to support arguments for nature conservation. Using examples from the Yangtze and Mekong Rivers, I ask also whether the benefits accruing from intact ecosystems are likely be enough to ensure their preservation. If the answer to either or both these questions is 'no', then what are the prospects for freshwater biodiversity in Anthropocene Asia?

Dr. David Dudgeon is Chair Professor in Ecology & Biodiversity at the University of Hong Kong, where he has spent over 30 years researching the ecology, biodiversity and conservation of the animals that inhabit the streams and rivers monsoonal Asia. In 2000, Dudgeon was awarded the 10th Biwako Prize in Ecology in recognition of his contributions to freshwater ecology and conservation in Asia.

Keynotes:

Asian tropical forests and plant-animal interactions

Takakazu Yumoto (Kyoto University)

Tropical forests in Southeast Asia are among three main blocks of those in the world. The forests are distributed from Indochina and Malaysian Peninsulas to the Malay Archipelago i.e. Borneo, Sumatra, Java and other islands, and are connected to New Guinea and India-Sri Lanka in biogeographically. Tropical forests include (i) lowland rainforests (ever wet, < 600 m a.s.l.), (ii) montane rainforests (wetter, rich in mosses and lichens, > 600 m a.s.l.), (iii) monsoon forest (with distinct wet and dry seasons) and (iv) others (topographic or edaphic ones including mangroves, heath forests, swamp forests, etc.). A plant family, Dipterocarpaceae, characterizes the lowland rainforests in Malay Peninsula and Borneo Island, and mass-flowering phenomenon is a typical feature of those forests. Mass-flowering phenomenon is a type of supra-annul flowering, and many trees of the Dipterocarpaceae and other families bloom at an interval of 3-7 years. Many tropical trees depend on insects, birds and mammals as pollinating and seed dispersal agents, so that this supra-annul flowering affects on many animals, including pollinators, seed-predators, seed-dispersers. The drastic changes of those animal diversity and abundant have been recorded in Borneo Island. Also, the climatic triggers of mass-flowering and the possible effects on flowering in the near future caused by global warming have been investigated in Borneo Islands and Malay Peninsula. Recent deforestation and expands of agricultural lands cause the fragmentation and isolation of pristine tropical forests, and many larger animals, such as elephants, gibbons, hornbills were led to the local and regional extinction. These forests, no logging but no animal, are called as “empty-forests”. The regeneration and consequently the fate of empty-forests are urgent issues to be studied in this area. Information on interactions of plants and animals is becoming more and more important, when we plan the conservation, sustainable use and rehabilitation of tropical rainforests in Southeastern Asia under the strong pressure of economic development and global warming.

Dr. Takakazu YUMOTO was born in 1959. He obtained phD in the Graduate School of Science, Kyoto University. He has been studying "plant-animal inter-relationships". After getting his first job at Kobe University in 1989, he moved to the Center for Ecological Research, Kyoto University in 1994. He obtained opportunities to study Southeast Asian forests. He moved to Research Institute for Humanity and Nature in 2003 to organize a collaborating project "A new historical and cultural exploration into human-nature relationships in the Japanese Archipelago". In 2012 he moved to Primate Research Institute, Kyoto University to resume his tropical studies in Africa, Asia and South America.

Ecology and Conservation of the Skywalker Hoolock Gibbon in China

Pengfei Fan (School of Life Sciences, Sun Yat-Sen University)

Gibbons (family Hylobatidae) are small apes that live in evergreen forests in Southeast Asia. They are among the most endangered animal taxa on the Earth. Due to rapid habitat loss and insufficient research and conservation, all the 18 species of gibbons are listed as threatened on the IUCN Red List, including one Vulnerable (VU), 12 Endangered (EN), and five Critically Endangered (CR). China has a rich assemblage of gibbon species, including six extant gibbons species, and probably several extinct species. Gibbons were still prosperous in central China dated back to the Tang Dynasty (~ 600 AD), however, anthropogenic activities such as deforestation, wars, farmland expansion associated with the increase of human population gradually extirpated gibbon populations and habitats. Since 1980s, gibbons were only found in small patches in remote areas in Yunnan, Guangxi, and Hainan Provinces in southwest China. In order to protect remaining gibbon populations and their habitats, Chinese government established many nature reserves and listed all gibbon species as Class I Protected Animals in 1989, which means all gibbons were legally protected since then. However, gibbon populations continued to decline even inside nature reserves. Consequently, the last population of lar gibbon (Hylobates lar) was extirpated in Nangunhe National Nature Reserve, and the last population of northern white-cheeked gibbon (Nomascus leucogenys) disappeared in Xishuangbanna National Nature Reserve. The other four gibbon species are too in poor conditions. The skywalker hoolock gibbon (H. tianxing) is a newly described species which distribute in between the Irrawaddy River and the Salween River, in Myanmar and China. Population status of H. tianxing in Myanmar is dark because of unstable politic, war, enormous habitat destruction, and uncontrolled poaching in northeast Myanmar. In China, there were fewer than 200 individuals left according to a survey in 2009, and the remaining populations were threatened by commercial logging, poaching, agricultural encroachment, and population fragmentation. As a result, it was listed as one of the 25 Most Critically Endangered Primate Species in the 2018 International Primatological Society Conference in Nairobi, Kenya. Since 2007, my team has been working on gibbon ecology and conservation in China. I will review the conservation status of gibbons in China in general, and will focus on ecology and conservation of the skywalker hoolock gibbons during this symposium.

