ダニが語る生物多様性～寄生生物の進化的重要単位の意義～

Mites Talk about Biodiversity - Ecological Significance of Evolutionarily Significant Units in Parasites.

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Hello everybody. I am Koichi Goka of the National Institute for Environmental Studies.

First of all, I must apologize in advance to those of you listening in English because I was late presenting my slides and the script of my speech is too long. This means I will have to speak so fast that the simultaneous interpreters may not be able keep up. So please read my English subtitles where they appear.

Also, as I have a great many slides please regard my presentation as if it was an animation.

At the request of Prof. Murata I am going to talk about mites and ticks which are my specialty subject. In particular, I intend to focus on biodiversity as seen through the study of mites. At the same time, I'd like to explain in an autobiographical manner about why I turned towards the study of mites and why I love them.

In today's workshop we have been hearing about various kinds of parasites, including mites. Parasites are organisms that have existed almost since the beginning of life on Earth. Ever since that time they have evolved together with the rest of the biosphere. Parasites attach themselves to other living things in order to live and, as you are probably aware, there is a theory that they played a role in the development of sexual reproduction. Many organisms have male and female individuals and reproduction between two sexes is the most common way in which reproduction takes place.

Many kinds of living creatures, from primitive organisms such as insects and plants to human beings, exist as male or female, as this slide illustrates.

As I mentioned just now, parasites played a major role in the evolution of sex according to an idea known as "the Red Queen' hypothesis". One of many current ideas concerning evolution, the hypothesis takes its name from the character in Lewis Carroll's second "Alice" book, Through the Looking-Glass, and What Alice Found There. In the story, the Red Queen says, "It takes all the running you can do, to keep in the same place." Here the Red Queen is used as a metaphor for the idea that species, individuals and genes have to keep evolving if they are to survive. In order for multicellular species to keep warding off continual attacks by viruses, the species needs to be equipped with sufficient variation at the genetic level. Clearly, there is a difference in the tempo at which evolution can take place in viruses and in multicellular organisms consisting of an enormous number of cells. So if multicellular organisms were to counter the attacks of viruses by means of ordinary mutation alone, they would never be able to win the evolutionary battle. Instead, they have evolved as a result of gene exchanges and the creation of new genotypes through sexual reproduction. This hypothesis is one of several that attempts to account for the evolution of sexual reproduction.

Parasites have various ways of making a living. For example, some kinds of organisms parasitize higher order organisms, while others practice kleptoparasitism. This is a photograph of a Great Reed Warbler (Acrocephalus arundinaceus) feeding a Common Cuckoo (Cuculus canorus) chick in an example of what is known as "brood parasitism". When we consider that parasitism itself is always associated with the evolution of organisms, and that some parasitic species exist inside almost all species of living things, parasites can therefore be said to play a major role in promoting biodiversity.

When we think about it, we human beings are living as the biggest parasitic organisms on the Earth, and our style of parasitism creates numerous problems. But at the same time, parasitic organisms have very important functions within the ecosystem. As two other lecturers noted earlier, in a sense parasites play very important roles, and while they are universally disliked, we also have to recognize that their roles make them very precious organisms.

From this point on I am going to talk about mites.

My specialty is acarology (the study of mites and ticks), and although I am involved in a variety of work concerning the preservation of biodiversity, the things I actually like most are mites. Actually, there is an organization called the Acarological Society of Japan. And although the study of acarology is not very well known, there is also an International Congress of Acarology, which is held every four years. Two years ago, I attended the International Congress of Acarology held in Brazil where, for an entire week I took part in happy and harmonious conversations with acarologists from around the world about mites and nothing but mites.

Now, what kind of creatures are mites? Since many of you here today are specialists perhaps I don't need to explain, but many members of the general public are confused that mites are insects. In fact, mites are not insects. The mite body is very simple. It consists of only one section to which the limbs and mouth are directly attached.

The insect body is separated into three sections, the head, thorax and abdomen, with six legs and up to four wings attached to the thorax. That's the insect archetype. So insects have a far more complex structure than mites do. Like spiders, mites have eight legs. But the spider body is divided into two sections, cephalothorax and abdomen, so spiders also have a more complex structure than mites do.

However, even though mites have very simple bodies, these animals are distributed everywhere on Earth. Also, the life histories and food sources of different species of mites are amazingly varied, and the total number of mite species is enormous. There are around 50,000 known species recorded at present, and it has been estimated that there may be up to a million species of mites all told.

Mite habits also vary widely. For example, some species even live in the ocean. In this respect, mites have gone farther than insects as no insects live in the sea. Mites can inhabit both salt water and freshwater environments where they engage in eating plants and in sucking the blood of animals. Also, there are predatory mites that eat other mites and there are scavenger mites. There are many varieties of mites in the soil which break down organic matter and convert it to inorganic matter which helps create a rich soil. In these and other ways, mites are organisms that carry out a wide range of functions and help to support biodiversity.

Hearing such a story, you might very well be thinking that however important mites may be as an element in the web of life, as a human being you don't like them personally. You may wish also that mites were organisms that did not concern human life at all. However, mites of the species Demodex folliculorum are in all probability living happily on your face. As a matter of fact, almost 80% of Japanese people are hosts to this species. Of course, newborn babies don't have these mites to begin with but when a mother rubs her cheek against her baby's face, the mites are transferred. In this way, every human family has its own mites that are passed down the generations. So please bear in mind that mites are an excellent part of biodiversity as a whole.

