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Message from the Chairperson

Shin-ichi Nakano

Unfortunately, we still have the serious spread of COVID-19 all over the world. The COVID-19 problems have had a negative impact on CER as well as others, and we made "lock-down" from 27 April to 15 May at the closure request by Shiga Prefecture. Many colleagues were under the stress of "Stay-at-home" mission, inconvenient life, loneliness and negative news during the lock-down. CER has been released from lock-down now, and we have been gradually opening and re-starting our research activities. Some of you might think that the COVID-19 problems would be tackled and solved by medical, viral and pharmacy researchers. However, I believe that ecologists and biodiversity researchers can contribute something to settle the problems. It can be said that COVID-19 virus would have diversity because it would not be a single virus, consisting of some or many genotypes. At the present, medical, viral and pharmacy researchers all over the world have been studying and developing vaccine and/or specific medicine for COVID-19. Because there is a possibility that each country/region has different genotype(s) of COVID-19, various types of the vaccine and/or specific medicine for COVID-19 must be studied and developed. Ecologists and biodiversity researchers would be able to provide necessary tools and information about analyses of genotype variation. In addition, the spread and/or biogeography of microorganisms are one of important research fields for ecology and biodiversity. Ecological approach would be needed to know the process of transportation and acclimation by newly invading biological species, and biodiversity research would be necessary to know their variation of survival. Not only medical, viral and pharmacy researchers but ecologists and biodiversity researches would also have important roles for solution of COVID-19 problems. Thus, we can scientifically contribute to prevent the virus from the spread. I hope all the people in our planet would be freed from the threat by COVID-19 soon.

Message from the Secretary General

Atsushi Ishida

Many researchers and policy makers are confronted with a difficult situation to continue their usual study, lecture and meetings because of COVID-19 pandemic now. Unfortunately, we have to postpone or cease the International Field Biology Course (IFBC) in this year. Although the first weave of COVID-19 has been closed in Japan, we cannot predict coming of the second wave. I am aware that you still suffer from the first wave in many countries in the world.

Separately from COVID-19, I feel that the frequency of new infections, such as SARS and MARS, is increasing recently. It comes due to the globalism, and it also may be related to the global warming and the progressing nature destruction in the world. However, this pandemic has clarified the importance of sharing exact information speedy all over the world. Furthermore, we learned the importance of working altogether to overcome various troubles by holding hands in the world. This is common issue in not only the pandemic but also global warming and the decline of biodiversity. We will use online systems for lectures and meetings to keep social distance from now. And we will know the merit and demerit of both online and face-to-face systems. Furthermore, we have to remake the social structure with citizen, governments and researchers altogether to overcome various issues. I am certain that platform to exchange information will be more important. DIWPA must contribute to the significance.

We will upload more information about IFBC in this year on our HP depending on the COVID-19 pandemic. I appreciate your support to keep and enhance DIWPA activities.

What is necessary to suppress global warming up to 1.5℃ ?

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Ongoing climate change has caused severe drought, being reported all over the world. The Work Meteorological Organization (WMO) confirms 2019 as second hottest year on record. The global mean temperature for 2019 was 1.1℃ above pre-industrial levels (WMO 2020). Air temperature is one indicator of the ongoing climate change. Heat waves with prolonged drought induce not only forest fires but also flood. In Australia, it was driest and hottest on record in 2019; the averaged maximum temperature across the country reached 41.9℃ on December 18, 2019. The greatest forest fire on record continued during 240 days from July of 2018 to March of 2019 in Australia. The prolonged drought induced large tree death and resulting forest fire killed more than 1 billion endemic animals. Enormous cost and time will be needed for the recovering of ecosystems, and it may be difficult to be back to the entirely original nature. In California, the longest drought occurred from December of 2011 to March of 2019, lasting 376 weeks. The reductions in the crop and livestock production led to food insecurity. The drought of the future is likely to be more frequent, severe, and longer-lasting than they have been in recent decades (Ault 2020). The Intergovernmental Panel on Climate Change (IPCC) Special Report: Global Warming of 1.5℃ (IPCC 2018) summarizes the future risks on natural and human systems at 1.5℃ versus 2℃ of global warming, and concludes that the limiting warming to 1.5℃ above temperature in pre-industrial levels is needed for maintaining sustainable natural and human systems.