Dr. Pengfei Fan is a professor at the School of Life Sciences, Sun Yat-Sen University. He has been working on behavior, ecology and conservation of gibbons since 2002. He is also interested in otter ecology and conservation. He discovered two new species of primate: the white-cheeked macaque (Macaca leucogenys, 2015) and the skywalker hoolock gibbon (Hoolock tianxing, 2017). He is a founder member of a local NGO (Cloud Mountain Conservation)that is dedicated to conserve gibbons and their habitats in China. He has published over 60 papers in Biological Conservation, American Journal of Primatology, Frontiers in Zoology, etc. Prof. Fan is editoral board member of American Journal of Primatology, International Journal of Primatology, Zoological Research and Acta Theriologica Sinica.

Deep-sea vent bacteria: who's there, what are they doing, and what's new?

Satoshi Nakagawa (Kyoto University)

Deep-sea is the largest habitat on earth and is largely unexplored. Deep-sea hydrothermal fields are typically located at depths greater than 1,000 m, and can be characterized by nutrient-rich hot water emanating from the seafloor. These areas harbor the light-independent, highly productive ecosystems driven primarily by chemoautotrophs. A surprising number of invertebrates thrive there through their relationship with symbiotic chemoautotrophs, that represent one of the most surprising findings in oceans in the last 40 years.

We have analyzed ecophysiological characteristics and genomes of deep-sea vent-dominating chemoautotrophs. Chemoautotrophs are microorganisms that are able to fix inorganic carbon using a chemical energy obtained through the oxidation of reduced compounds such as hydrogen and hydrogen sulfide. Their genomes encode for multiple systems for respiration, sensing and responding to environment, and detoxifying heavy metals. In addition, population genetic analysis led to the identification of geographic barriers isolating their populations. Furthermore, genomic analysis suggested that there were previously unrecognized evolutionary links between deep-sea vent chemoautotrophs and human/animal pathogens, e.g. *Helicobacter pylori* (causative agent of gastric ulcer and cancer) and *Campylobacter jejuni* (causative agent of gastroenteritis and neuromuscular paralysis). Characteristics of deep-sea vent bacteria could provide fresh insights not only into their unusual niche on the deep seafloor, but also into the origins of virulence in our intimate pathogens.

Dr. Nakagawa is an associate professor at Kyoto Univerisity. He studies ecophysiology and evolution of “earth-eating” microorganisms. CV and google scholar are on following websites:

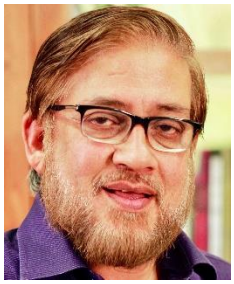
http://www.kanbi.marine.kais.kyoto-u.ac.jp/Site/CV.html

http://scholar.google.co.jp/citations?user=yl3YnUUAAAAJ&hl=ja&oi=ao

Beyond Species Diversity – Measurement and Apportionment of Behavioural Diversity in the Primitively Eusocial Wasp *Ropalidia marginata*.

Raghavendra Gadagkar (Centre for Ecological Sciences and Centre for Contemporary Studies, Indian Institute of Science)

Most studies on biodiversity are restricted to measurement, understanding the causes and consequences of, and monitoring changes in, species diversity – the numbers and relative abundances of different species in different habitats. This is such a daunting task that we have been able to devote little attention to diversity at other levels of biological organization, at the sub-organismal level of genes or at the super-organismal levels of genera, families, orders, classes and phyla. Even more neglected is the idea of behavioral diversity among different members of a given species. In this talk I will present a new approach to measure behavioural diversity, using the primitively eusocial wasp *Ropalidia marginata* as an example, and to apportion it into different hierarchical levels such as, individuals, castes, colonies and species. I will then speculate about how behavioural diversity might influence, and in turn be influenced by, social evolution.