Now I will proceed with my own story. I will explain about why I started to research the subject of mites in the first place. When I was a student in the Department of Agriculture at Kyoto University, I chose spider mites as my research subject. These are a family of herbivorous mites that parasitize plant leaves. From the human standpoint spider mites are a terrible problem because they get onto various plants and suck the juices from the leaves. They eventually kill the plants and cause major problems as a worldwide agricultural pest.

Regarding their living environment spider mites begin life as eggs and go through several stages before reaching the adult stage. They exist as males and females and reproduce sexually. Mating between males and females is effective only one time. When a female engages in mating, her semen tank becomes full with the result that subsequent mating is ineffective. So for males, the obtaining of virgin females is a very important breeding strategy. In view of this, the kind of behavior spider mites have evolved includes pre-mating guard behavior. The male climbs onto a female pupa before the adult stage and guards it. Then, as the female starts to cast off the chrysalis, the male helps out, and then performs mating immediately. This is the spider mite's reproductive strategy.

Given this state of affairs, virgin females are a very precious asset for the males. If another male comes along, the result is a fight. Two males will enter into a violent combat that involves fencing using their stylet-like mouthparts. (These mouthparts are usually employed to suck the juices out of plants). Often the fight continues until one kills the other and while they are engaged in this battle, a third male may come along and mate with the virgin female. This kind of thing occurs quite often.

In my student days, there was a laboratory class during which we could observe these things taking place through a microscope. I first got into mite research when I saw these things. I was very impressed that mite ecology was so graphically revealing of the meaning of reproduction.

There was another experiment in which we observed what happens when one male is placed alone in a place where there are many virgin females. The point of this was to test the male mites' reproductive capabilities. Results showed that the more that virgin females are available, the more mating the male will perform. Given the opportunity, a male will keep mating whenever and wherever it can until the point where it almost dies of exhaustion. I totally got into mites as living organisms that embody the male's fate as it is. I earned a master's degree and a PhD by studying mites and after that went to work for a pesticides manufacture where I was involved in developing miticides.

At that time too, in the battle between mites and miticides, we found that no matter how many types of miticide we produced, they would soon lose their effectiveness. We investigated many things related to spider mites including their DNA and came to the conclusion that spider mites encompass a huge range of diversity and that they maintain their resistance by continuously evolving. From this, I realized more clearly how important biodiversity is. In any case, the miticides we developed didn't sell well, and the company where I was working declined. So I left that company and joined the research institute where I am employed now taking up work on the preservation of biodiversity.

My initial research work at the institute was on the subject of alien species control, and I am still mainly involved in this work. The first alien species I worked on was the Buff-tailed Bumblebee (Bonbus terrestris), which was imported to Japan from Europe.

This species of bee has been bred commercially for use in pollinating tomatoes and other crops in greenhouses. A species native to Europe, the Buff-tailed Bumblebee has been imported to Japan in large numbers. As you can see, the beehives are installed in greenhouses in this way, and the bees fly around carrying pollen and carrying out the pollination tasks that previously had to be performed by the farmers themselves, while significantly improving the tomatoes' productivity in the process.

However, some of these bees of European origin escaped from the greenhouses and began to live in the wild as an alien species, which had a very bad effect on the native Japanese Bumblebee (Bombus hypocrita sapporoensis). Because of this, use of the Buff-tailed

Bumblebee is now strictly regulated by the Ministry of the Environment to ensure that individuals of this species do not escape from greenhouses.

While I was carrying out this ecological risk evaluation I thought that, in importing the beehives from Europe, they must have also brought in some strange parasites. So I looked for parasitic mites and detected the presence of an endoparasitic mite species called the Tracheal Mite (Locustacarus buchneri) on the bodies of these bees. Then I surveyed how widely these mites had been introduced into Japan.

However, I discovered that the Japanese Bumblebee also carries this same endoparasitic mite. As a result of analyzing the mites' DNA, I ascertained that the Japanese and European forms have different DNA, which means that these mites also exhibit local endemism.

While conducting this research, I have paid particular attention to parasite co-evolution. Originally parasites and their hosts evolve in a kill-or-be-killed relationship, but when they continue in this over a long period, they eventually become tired out. Then they move to the next step, which is a symbiotic relationship. For example, the power of viruses becomes attenuated because their hosts are able to use their immune systems to control the viruses to a certain extent. Accordingly, symbiotic relationships represent the evolutionary end point of the battle between parasites and hosts.

What this means is that, in order to prevent pandemics and limit the disease damage that may be caused by various parasites in future, it is important to know the preexisting evolutionary histories of hosts and parasites. In other words, it is important to know where the original parasite evolved and where it lives. So in the case of the Tracheal Mite, I tried to find out about its origin and how it has evolved up to now by gathering bumblebees and the mites that parasitize them from all over the world.

I checked the DNA of each of the types of organism I found. A convenient point about molecular phylogenetic analysis is that it allows us to guess at once the effective evolutionary times of organisms such as different mites and bees, which may be very different morphologically and taxonomically, because they have some similar genes. This method is beneficial in that we can get to know the effective evolutionary times of species by studying the genes that control identical characters in different species and calibration can be performed by means of the molecular clock method. Using this method, I located the region governing the assembly of the enzyme cytochrome c oxidase in the mitochondrial DNA of both mites and bees. By searching and analyzing the genes in this region I was able to construct an evolutionary tree for each species.