The report of IPCC comprehensively describes the high risks of global warming in extreme weather, sea-level rise, ecosystems, health, food, and water resources with a focus on how risk levels change from 1.5℃ to 2℃ of global warming (IPCC 2018). According to the report, the sea-level rise is estimated to be suppressed within about 10 cm in 2100 years at 1.5℃ compared to 2℃. On land, the impacts on biodiversity and ecosystems, including the extinction of species, are expected to be lower at global warming of 1.5℃ compared to 2℃ (IPCC SR1.5 SPM B2). In terrestrial ecosystems, a warming of 1.5℃ will result in 6% of insects, 8% of plants, and 4% of vertebrates losing more than half their climatically determining geographic range. On the other hand, 2.0℃ will result in 18% of insects, 16% of plants, and 8% of vertebrates losing more than half their climatically determining geographic range (Warren *et al.* 2018). In addition, the increase in CO_2 associated with global

warming leads to ocean acidification, affecting species growth, development, calcification, and survival in marine ecosystems. This is more pronounced at a 2℃ rise than at a 1.5℃ rise. In the case of coral reefs, it is estimated that a rise of 1.5℃ will reduce 70% to 90%, and that of 2℃ will lose 99% or more. An increase of 1.5℃ will thus have an impact on the ecosystem and humankind, but it will be suppressed more than an increase of 2℃ (IPCC SR1.5 SPM B4). The IPCC report has enhanced that it is necessary to reduce global net CO_2 emissions to zero by 2050 for suppressing global warming to a rise of 1.5℃ (IPCC SR1.5 SPM C1).

The IPCC report derives a wide range of economic growth, technological advances, lifestyles, etc. regarding mitigation routes to keep the air temperature rise to 1.5℃ before the Industrial Revolution (IPCC SR1.5 SPM C2). It suggests that carbon dioxide emissions need to be reduced by about 45% from 2010 levels by 2030 to reach a net-zero level by 2050, to limit global warming to a rise of 1.5 (IPCC SR1.5 SPM C1). The most effective scenario for greenhouse gas reduction will be energy system transformation in society. It is a scenario in which energy demand is suppressed by energy-saving technology and sharing economy. We need to increase the electrification ratio and the ratio of renewable energy in electric power to 70-85% in 2050, and to reduce the coal-fired power to almost zero (IPCC SR1.5 SPM C2.2). The investment for the transform of energy system is estimated to be about $ 2.4 trillion annually, which is about 2.5% of the world's GDP. The investment in renewable energy will increase, but the investment in fossil fuels will decrease. As the result, the investment for transform of energy system will only increase by about 20%. With the transform of energy system, we need the rapid system transformation in society, such as land use, infrastructure and industry (IPCC SR1.5 SPM C2.6). It is also necessary to remove CO_2 from the atmosphere, and to permanently store it into underground, land or sea reservoir and products (Carbon Dioxide Removal: CDR). CDR includes bioenergy, which can capture and store carbon that CO_2 is not released into the atmosphere, and afforestation and reforestation. The IPCC report estimates that in 2050, the CDR will be used for about 100 to 1,000 Gt CO_2 over the 21st century (IPCC SR1.5 SPM C3). Scenarios that rely heavily on CDR includes risks. If the CDR relies heavily on a special technology, and if the technical defects in CDR are exposed or the society does not accept it, the plan for CDR unable to be achieved. In another scenario, because a naturally CO_2-assimilate sink in the marine or terrestrial ecosystems is considered to last for a long time period, it is allowed for temporal overshooting of the target air temperature (1.5℃ before the Industrial Revolution) (Matsuno *et al.* 2012). However, when the air temperature exceeds 1.5℃ of global warming, understanding of carbon cycle in climate systems, including the carbon

balance within forests and predicting forest dynamics in future, is required to lower the air temperature.

For the adequate understanding of carbon cycle, physiological study and long-term monitoring of trees and forests are useful. Conspicuous tree death and afforestation with prolonged drought have been reported in many biomes in the world. For estimating forest change to global climate change, Eller *et al.* (2020) have developed a model with the joint UK land environment simulator (JULES), including a physiological-based model of plant CO_2 absorption estimated from stomatal response to environment by the group of Sperry (Sperry *et al.* 2016). This model has used constant values obtained from model plants in crops, such as tobacco, in various plant physiological parameters. For example, CO_2 diffusion resistance in mesophyll within lamina is assumed zero. However, CO_2 diffusion resistance in mesophyll will be large because of thick cell walls in mesophyll cells, and it will be unable to be ignored when we estimate CO_2 absorption of plants through stomatal response to environment. In addition, it has been recently found that there is a large interspecific variation in plant physiological parameters, such as the substrate specificity (Sc/o) of photosynthetic enzyme, rubisco, in mesophyll cells (Galmés *et al.* 2017). This model in JULES assumes no interspecific variation in Sc/o. I have measured the specific variations of CO_2 absorption through stomatal response under changing environment in drought-adapted woody plants in the Bonin Islands, Japan (**Fig. 1 A and B**). We are found that there is a large interspecific variation in photosynthetic rates at a given stomatal opening. The interspecific variation will be due to interspecific variations in CO_2 diffusion resistance in mesophyll and in Sc/o in photosynthetic enzyme. Understanding these interspecific variations improves the estimation of plant