Dr. Raghavendra Gadagkar is Honorary Professor in Centre for Ecological Sciences, Indian Institute of Science; DST Year of Science Chair Professor; the former president of the Indian National Science Academy. He is also elected as a Foreign Associate of the National Academy of Sciences, USA. His major research interest is the evolution of cooperation. His sophisticated empirical works using eusocial wasps has achieved significant contribution to the field of behavioral ecology.
http://ces.iisc.ernet.in/hpg/ragh
https://www.researchgate.net/profile/Raghavendra_Gadagkar

Poster Presentations

Name	Affiliation	Poster title
Wanyi Lee	Primate Research Institute, Kyoto University	Gut Microbe Shift of Japanese Macaques as a Result of Human Encroachment
Sayumi Yamada	Graduate School of Life Sciences, Tohoku University,	Death feigning by littral cladocerans contribute their survival rate
Hidetoshi Naganawa	The United Graduate School of Agricultural Science, Gifu University, Japan	Tadpole shrimp: a self-fertilization animal
Harold Buenvenida	Capiz State University	The Mangroves of Capiz: A Natural History
Kohmei Kadowaki	Kyoto University	Limited dispersal sustains cooperation in evolving microbial metapopulations
Shintaro Ishizuka	Primate Research Institute, Kyoto University	Rank-related success for protection against the cold in monkey huddles
Gaku Amada	Kyoto University, Agriculture	Ecological significances of leaf trichomes in Metrosideros polymorpha
Hikaru Wakamori	Primate Research Institute, Kyoto University	What kind of TAIL would you like to have? -Dose the body of an animal take the form of an optimal solution in terms of physics?-
Kobayashi Keito	Kyoto university	Life cycle of a bamboo species, Phyllostachys nigra var. henonis
Shitaro Taketomi	Kobe University	Convergent evolution of host specificity in myco-heterotrophic plants
Dian Rachmawati	Institut Teknologi Bandung	Species Richness of Soil Mesoarthropods and Soil Respiration in Coffee Plantation
Ryosuke Nakamura	Forest Sciences, Graduate School of Agriculture, Kyoto University	Silicon release from leaf litter of six tropical tree species during decomposition
Weerach Charerntantanakul	Graduate School of Global Environmental Studies, Kyoto University	Conflicts in the Yanbaru: Tankan Orange Farmers and Wildlife in Northern Okinawa Island
Kodzue Kinoshita	Wildlife Research Center, Kyoto University	Development of a field-friendly method for steroid hormone analysis of wild animals
Omweri Justus Ooga	Field Science Education and Research Center, Kyoto University	Flexible herbivory of the mysid Neomysis awatschensis (Brandt, 1851) in the Yura River estuary, central Japan
Hideki Sugiura	Wildlife Research Center, Kyoto University	Preliminary survey of camphor plantation by drone in Yakushima Island
Tati Suryati Syamsudin	School of Life Sciences and Technology, Institut Teknologi Bandung	Contribution of Imperata cylindrica on soil quality indicate by diversity of soil macrofauna
Tomoaki Muranaka	Center for Ecological Research, Kyoto University	Summarization methods for the daily and seasonal dynamics of the transcriptome in natura
Akihiro Yoshikawa	Seto Marine Biological Laboratory, Field Science Education and Research Center, Kyoto University	Morphological adaptation and habitat preference in the slipper limpet *Ergaea walshi* (Gastropoda: Calyptraeidae), a facultative associate with hermit crab living inside gastropod shells used by hermit crabs
Chiharu Endo	Laboratory of Animal Ecology, Department of Zoology, Kyoto University	Feeding performance in relation to continuous mouthpart variation in a single population of the pike gudgeon *Pseudogobio esocinus* in Lake Biwa
Hirofumi Kajino	Graduate School of Agriculture, Kyoto University	Relationships among Si accumulation, shoot growth and light environment in Broussonetia papyrifera (Moraceae)
Takahisa Ozaki	Shinshu University	The molecular phylogeography of the alpine gravel environment specific plant?Dicentra peregrina?(Papaveraceae) in Japan
Kudoh A, Minamoto T, Yamamoto S	Kyoto Univ. Dept. Agr., Kobe Univ., Kyoto Univ. Grad. Sci.	Detecting herbivore's DNA from feeding marks
Achmad Gazali	University of Alghifari, Indonesia	Biodiversity And Dominance Of Insects Species on The Organic And Conventional Strawberry Farms In Kopeng, Semarang, Indonesia
Tomoyuki Tajima	Graduate School of Science, Kyoto University	Male Reproductive Success in Bornean Orangutans
Hiroshi Kudoh	Center for Ecological Research, Kyoto University	Characterization of underground stolon 'rhizome' by transcriptome analysis.
Liesbeth Frias	Kyoto University Primate Research Institute	Parasites as neglected components of biodiversity
Monamie Ringhofer	Institute for Advanced Study, Kyoto University	Decision making of mares reacting to the stallion's herding in a harem group of feral horses (*Equus caballus*)
Sota Inoue	Wildlife Research Center, Kyoto University	Differences in spatial positioning of individuals among horse groups
Ayaka Kanaike	Graduate School of Global Environmental Studies, Kyoto University	Roosting behaviors and roost characteristics of two parakeet species in Singapore
Kiwako S. Araki	Ritsumeikan University	Characterization of phenological changes in rhizome meristems based on transcriptome analysis
Genki Yumoto	Center for Ecological Research, Kyoto University	Altitudinal dimorphism of leaf wax contents and its ecological function in a perennial Arabidopsis halleri subsp. gemmifera (Brassicaceae).
Keisuke Koba	Center for Ecological Research, Kyoto University	Stable Isotope Facility in Center for Ecological Research, Kyoto University
Giovanni Forcina	Wildlife Research Center, Kyoto University	Molecular phylogeography and Museum specimens: The case of the black francolin (*Francolinus francolinus*)
Kami Chitose	Center for Ecological Research, Kyoto University	Analysis of seasonal synchrony system for flowering and senescence in Arabidopsis
Maxime Marre	Center for Ecological Research, Kyoto University	Microbial diversity of Mallotus japonicus stigma, an ambophilous plant
Mie N. Honjo	Center for Ecological Research, Kyoto University	Annual balance in antagonistic interactions between plant virus and host in a seasonal environment