In this way, I was able to show that the evolutionary trees of both species were almost exactly the same shape. You can see that, in the case of the bees, there is a clear separation and differentiation between the bees of Eurasia and Asia on the one hand and those of America on the other. The evolutionary tree of the mites has an awkward shape as you can see. In short, the shapes of the trees of the two species do not match. What this means is that we can surmise that the bees and the mites did not evolve in the same way. In particular, we know that, compared with the Asian and Eurasian bees which have undergone a great deal of genetic differentiation, the mites that parasitize these bees exhibit only a very slight degree of genetic differentiation.

On the other hand, you can see that in America, the mites are parasitic on only one species of bee that has no mitochondrial DNA variation, but the mites themselves display very active genetic differentiation.

From the standpoint of diversity, in the case of Asia and Eurasia, the basic diversity index of the host bees is 0.04 while that of the parasitic mites is an order below that at only 0.005. On the other hand, in the case of America, the basic diversity index of the host bees is zero while that of the parasitic mites is 0.05, which is the reverse of the Asian and Eurasian situation. What this means is that these mites and bees have undergone different evolutionary processes and their origins are also different.

Basically, a lot of evolutionary research has been carried out on the bees. They are considered to have originated in the central region of Asia and then rapidly expanded. As for the mites, from their present mitochondrial DNA tree, they are considered to have originated in America and, after spreading across that continent, they switched their hosts to bees and travelled to Eurasia.

In America this mite is parasitic on locusts so we can suppose that in some way it must have switched hosts to bees and then newly evolved into its present form of Locustacarus buchneri.

When a parasite switches hosts we often focus on the point that introduced alien species usually have a bad influence on native species. But actually, when alien species enter Japan, Japanese parasites also transfer to these alien species and begin evolving into new forms, and Japanese parasites are also capable of generating pandemics on occasion.

An example of this is a Japanese mite that has explosively parasitized alien bees despite the fact that this mite does not parasitize native bees very much. So parasites can utilize different strategies for living and, in many instances, they can more easily parasitize hosts that they have not co-evolved with.

After mites and bees, I turned next to stag beetles. Individuals of alien species in this family are imported into Japan in large numbers for commercial purposes, and their introduction has created problems. In Japan alone, there are many species of stag beetles, and throughout Asia the amount of speciation is greater still. The beetles shown here are all of different subspecies of a species called the Giant Stag Beetle (Dorcus titanus), which is distributed in Japan and across Asia. In order to know how much genetic diversity this species possesses, I made an evolutionary tree using mitochondrial DNA. As a result, I discovered that this single species encompassed a huge amount of genetic diversity. This one species exhibits clear differentiation in each region and each island throughout its range. When we examine this in more detail, we find that it is differentiated into the 'big blue' family in the northern part and the 'big red' family in the southern part of its range, and at the root of this tree is the ancestor of all the subspecies of Giant Stag Beetle that exist today. In fact, the point of differentiation occurred 5.2 million years ago. Even species of such small insects achieve genetic differentiation over time by spreading out their ranges, and in the case of the Giant Stag Beetle this has created subspecies with a history spanning more than 5 million years. We call such a population an evolutionarily significant unit (ESU). In the near future, we will no longer be able to classify organisms merely as species, but we must also handle them as units in which we consider the evolutionary history of each genotype and its weight.

This next story concerns conservation. Again, I am going to turn my attention to mites. This time, I would like to talk about mites that parasitize beetles. There is a genus of mites called Coleopterophagus that live by attaching themselves thickly to the backs of beetles. I'm sure that people who keep beetles have seen these mites. Many beetle lovers hate them and brush them off the backs of their pet beetles with considerable enthusiasm. Because so many of these mites attach themselves to the back of a single beetle, the beetle looks poorly, which is why the common Japanese name of this mite is the 'kuwagatanakase', which literally translated into English means "beetle's bane".

However, these mites are merely scavengers. They are cleaners that eat the fungus that grows on the stag beetle's back or any waste matter that gets attached. So actually, these are very good mites as far as the beetles are concerned. For this reason, I would advise people who keep these beetles not to remove the mites. Moreover, the kuwagatanakase can only live on the backs of stag beetles. They would die even if they were placed on some other insect or given double the amount of waste to eat. For this reason, it is considered that the stag beetles and the mites that live on their backs have co-evolved.

This is a close up of one of these mites. The photo will appeal strongly to mite lovers, but if you hate mites you probably won't be able to stand it.

I love mites more than beetles, so I want to know about the evolution of mites. Actually, these kuwagatanakase mites are not only found on Japanese stag beetles. They also live on stag beetles all over Asia. I performed a search of the beetles' DNA and, along the way, I also took a great deal of interest in the sort of trivia that only an acarologist would care about. I refer to things such as the amount of genetic diversity within the genus Coleopterophagus, the evolutionary history between the beetles and the mites, and place from where the kuwagatanakase mites originally came. In order to find out as much as I could I collected stag beetles from all over Asia and the mites attached to their backs as well. Using the information in their DNA I built up an evolutionary tree. This is a mitochondrial evolutionary tree of the stag beetle species living in Asia including the Giant Stag Beetle. Since the tree is so large, you can't read the writing on this slide, but please don't worry about that.

In order to complete this evolutionary tree, I had to read approximately 2,000 bases. From this evolutionary tree, we can see that the host species has a huge amount of genetic diversity. And here is the evolutionary tree of the mites that live on these beetles. Somewhat surprisingly, this species' genetic differentiation has also progressed to a great extent. Moreover, if we try to link up the relationship between the host and parasite, we can obtain a one-to-one relationship like this.