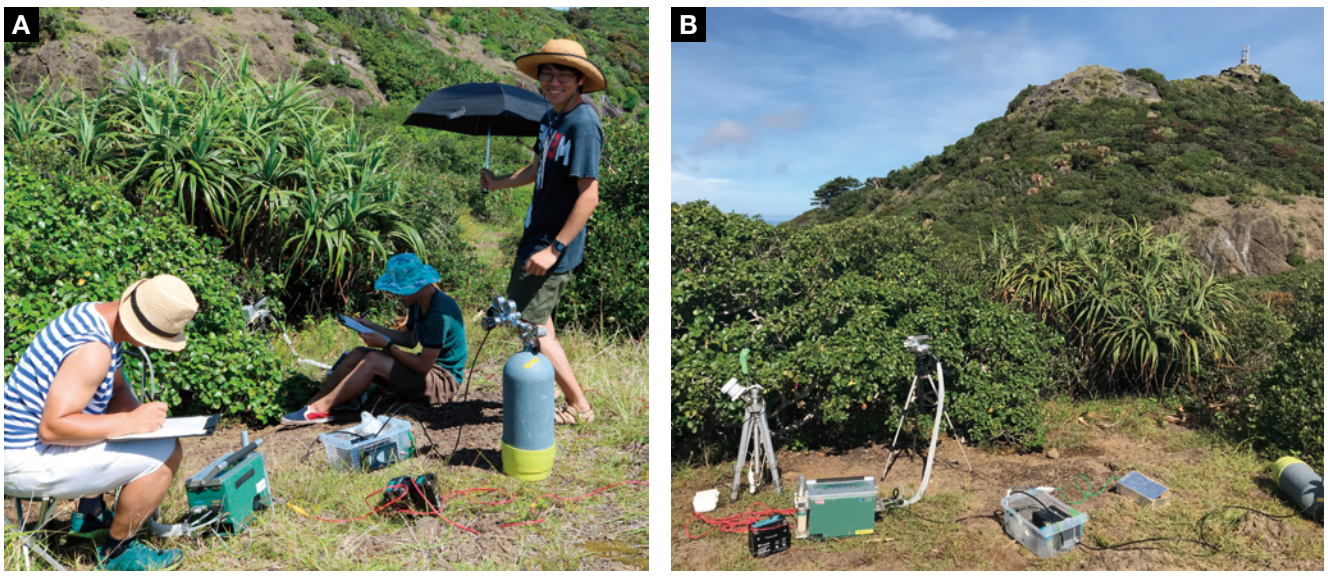

Fig. 1. Leaf gas-exchange measurements in drought-adapted trees (A) and the vegetation of a dwarf dry forest (B) in the Bonin Islands. The soil is thin and the tree heights are relatively thin at this study site.

CO_2 absorption through stomatal response to environmental change in the future. My study will contribute to improving the prediction of forest dynamics, carbon cycle within forests, and CDR in terrestrial ecosystems. To suppress the increase in air temperature lower at 1.5℃ before the Industrial Revolution, collaboration with researchers, policy makers and citizen is needed through approach based on not only scientific evidence but also the transform of energy system in society.

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Field survey on social behaviors of snakes foraging on sea turtles in Yambaru National Park, Okinawa Island

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Yambaru National Park, located at the northern end of Okinawa Island, was designated as the 33rd National Park in Japan on September 15, 2016. There are approximately 20 sandy beaches known as the main nesting sites of green sea turtles, *Chelonia mydas*, and loggerhead sea turtles, *Caretta caretta*, in the coastal area of Yambaru National Park in the central Ryukyu Archipelago. One of these sandy beaches, which is my study site, is located adjacent to Oku Village (**Fig. 1**, 128°17' E, 26°50' N). On this beach, a unique behavior of wild snakes is observed. The shore line length of the beach is approximately 800 m, and the distance from shore line to the bush line is approximately 30 m. The beach mainly consists of fine bioclastic sand such as coral and shell fragments. The island side of the beach is surrounded by steep mountains with an altitude of approximately 70 m, and the sea side is surrounded by coral reefs with a distance of approximately 400 m from shore line to reef edge.

On this beach, a unique behavior of wild snakes is observed. Sea turtles made over 70 nests on the beach from May to September each year. Each nest contains over 100 eggs and the hatchlings emerge from the nest about two months after their oviposition. At night, the Ryukyu odd-tooth snake, *Dinodon semicarinatum*, appears on the beach to prey on the eggs and the hatchlings.