Yayan Wahyu C. Kusuma	Laboratory of Forest Biology, Graduate School of Agriculture, Kyoto University	Species delimitation of the parasitic plants Rafflesia spp and insight on their genetic diversity and structure
Shin Matsuyama	Center for Ecological Research, Kyoto University	Roles of enhanced mesophyll conductance on leaf gas exchange in drought-adapted tree species in the Ogasawara (Bonin) Islands, Japan
Yuiko Noguchi	Graduate School of Agricultural Science, Kyoto University	Height-related changes in hydraulic structure of Old and Mature C.camphora trees
Mariko Kawamura	Seto Marine Biological Laboratory, Field Science Education and Research Center, Kyoto	Life history of a giant jellyfish Nemopilema nomurai from East China Sea and Sea of Japan
Yutaro Fujimoto	Graduate School of Agriculture, Kyoto University	Community-ecological analysis of lianas in a seasonal evergreen forest in northeastern Thailand
Mayako Fujihara	Wildlife Research Center, Kyoto University,	Cryopreservation of immature follicles; the new target for female fertility preservation in wild animals
Haruka Yamazaki	Shinshu University	Molecular phylogeographic study using feces from the water shrew, Chimarrogale platycephalus
Makoto M. Itoh	Graduate School of Global Environmental Studies, Kyoto University	Using mimicked reject signals of related species reduces hybridization in Pelophylax porosus brevipodus
Hiroshi Inoue	Agriculture, Department of Applied Bioscience, Kyoto University	Food habits of deep sea in the Sea of Japan
Alisa Kutzer	Graduate School of Global Environmental Studies, Aquatic Environmental Biology, Kyoto	Foraging of Japanese eel between salinity boundaries revealed by stable isotope analysis
Haruhi Nonaka	University of the Ryukyus	The trade-off between foraging performances in an ant community
Sai Kichi	Center for Ecological Research, Kyoto University	The ecology of picocyanobacteria in Lake Biwa, with special reference to the effects of grazers
Kanako Momose	Graduate School of Global Environmental Studies, Kyoto University	Phylogeography of Epeorus aesculus in the central mountain region of Japan
Daiki Yokoyama	Graduate School of Agriculture, Kyoto University	Soil microbial turnover as a P source supports gigantic lowland tropical rainforests in Borneo
Nuria Jimenez Elvira	Center for Ecological Research, Kyoto University	The effect of copper contaminated soil on Ptychostomum capillare, a resistant moss species and its phytoremediation potential.
Shoko Sakai	Center for Ecological Research, Kyoto University	Forty Years of Forests in Rural Villages Revealed by Land-cover Maps andSocial Surveys in Borneo
Shigeto Dobata	Graduate School of Agriculture, Kyoto University	Regulatory mechanism predates the evolution of self-organizing capacity in simulated ant-like robots
Shun Kurokawa	Kochi University of Technology	Evolution of cooperation in the case where the information upon the opponent player's behavior is imperfect
Ryuichi Takeshige	Department of Agriculture, Kyoto University	Estimating the recovering speed of above ground biomass after selective logging in Bornean lowland tropical forest
Mao Asami	Primate Research Institute, Kyoto University	Isolated teeth fossils of Macaque from Guangxi region, China