This means that the mites have not simply been drifting in their evolution and their mode of living. They have walked and lived together with their beetle hosts along an evolutionary history that stretches back for over 12 million years. The fact that different populations of these two species have been evolving together for such long time also indicates that these small mites also exist as evolutionarily significant units.

This is a computer graphic image of a Tracheal Mite. I do computer graphics as a hobby and I'm proud to say that this image is one of my own efforts. When I have an opportunity to talk about mites, I purposefully put in a slide like this in an effort to educate people as to the splendor and beauty of mites. However, these efforts often come to grief as the bigger I make the slides, the more people say they feel sick. When I drew this image, I thought it was well done, so I sent it to the publisher of an international acarology journal in the United States and they used it on one of their cover pages. The publisher was very impressed with the image and assumed I was an artist. He invited me as an artist to attend the journal's 60th anniversary party and requested that I bring the original image with me. I felt frustrated that I wasn't recognized as an acarologist, so I told the publisher, "I am not an artist, I'm an acarologist!" and sent them one of my papers. They replied, "Never mind your paper! Just send your picture." Since the party was being held in Ohio and it was too much bother for me to travel there, in the end I sent the picture after all. This made the publisher very happy, and they turned it into a memorial postage stamp. So if you are in the United States, please look out for a memorial postage stamp with a mite pattern and buy it.

Another thing, when the COP 10 conference on biodiversity was held the year before last, the Emperor and Empress visited our research institute and I was one of the people guiding them around. At that time, I put a lot of pictures on the wall. The Empress showed interest and asked me what they were. I'm sure that up until then she hadn't seen any big pictures of mites. From that point, I became a bit hyperactive. I stopped talking about the institute and about biodiversity and instead I talked about mites for ten minutes. The Emperor and Empress seemed very impressed and they took one of the pictures back to the Imperial Palace with them. This became a historical monument as the first picture of a mite to be taken into an Imperial residence.

Recently I appeared on TV, where I had photos of myself taken with many entertainers. Among them, Shokotan (Shoko Nakagawa) took the most interest in mites. I told her a lot about how mites couple, and she responded that she would like to see mites coupling. So

I devoted all my time over Golden Week to completing a computer graphic image of two mites coupling. This is that picture. The larger mite is the female, and the other one, which is holding up its bottom, is the male. They take a very unusual sexual position. I gave this picture to Shokotan and she was very happy with it. Moreover, when former Environment Minister Ryu Matsumoto visited our institute, I also presented the same image to him, explaining, "This is a picture of two mites coupling." He casually brought it back with him, but he actually had it put up on the wall of his office. Since he later resigned in controversial circumstances, this is now a sad memory for me.

I've wandered off the subject, but to come back to point I wanted to make, even mites exhibit endemism and diversity. These days, however, with problems such as globalization and the introduction of alien species, the endemism and diversity of mites is in a critical situation.

This is a spider mite. These mites are agricultural pests. I myself researched this both in my student days and when I was working for the pesticide manufacturer. Spider mites also exhibit endemism and diversity, and this is also in a critical situation. As an example, this Two-spotted Spider Mite (Tetranychus urticae) is one of the many spider mite species and it is a serious agricultural pest on a worldwide scale. This species comes in two color varieties—a red variety and a green variety. This is a rare intra-species variation, which is considered to be part of an on-going process of genetic speciation. Accordingly, I have taken an interest in this process and tried to study the degree of differentiation of the intra-species variation. And to do this I have collected red and green mites from all over Japan and Europe and analyzed their DNA.

As a result, I was able to construct this evolutionary tree, and from it I found that the green mites became differentiated from the red mites, perhaps through pigment decolorization. Here, I would like to draw your attention to the fact that the red mites' genetic differentiation is unusually active even within Japan. Indeed, this differentiation has progressed almost to the species level. What has caused this? I thought it was curious that such extensive genetic exchange was taking place in such a limited region as Japan. So I studied those individuals for which differentiation was particularly pronounced, and ascertained that they were all parasitic on carnations.

As these mites are specifically parasitizing carnations, it would be quite reasonable if they were genetically homogeneous. So why was there this much genetic variation among them? I studied this question and found out that most carnations are not grown in Japan but are cultivated abroad and imported and sold as cut flowers. These carnations are grown in many countries, and Two-spotted Spider Mites live in all of these countries. That's the reason why there is now so much genetic diversification among the Two-spotted Spider Mites that live in Japan.

In fact, I interviewed carnation farmers asking them where they purchased their carnations, and found that they imported them from many countries as shown here. Moreover, almost all the mites that exhibit genetic differentiation are of foreign origin. Clearly these mites were brought into Japan from overseas.

An even more troublesome thing is that because these mites are pests, their drug sensitivities differ from those of ordinary spider mites. When exposed to miticide, since the green type mites are very similar genetically, they all die straight away, and most of the red type monophyletic mites, which are the main variety in Japan, also die.

However, such miticides are totally ineffective against the spider mites that have been imported from abroad because these mites had sufficient genetic resistance to the miticide from the beginning. When this much genetic variation is so widely distributed within a group, there must be some mites that have resistance, and these survive and breed.

Since these mites are pests, they should have been prevented from entering the country by means of plant quarantine in the first place. So I investigated why so many things (that should have been incinerated) were allowed to come into Japan. Now, the World Trade Organization is aiming for global free trade and a part of that effort is the Trans-Pacific Partnership (TPP). This organization, which promotes free trade, is promoting agricultural pests as well.