Dinodon semicarinatum is an endemic colubrid snake distributed on islands in the central part of the Ryukyu Archipelago. This snake is considered to be a nocturnal dietary generalist, preying on almost all kind

Fig. 1. A sandy beach in Yambaru National Park, Okinawa Island

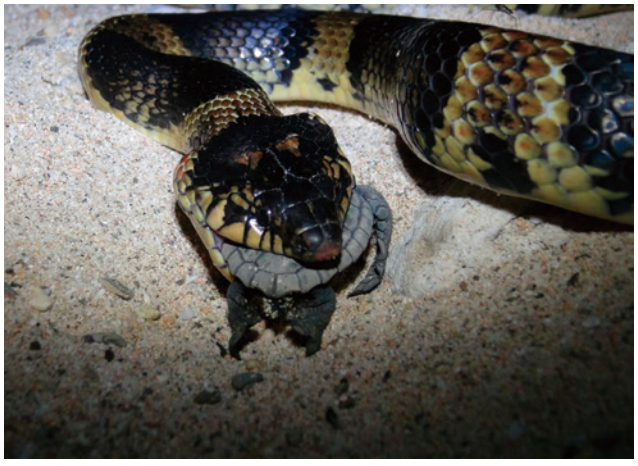

Fig. 2. *Dinodon semicarinatum* swallowing a hatchling of loggerhead sea turtles

of small vertebrates. On Okinawa Island and several islands of the Kerama Group, coastal populations of snakes have been reported to feed on sea turtles. Snakes capture hatchlings of sea turtles crawling to the sea or burrow the sandy ground to eat eggs in the nest (**Figs. 2 and 3**). When several snakes come to the same nest simultaneously, interactions between individuals sometimes occur. Such interactions by wild snakes are generally very difficult to observe in any species of snakes.

I have conducted field surveys on the beach by route census and using fixed infrared video cameras, and observed foraging behaviors of *D. semicarinatum* more than 500 times in total from 2014 to 2019. Most of the snakes appeared on the beach were large adult males with a snout-vent length of over 1,200 mm, but a small number of females and small males also came to search for sea turtles (*D. semicarinatum* shows a sexual size dimorphism with females being smaller than males). However, only large males were allowed to swallow hatchlings and burrow deep tunnels to egg chambers of nests. The tunnels from the surface of the beach to the egg camber remained for several days. Generally, the snakes were not always able to reach egg chambers by burrowing into nests, and its snout was sometimes injured by its head poking into the sandy ground. Therefore, the tunnels made by some snakes were used by many other snakes. Small snakes succeeded in foraging on eggs only when using such tunnels.

Interactions between individuals of snakes on nests with the tunnels were recorded frequently. These interactions indicate the occurrence of two social traits based on the behavioral characteristics. First is "territoriality": snakes defend the food resources from other individuals by combat dance, which is a ritualized fighting (**Fig. 4**). Furthermore, whether a snake challenges against another snake seemed to depend on the opponent. This implies the presence of "dominance hierarchy": if a snake does not challenge against an opponent, the former snake keeps waiting for a few hours near the nest until the opponent finishes eating

Fig. 3. Predation by *Dinodon semicarinatum* on eggs in a nest of sea turtles

Fig. 4. Combat dance by two individuals of *Dinodon semicarinatum*

eggs and leaves the nest. In addition, snakes seemed to avoid excessive contact with other individuals: when a snake captured a hatchling on a nest, the snake immediately leaves the nest for the bush area while grasping the hatchling with its jaws before swallowing it. These behaviors suggest that *D. semicarinatum* are highly social.

I have also conducted radio-telemetric surveys of 18 individuals and tracked their movements around the coastal area from 2016 to 2020. During the nesting season of sea turtles, the snakes repeatedly moved back and forth between the beach and the mountains. In contrast, the snakes never come down to the beach during non-nesting period. Once snakes came down to the beach area, they tended to stay near the beach for several days. In addition, several snakes sometimes remained on the same place, because there was a nest with the tunnels made by other snakes. Then a small group was formed temporarily. When a video camera was set on such a place, the interactions mentioned above were recorded more frequently.

In general snakes are considered solitary animals and least social among reptiles. However, *D. semicarinatum* that forages on sea turtles on the sandy beach on Okinawa Island, develops highly social behaviors that have never been reported in snakes. This study shows, for the first time, a possibility that snakes have a high degree of sociality, based on quantitative observations of interactions between individuals in the field. Therefore, the sandy beach in Yambaru National Park is a unique study site to investigate reasons why the solitary snakes develop social behaviors.

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