Naoki Yui	Center for Ecological Research, Kyoto University	Does growth of stream-dwelling fishes increase in post-snowmelt floodplains?
Sigaud Marie	Primate Research Institute, Kyoto University	Sex-based behavioural strategies in a nocturnal primate species, the Javan slow loris
Annegret Moto Naito	Wildlife Research Center, Faculty of Science, Kyoto University	Individual identification and evaluation of genetic diversity of the endangered Japanese golden eagle using microsatellite markers
Chung-Kun Lee	Department of Botany, Division of Biology, Graduate School of Science, Kyoto Univeristy	Phylogenetic Analysis of Murdannia (Commelinaceae) with special reference to East and Southeast Asian Species
Yu Hirano	Tokyo University of Agriculture	Effects of nitrogen and phosphorus fertilization on the morphology and phosphatase activity of fine roots in Bornean tropical rain forests
Yumiko Higuchi	Center for Ecological Research, Kyoto University	Does leaf lobation on a host plant inhibit cradle formation of a leaf-rolling weevil ?
Cecile Sarabian	Primate Research Institute, Kyoto University	Conservation through disgust and public health
Nguyen Tien Hoang	Department of Urban Management, Graduate School of Engineering, Kyoto University	Geospatial modeling for delineating biodiversity conservation corridors: A case study in Thua Thien Hue province, Central Vietnam
Ardhiani Kurnia Hidayanti	School of Life Science and Technology, Bandung Institute of Technology	Bacterial Diversity in Compost Processed by Black Soldier Fly Larvae using Next Generation Sequencing
Tomoya Kanno	Center for Ecological Research, Kyoto University	The effect of forest edges for the sika deer and forest animals ~analysis by mathematical model~
Atsushi Yamauchi	Center for Ecological Research, Kyoto University	Theory of coevolution of gynodioecy and selfing in plant
Shohei Shibata	Primate Research Institute, Kyoto University	Fission and Aggression among Male Chimpanzees in Kalinzu Forest Reserve, Uganda
Kazuya Takeda	Center for Ecological Research, Kyoto University	Slippery petals as a mechanism of defense against nectar thieving ants
Shigeo Yachi	Center for Ecological Research, Kyoto University	Stakeholder diversity and long-term ecosystem resilience: reunion with the insurance hypothesis
Kseniya Lyalina	Center for Ecological Research, Kyoto University	C, N, S isoscapes in estuaries to predict origin of mobile organisms
Chikae Tatsumi	Graduate School of Agriculture, Kyoto University	Soil nitrogen cycling is more strongly determined by forest type due to the difference in mycorrhizal type than by geographical distance along the aridity gradient
Tzu-Hao Lin	Japan Agency for Marine-Earth Science and Technology	Listening to the ecosystem: an integrative approach of informatics and ecoacoustics
Saori Furukawa	Center for Ecological Research, Kyoto University	Differences of mutualistic ability between pollinators sharing host plants in the Glochidion obligate pollination mutualism
Ittetsu Kamata	Center for Ecological Research, Kyoto University	The role of plant cuticular wax in host selection of Cucurbit leaf beetle (*Aulacophora femoralis*)
Kentaro Noda	Kyoto University	Human-wildlife interface of Endangered Zanzibar Red Colobus (*Procolobus kirkii*)