Originally, the Two-spotted Spider Mite was on the list of species for which importation into Japan was prohibited. However, in 2004, they were found on apples imported from the United States and the apples were incinerated. This provoked an angry response from the US side, which sued Japan through the WTO. The US argument was that since the Two-spotted Spider Mite already existed in Japan it was unreasonable to quarantine imports from the US on the grounds that they harbored the mites. Japan lost this case and as a result, was forced to abolish the quarantine measures for the Two-spotted Spider Mite, allowing this species to be imported freely into the country.

This is a very inconsistent approach. As I explained earlier, perhaps these mites do look the same but they have very different genes and their sensitivity to drugs also varies widely. Now they are freely imported. And although most of us are unaware of the fact, the liberalization of agricultural pest species has been proceeding apace.

The Plant Protection Act was finally revised in the spring of last year. Under the revised law, Japan has moved from a 'white list' system to a 'black list' system. Under the white list system, the importation of all pests that damage plants was banned in principle. Only those species of insects, etc., that were on the white list (such as stag beetles and unicorn beetles) were considered safe to import. The white list was a very strict regulation. By contrast, the black list system operates on the principle that all species can be imported unless they have been examined and specifically placed on the black list. So only those species considered to constitute a risk are prohibited from being brought into the country. Any species not on the black list can be freely imported. This is the same system as specified by the Alien Species Act. A consequence of the change to the black list system is that the release ratio of agricultural pests has become higher. Since only those species deemed to present a risk are listed, almost all agricultural and forestry pests can now be freely imported.

The TPP, which has become a major subject of talk, presents us with the same situation. One government minister has described the TPP as the 'third opening of the country'. Whenever the country is opened the number of alien species increases. So if we think about protecting biodiversity in a true sense, in future, we should pay a lot of attention to this TPP argument from the ecological science and animal hygiene standpoints.

As a case example, I'd like to talk about a dangerous mite that is brought into Japan together with imported living organisms. Up to now I have been talking about rather mild things unrelated to human health. But what I'm going to talk about now are ixodid - hard-bodied ticks - which feed on the blood of animals and spread various diseases. The most dangerous ones can transmit zoonoses to humans.

In the current situation, there is concern that with the large numbers of reptiles being imported into Japan and with almost all of them taken from the wild, many kinds of ixodid ticks are being brought in with them. What is even more troubling is that legal protections such as guarantees on the safety of imported animals mandated under the Infectious Disease Law by the Ministry of Health, Labour and Welfare and animal quarantine provisions are limited to warm-blooded animals. Reptiles and amphibians can be brought into Japan without any guarantees at all. I was concerned about this so I began a project to study the matter jointly with Prof. Kawabata of the National Institute of Infectious Diseases. In the course of this research, as I had expected, we found ticks of the genus Amblyomma on turtles and many kinds of mites attached to reptiles imported into Japan.

Moreover, the number of countries from where these living things are imported is surprisingly large, including such widely separated places as Sri Lanka, Tanzania, and Suriname. I wasn't even sure of precisely where some of the countries of origin were so, due to this research, I also had an opportunity to study geography. What especially worried me was that the mites themselves might be carrying some dangerous pathogens so I asked the NIID to do some testing. The results came back positive. We discovered the presence of the bacterial genus Borrelia which can infect humans with many diseases. I studied the genetic differentiation of this genus and produced an evolutionary tree. I noticed that the genus includes a species that is the agent for Lyme disease and a species that causes tick-borne relapsing fever. This information was so complete that I was able to make use of it in conjunction with the evolutionary tree. The new Borrelia bacteria we discovered were not members of either of the above species. They are a totally new type. This is a very dangerous situation because nothing is clear including the pathogenicity and, even more troublingly, no risk evaluation has been made of these bacteria because it has not been possible to grow them in isolation up to now. In view of this I have to say that, under the current free trade situation, people who want to keep reptiles as pets need to seriously consider the potential risks they are taking.

For my own research I previously chose only visible large alien species. But now I am paying attention to invisible alien species as well. What set me off in this direction was a disease called chytridiomycosis, an infectious disease of amphibians that is often fatal. Perhaps you have heard of it. Chytridiomycosis is an emerging disease that has spread worldwide and wiped out entire species of frogs in some places. It landed in Japan several years ago and caused considerable uproar. I dislike frogs but I worked on this theme out of necessity, and I was shocked by my results. I don't have time to go into the details now, but I'd like to tell you about it when I get an opportunity.

As Prof. Nakamura said at the beginning, the reason why such emerging diseases that are close to being zoonoses are being encountered more often now is because biodiversity is being gradually destroyed. Parasites and their hosts establish peaceful and stable relations after a long period of co-evolution. Biodiversity is a cradle in which these organisms can grow and develop together, but it can also serve as a cradle for pathogens. When human beings destroy this biodiversity there follows a collapse of evolutionary history and co-evolution, and in its place, pandemics occur. Examples of this process at work include SARS and HIV/AIDS. They have their respective origins in horseshoe bats in China and in chimpanzees in the Cameroon, and were living quietly with their hosts. The reason why they turned into emerging diseases is that humans destroyed the habitats of the hosts, allowing the viruses to cross the species barrier. Now the viruses are desperately evolving in order to survive in their new hosts, human beings, of which there are about 7 billion individuals at present. They have already arrived in the urban jungle.