Drone-workshop Program

February 22, 2019 <Center for Ecological Research, Kyoto University>

10:00-10:20 Tour for the CER

10:20-10:40 Wataru Mamiya Uryu Research Forest, Hokkaido University
Efforts for Drone utilization in Hokkaido University Experimental Forest

10:40-11:00 Cuong The Chu Vietnam Academy of Science and Technology
Unmanned aerial vehicles (UAVs) for surveying marine ecosystems in Vietnam: a case of seagrass beds in Phu Quoc island and My Tuong areas

11:00-11:20 Satoshi Hirata Wildlife Research Center, Kyoto University
Use of drones in animal behavior research

11:20-11:40 Sung Je LEE National Institute of Ecology, Korea
Ecological and Natural Maps: Conservation of Biodiversity

11:40-12:00 Sohei Kobayashi Disaster Prevention Research Institute, Kyoto University
Using drone for river surface envrionmental surveys

12:00-12:20 Tomoichiro Tanaka Tanaka Sanjiro CO.,LTD.
Radio telemetry combined with drone technology to replace the manual tracking method

~Lunch Time~

13:00-16:00 Drone workshop (Dr. Satoshi Hirata)

Efforts for Drone utilization in Hokkaido University Experimental Forest.

Wataru Mamiya (Uryu Experimental Forest, Hokkaido university)

Our experimental forest introduced drones (UAVs) in earnest from 2017. We are now utilizing them, with trials and errors, for many activities including education, research and forest management. For field validations and presentations for public, aerial pictures and animations collected by a drone fulfill the purposes sufficiently. However, for researches and forest management, quantitative data are required. So, we tried to combine the utilization of a drone with SfM (Structure from Motion) and GIS (Geographic Information System) technologies. This approach make it possible to build 3D-models of forest and terrain, and can obtain various quantitative information such as tree height and width of tree crown.

Example 1 (For research purpose)
- Aerial photographs of a floodplain spreading around a natural river -
The object of the study is to investigate dynamics of amphibia, which spawn in seasonal ponds. It was necessary to check the exact location of the ponds just after the increased water-level of the river in early spring. We took about 2500 aerial photographs with a drone and made orthophotos (pictures without distortion) for about 50 ha wide area. We extracted ponds from the orthophotos, and retrieved their locational information in a handy GPS (GNSS) receiver. In the field, we could easily access 322 ponds in the area, and find sufficient amphibia data (nearly 3000 eggs). Such a study was impossible without the drone-related system.

Example 2 (For forest management)
- Topographical survey and silvicultural planning -
We are conducting afforestation (tree-planting) activities for non-wooded area in the forest. The operation have begun with a time-consuming land survey on foot, using a magnetic compass or GPS. Instead, we utilize drone for deciding the target area. First, we took 376 aerial photographs in 15 ha area, and delineate non-wooded patches which are suitable for tree-planting on the orthophoto. The field work required was only 30 minutes, and the SfM and GIS procedure enable us to decide the planting area, with estimation of the number of planting trees required, in a few hours. We conclude that the drone-related system is a very useful tool for education, research and forest management. It is necessary to develop and verify the technology, in order to deal with many more purposes.

Mr. Mamiya is born in Hokkaido, Japan. 31 years old. After graduating from Hokkaido University Master's course (Environment Science), working in Field Science Center for Northern Biosphere, Hokkaido University as a Technical Staff.

His jobs are field management, and various technical support for research and education, including drone operation and analysis.

Unmanned aerial vehicles (UAVs) for surveying marine ecosystems in Vietnam: a case of seagrass beds in Phu Quoc island and My Tuong area

Chu The Cuong (Institute of Marine Environment and Resources, Vietnam Academy of Science and Technology)

The UAVs offers an effective and inexpensive tool to acquire aerial imagery, giving a potential quick and cost-effective method to monitor of ecological processes. By using a lightweight UAV (DJI Mavic Pro) equipped with a consumer-grade RGB digital camera and Drone Deploy application, the high spatial resolution (3 cm pixel^{-1}) orthomosaics of the seagrass meadows in Phu Quoc island (Kien Giang province) and My Tuong (Ninh Thuan province) have been produced. Our results show that without in field survey data assisted, it was very difficult to classify species seagrass by aerial images (short seagrass leaves type *Cymodocea serrulata, Thallassia hemprichii* and long seagrass leaves type *Enhalus acoroides*). However, these imageries could be useful to identify area, distribution and coverage of seagrass meadows in the shallow zone (depth less than 2.5 m) and clear water.

Dr. Chu The Cuong is a marine biologist from the Institute of Marine Environment and Resources, Vietnam Academy of Science and Technology. Even though his major interested is sea turtle biology and management, the original intention was using the unmanned aerial vehicles (UAVs) to study sea turtles, through practical surveys he has learnt that this tool can be also applied in study of coastal ecosystems, especially in remote areas and very suitable for developing countries like Vietnam.

Dr. Chu The Cuong is a DIWPA fellow! Please join us!

DIVERSITAS in the Western Pacific and Asia (DIWPA) is an international network for the promotion of cooperative studies and information exchange on biodiversity in the Western Pacific and Asia, under a close cooperation with its mother program, DIVERSITAS, organized by ICSU, IUBS, SCOPE and UNESCO.

The main functions of DIWPA are ***(1)*** promotion of research projects and science on biodiversity in the Western Pacific and Asia, ***(2)*** promotion of governmental and nongovernmental activities for the conservation and utilization of biodiversity, ***(3)*** facilitation of information sharing and research cooperation on biodiversity, and ***(4)*** capacity building of scientists in particular young scientists from developing countries.

DIWPA aims to connect existing networks of people working on biodiversity and research projects in Asia and the Western Pacific. DIWPA is not an overarching organization; it is instead a flexible network of networks.

For more details: http://diwpa.ecology.kyoto-u.ac.jp/index.html

Use of drones in animal behavior research

Satoshi Hirata (Wildlife Research Center, Kyoto University)

Drones are more formally known as unmanned aerial vehicles or unmanned aircraft systems. Essentially, a drone is a flying robot that can be remotely controlled or fly autonomously through software-controlled flight plans in their embedded systems, working in conjunction with onboard sensors and GPS. Drones were most often used in military situations in the recent past, but now started to be used in wide range of purpses. The merit of drones is that one can obtain a view from above, which is different from views at human eye level. Although drones are not beneficial in studying forest dwelling animals as forest canopy, leaves and branches block the view from the drone, use of drones is advantageous for research of animals living in a plain field. We have started to use drones for our study of feral horses in February 2016. Using drones enables the recording of all members of a group from the sky, which is optimal for analyzing spatial positions, as long as no obstacles come between the drone and subject animals. Feral horses meet the first requirement of this methodology because they usually live in relatively monotonous plains that are covered with grasses and herbs, as opposed to complex three-dimensional spaces that include tall trees or thick bushes that can block a drone's line of sight. The results of our study revealed the following characteristics: (1) the male in between social and spatial relationships indicated that they are independent from each other. Our study is the first to reveal the characteristics of spatial positioning in a mammalian group using drone technology. The harem group was located in the periphery; (2) as in other species, individuals had areas of repulsion and attraction, and (3) nearest neighbors were located more toward the sides than to the back or front. The second example where drones are beneficial in research of mammals is the case of marine mammals. Observing marine mammals is challenging as our way to get access to hem is limited. Flying a drone enables to overcome this challenge. My colleague, Morimura and Mori (2019) used drones to observe finless porpoise in Misumi Bay, Kumamoto Prefecture. They focused on describing the behavioral responses of single and aggregated finless porpoises to boats passing at Misumi Port by using a drone characterized with a high-precision bird's-eye angle. Their results indicated that each individual porpoise was motivated to keep the group cohesion consistent when floating even after the risk had dissolved, which is comparable to the behavior of porpoises that dive when riskier conditions are present, such as when a boat approaches an aggregation. Pros and cons of using drones are discussed in my talk by referring to studies described above.

Dr. Satoshi Hirata is a Professor at the Wildlife Research Center of Kyoto University. He has been conducting research on chimpanzees and other great apes from a comparative cognitive perspective to better understand the evolutionary origins of human behavior and cognition. In addition, he has started a study of feral horses in northern Portugal and introduced drones to observe the horses from the sky.

Ecological & Natural Map: Conservation of Biodiversity

Sung Je Lee (National Institute of Ecology: NIE)

Ecological & Natural map (ENM) is the rating map of natural environment based on ecological value, natural characteristics, landscape value, etc. The ENM consists of 800 parts covering the entire South Korea, excluding some regions. The map has been produced by the National Institute of Ecology (NIE) since the 2014, which transferred from a subsidiary organization of Ministry of Environment.

ENM's composition is divided into 1st to 3rd grade zones, and separately managed zone. It is classified into conservation, minimization of damage and systematic development according to the grade zones. Based on this result, it is utilized in comprehensive plan for national environment, environmental impact assessment projects, etc. or to hold a consultation about development projects.

For drafting of ENM, Collected is the results of the National Ecosystem Survey, the Intensive Ecosystem Survey, and the Winter Waterbird Census of Korea, etc. (i.e., basic researches) conducted by NIE, other public Institutes, and local governments. These data are then compiled as a database to prepare the basic thematic maps. The ENM performs a rating assessment by overlapping the basic thematic maps.

The objective of ENM, like the objective of basic researches, is to conserve biodiversity and natural environment.

Lastly, when there is an objection to the ENM grades, field survey and drone images can be used to respond quickly and accurately to complaints.

Dr. Sung Je LEE is Senior Researcher in Bureau of Ecological Survey & Assessment at the National Institute of Ecology, South Korea. He earned a doctorate in environment science from Yokohama National University in Japan, and has researched the vegetation ecology.

The Center for Ecological Research, Kyoto University signed an academic exchange agreement (MOU) with the Korea National Institute of Ecology (NIE). NIE is a new laboratory of ecology and biodiversity science founded in Seocheon-gun (district), Korea in 2013.

NATIONAL INSTITUTE OF ECOLOGY

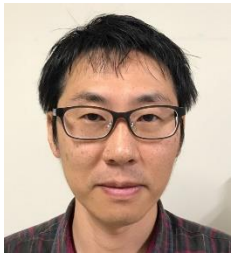
Evaluation of the ecosystem functions of gravel bars in rivers using drone

Sohei Kobayashi (Disaster Prevention Research Institute, Kyoto University)

Gravel bars, accumulations of sediment in the channel, are essential elements of river ecosystem. First, they are the basis of habitat diversity by forming riffles, runs, pools, alcoves, and temporal ponds in the channel. Second, they are the main spot of hyporheic exchange of water between surface and subsurface. The hyporheic outflow is usually a clear water by a filtering processes in the bar, and is usually more stable in terms of flow and temperature than the surface flow.