The important thing here is that, in line with the evolutionary rule that has always been followed until now, hosts that are infected either die or else they survive. Those that survive are more likely to pass on their genes to the next generation. In this way, succeeding generations have better resistance to the effects of the virus and the two species gradually enter into a symbiotic relationship. Today, however, we attempt to contain dangerous viruses by any means available including the use of antiviral drugs and other pharmaceuticals. The result is that the viruses continue to evolve rapidly in response to the drugs they are exposed to. This becomes a non-stop fight between humans and viruses. Only humans break this evolutionary rule. When we consider the evolutionary history of viruses there is a high possibility that humans will lose this fight one day.

So, if we want to stop this fight, it is important for humans to keep at a distance from biodiversity from now on. The idea of "natural symbiosis" or "living in harmony with nature" is often talked about. But this does not mean it is OK for owners to kiss their pets or something like that. Humans have evolved as naked apes who can survive in the concrete jungle so when we talk about 'natural symbiosis' it is important to apply some kind of zoning between the wild world and the human world and to properly separate their functions.

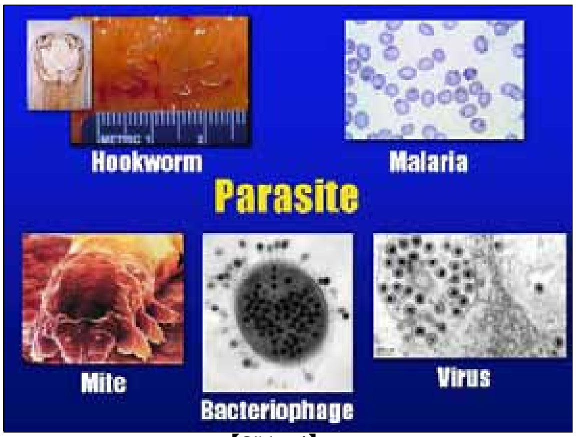
In that sense, protecting biodiversity has another important meaning. It can serve as a means of preventing the expansion of emerging infectious diseases. Biodiversity does not exist only to be applied to beautiful living things. Even parasites are encompassed within biodiversity. So please extend your support to the mites and ticks too.

That completes my talk. Thank you very much for listening.

【Slide 1】

【Slide 2】

【Slide 3】



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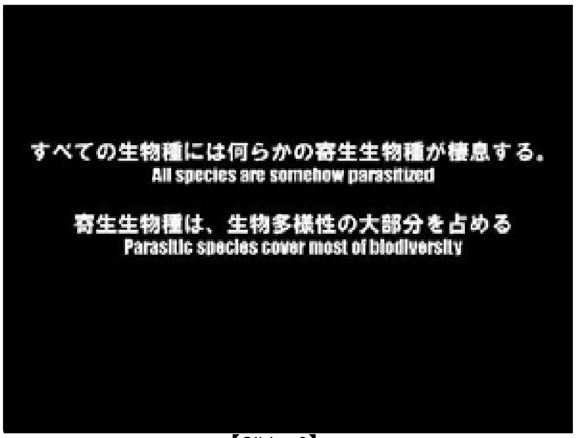
【Slide 5】



【Slide 6】

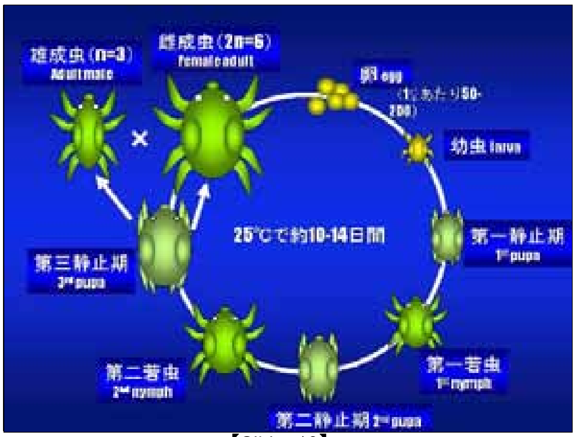
【Slide 7】

【Slide 8】

【Slide 9】

【Slide 10】

【Slide 11】



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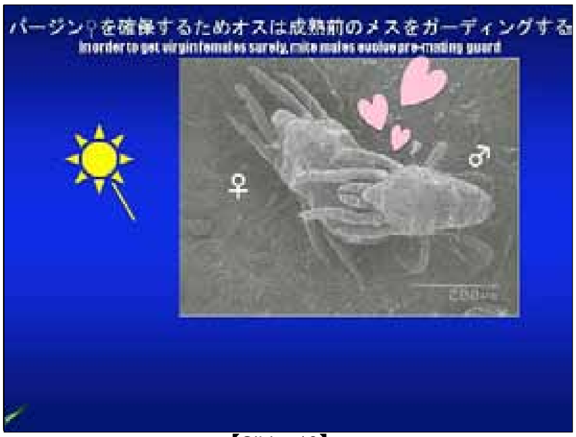

【Slide 13】

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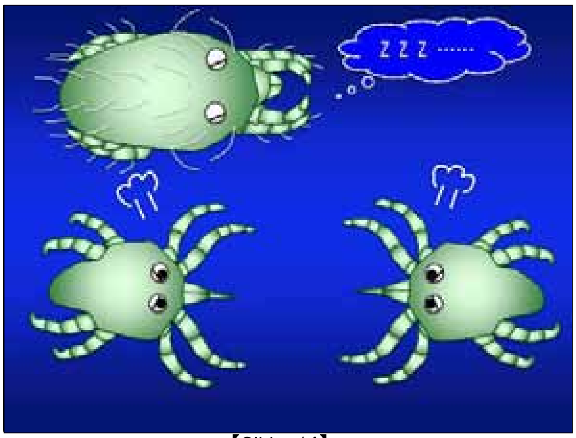