Drone is a suitable tool to measure properties of gravel bars and habitat structure in rivers. For large gravel bars (e.g., >100m in length), it usually takes 1 or more days to measure topography, bed grain size, and spatial distribution of habitats by a classical ground-based survey. Drone can take photos, which provide information of these characteristics, for large gravel bars within a few 10 minutes. For example, if we take largely overlapping photos covering the whole area of a bar by a drone 100 m above in the air, DEM (digital elevation model) and orthoimage of the whole bar can be easily obtained using a SfM-MVS technique software. Based on such orthoimage, area of gravel bar, water, vegetation, and different habitats can be quickly measured. Some software can automatically detect and measure size of riverbed materials. If we take video of flow 50-100 m above in the air, spatial distribution of surface flow speed and direction can be estimated by PIV (particle image velocimetry) or STIV (space-time image velocimetry) method.

Spatial distribution of hyporheic outflow, which is a clear water, can be evaluated by drone photos if the surface water is turbid. Because hyporheic outflow and surface water usually differ in water temperature, the hyporheic outflow can be also detected by a thermography-camera equipped drone. The thermography images can detect the hyporheic outflow even the difference in temperature between surface and hyporheic is less than 1 degree. The thermography images also show other types of spatial heterogeneity in water temperature (e.g., a difference in mid-flow and periphery). One of our recent interests is to understand which type of gravel bar has high hyporheic exchange potential by examining the relationship between bar properties and the distribution of hyporheic outflow.



Dr. Kobayashi has studied river macroinvertebrates and riverbed morphology for 20 years from headwater forest streams to lowland open rivers in various regions in Japan. Recent study topics are sediment-bedform-invertebrate relationship and mass emergence of caddisflies in lake-outlet river.

Radio telemetry combined with drone technology to replace the manual tracking method

Tomoichiro Tanaka (CEO, Tanaka Sanjiro Co.,Ltd)

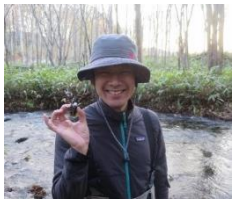
Researchers often employ radio telemetry to locate animals. This radio tracking is normally done manually by moving around the survey area with a radio receiver attached to an antenna. This process is not only time consuming but sometimes difficult to apply especially when the access to the study area is not suitable due to the ground condition or the terrain.

In 2016, we started a research project to find out where female signal crayfishes carrying eggs inhabit in winter at Uguisuzawa river in Hokkaido corporated with Mie University and Bihoro Museum. This signal crayfish locally called "Uchida Zarigani" is invasive alien species originally from North America. The amount of this species has kept increasing over years at this river endangering local species in spite of extermination activities by a group of local researchers and volunteers. The purpose of this research was to find out more effective methodology to decrease the population by locating their habitats in winter. We released three radio-tagged individuals in Oct. 2017 and locate them in winter but the problem was the way how to find them when deep snow prevents us from approaching the river. We then came up with an idea to mount a radio receiver and an antenna onto a drone and search them from the sky.

The idea was simple but the development was not so easy since there is no existing receiver or antenna to meet the requirements and we had to build up everything from scratch. The primary requirement for the equipment is weight and size. The payload of the equipements not only limits the flight time but also impairs the safety of the flight especially when the size is big. We tried to make the whole system as light and small as possible so the drone can cover the study area in limited number of flights, and also to fly safely. It also has to have good noise immunity not only from the environment but also from the drone itself. Finally, the detection range has to be long enough so it receives signals from the transmitter while flying over trees covered on the research area. Besides, we developed a software to plot the location, signal strength and tag ID and obtained the know-how to create suitable flight plans to fly the drone low enough from the ground to receive the signal while avoiding obstacles like trees.

In Dec. 2017, we searched three radio-tagged individuals we released two months before. After the survey flights, the data from the radio receiver showed rough locations of all three, and we successfully recaptured them after manual radio tracking, and we found their habitats in the underground water pathways, one to two meters away from the river edge and approx. 60cm underground.

Based on the result, we concluded that catching individuals does not lead to the extinction of this spices and alternative methodologies needs to be introduced while radio telemetry combined with drone technology has wide application potential for the species too small for large transmitter or for the survey area difficult to approach.



Mr. Tomoichiro Tanaka is a CEO, Tanaka Sanjiro Co.,Ltd since 2008. As a CEO of the long-lasting fishing and environmental company, he not only possess deep knowledge about his products, but also he himself invent equipment and contribute to scientific activities.