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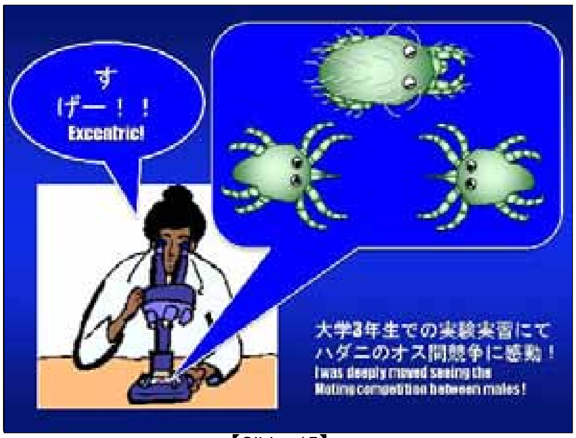

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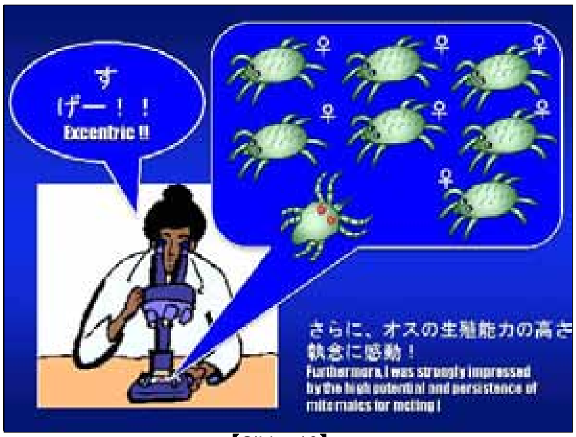

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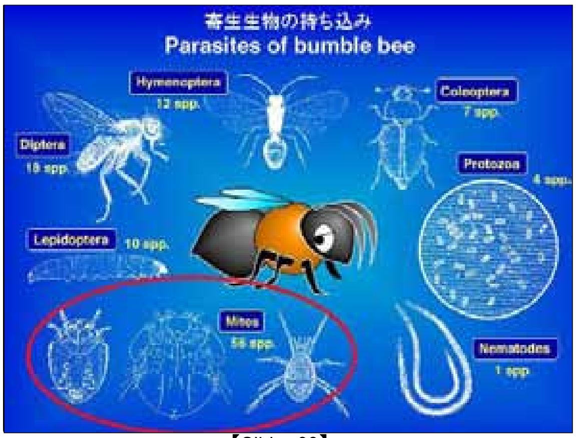
【Slide 20】

【Slide 21】

【Slide 22】



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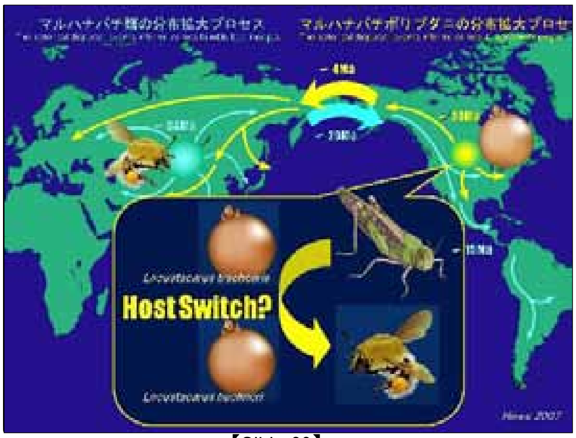
【Slide 24】

【Slide 25】

【Slide 26】

【Slide 27】

【Slide 28】



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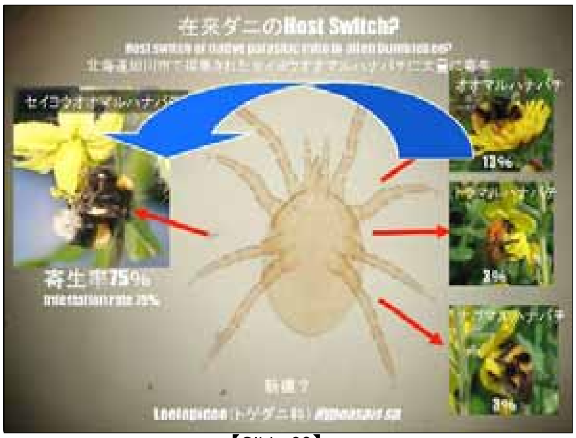

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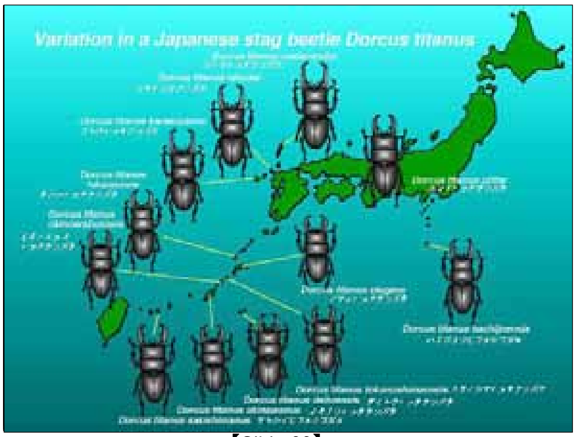

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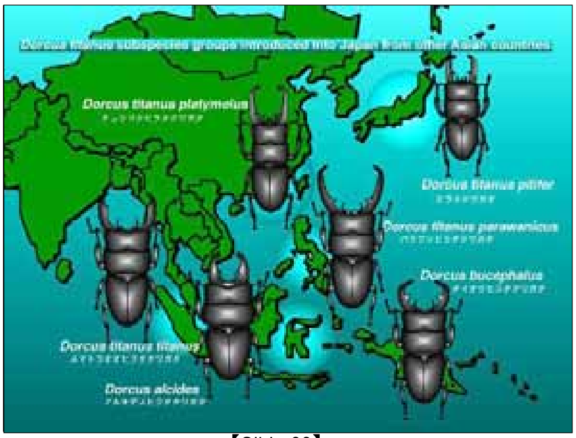

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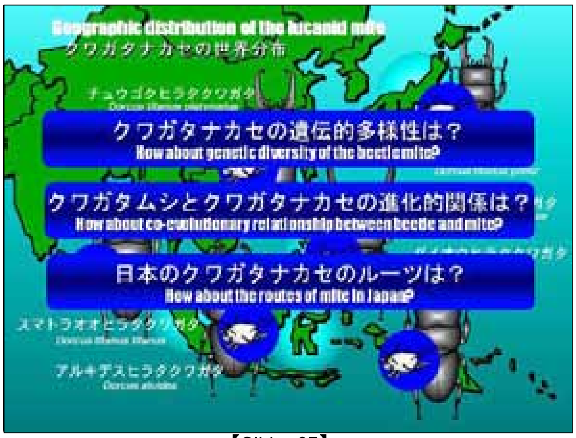
【Slide 34】

【Slide 35】

【Slide 36】



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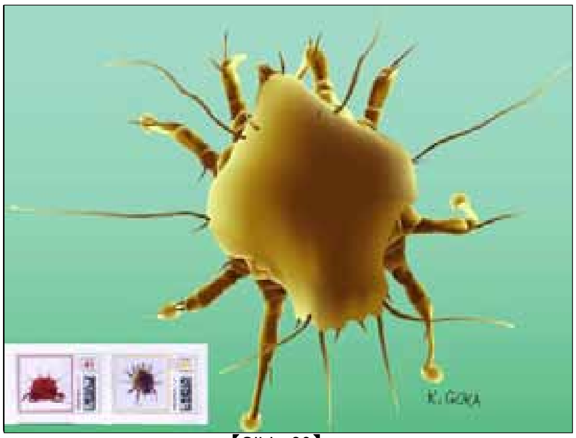
【Slide 41】

【Slide 38】

【Slide 42】



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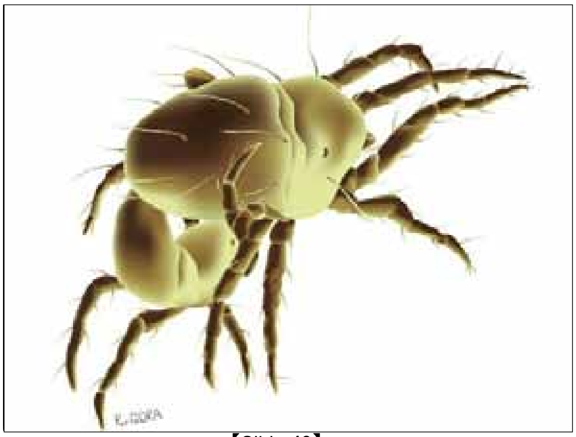
【Slide 43】



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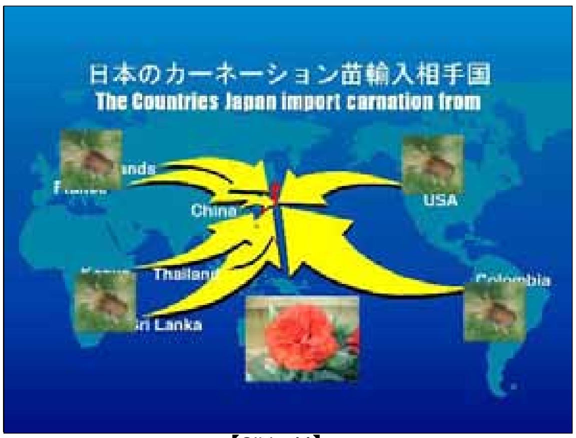


【Slide 44】

【Slide 45】

【Slide 46】

【Slide 47】

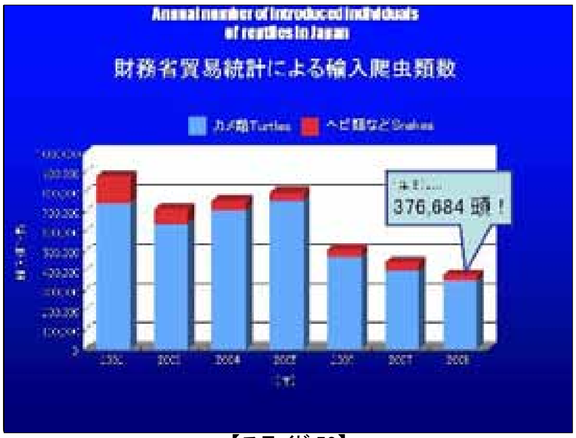
【Slide 48】

【Slide 49】

【Slide 50】

【Slide 51】

【Slide 52】



【スライド 53】

【スライド 54】

【スライド 55】

【スライド 56】

【スライド 57】

【スライド 58】

【スライド 59】

【スライド 60】