2013

The Study on the Impact of the Fukushima Nuclear Accident on Animals

Ito Nobuhiko
Kitasato University

The Study on the Impact of the Fukushima Nuclear Accident on Animals

An organization for investigation and research

Assignment

○Supervising editor, Introduction, Summary
Nobuhiko Ito, DVM, Vice-President, Kitasato University

○Vice-supervising editor
Masahiro Natsuhori, DVM, Professor, School of Veterinary Medicine, Kitasato University

○Editor
Seiichi Wada, DVM, Associate Professor. School of Veterinary Medicine, Kitasato University

○Companion animals
Jun Kawamata, DVM, Director, Chiba small Animal Clinic

○Companion animals, Horses, Food animals,
Shigeki Imamoto, DVM, Director, Shinjo Animal Hospital

○Companion animals
Kunimitsu Masuda, DVM, Director, Masuda Animal Clinic

○Food animals
Toshiriro Sato, DVM, Director, Sato Livestock Hospital

○Animals reared in school
Akiko Kawasaki, Japan Animal Welfare Society

○Wild animals
Takehiko Kakizaki, DVM, Assistant Professor, School of Veterinary Medicine, Kitasato University

30 May 2013

Index

1. Introduction

The Great East Japan Earthquake on March 11th, 2011, caused the TEPCO Fukushima Dai-ichi nuclear power plant to suffer the worst nuclear catastrophe since the Chernobyl disaster. The following day, the area within a 20-km radius was designated as an evacuation zone. In addition, on April 22nd, 2011, access was strictly restricted within the 20-km exclusion zone. In the aftermath of the accident and the resulting spread of radioactive isotopes, an increase in the air radioactivity dose rate was detected even beyond this area throughout Fukushima Prefecture. As a result, animal husbandry within the 20-km exclusion zone was largely neglected, and, beyond this area, the movement and management of animals was controlled. The effect of radiation exposure on animals has been a major concern.

The purpose of this study was to determine the state of animals after the nuclear accident and to ascertain as to what steps were taken to assist animals during the time of the accident.

The study will emphasize on companion animals such as cats and dogs. Furthermore, horses were also included because of being the large number of horses in Fukushima Prefecture. In addition, this study examined the effects of the accident and its aftermath on animals kept in schools, animals used for food (particularly cattle but also pigs and chickens), and wild animals.

In Japan, there are three regulatory agencies related to animal management. The jurisdiction of the Ministry of the Environment (MOE) is responsible for animal welfare and appropriate management of animals to prevent nuisance and harm to others. Animals for management include household animals, animals used in exhibitions, animals used for production, and animals used for experiments. Moreover, wild animals are managed by the Ministry of the Environment in order to preserve natural environments. However, the Ministry of Agriculture, Forestry and Fisheries (MAFF) is responsible for the productivity of animals used for production. This ministry is also responsible for the farm products to prevent from wild birds and beasts. In addition, the Ministry of Health, Labor and Welfare (MHLW) is responsible for managing the registration and vaccination of dogs, as well as the impounding of feral dogs from a view of rabies prevention. This ministry is also in charge of food safety and examination of animals used for food from a view of ensuring food safety. In some cases, the same animal can fall in the jurisdiction of some agencies. As another example of this complex management system, guide dogs for the physically handicapped person under the jurisdiction of the MHLW, but the responsibility for rearing and training these dogs is in charge of the MOE.

As mentioned above, the legislation on animal management on a national level was not simplified, responses taken by local governments are complex. This administrative jumble is one reason why animal protection and husbandry did not smoothly proceed after the nuclear accident.

Although the number of farm animals before the accident could be speculated with some degree of accuracy, the number of other domesticated animals, except for dogs, was unknown. Even in case of dogs, while the health centers had information on the dogs registered under the Rabies Prevention Act, the registration rate was approximately 50%–60%; thus, the total number of dogs was merely an estimate.

The number of domestic cats before the accident, in comparison to the number of dogs, was not accurately known. Moreover, there was a great deal of uncertainty over wild

animals. Not only was the law around these animals very complex, but also the situation was further complicated because laws and ordinances governing nuclear power plant accidents did not take animals into consideration. This led to situations wherein farm animals wandered freely within the exclusion zone.

The present report relies not only on official published data, but also, as far as possible, on our own field work and interviews. Therefore, I believe it better reflects the real situation. However, it must be emphasized that the situation is dynamic and unstable; hence, the submitted report must be viewed as work in progress.

We believe that if the present report is published in English, it would help people around the world to precisely understand the complete story behind the suffering of animals after the catastrophe that occurred in Japan.

Nobuhiko Ito, DVM, PhD, Vice-President,
Kitasato University

2. The situation of companion animals (cats and dogs) during the disaster

(1) Summary

This chapter deals with companion animals, including cats and dogs that are household pets. It mainly mentions reports on the activities of the Headquarters for the Relief of Animals in Emergencies (HRAE) during the disaster.

During the Great East Japan Earthquake, many animals were affected by the earthquake, the consequent tsunami, and the disaster at the Tokyo Electric (TEPCO) Daiichi Nuclear Power Plant at Fukushima Prefecture. During the emergency evacuation after the disaster, many residents with pet animals were forced to reluctantly leave their animals at home. Later, an exclusion zone with a 20-km radius from the nuclear power plant (Fig. 1) was set up and entry was prohibited. At the time, a short evacuation period was anticipated; however, in reality, many residents still have to live in temporary housing, and have been unable to live with their pets. In some cases, it was observed that abandoned animals starved to death. Immediately after the earthquake there was no restriction to enter the exclusion zone, so many volunteer groups were able to save the lives of such animals through feeding and rescue operations.

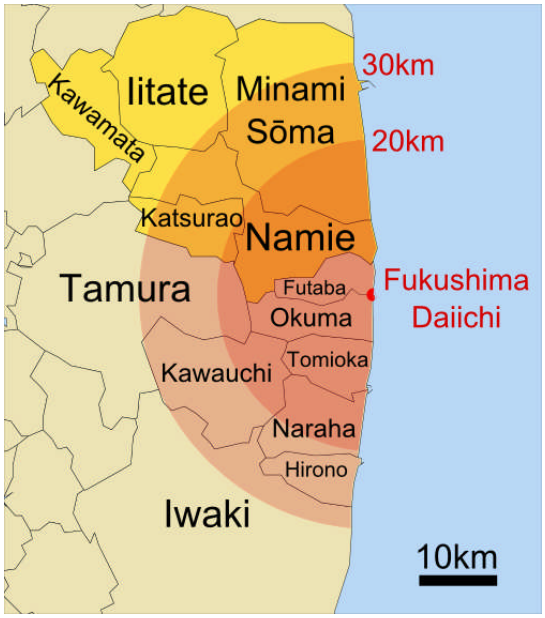


Fig.1 Map of exclusion zone

(2) Activities of domestic organizations for animal welfare

The Ministry of the Environment (MOE) supported aid for affected pets in conjunction with the HRAE and local government agencies. The HRAE is comprised of four groups: the Japan Society for the Prevention of Cruelty to Animals, the Japan Pet Care Association, the Japan Animal Welfare Society and the Japan Veterinary Medical Association. These societies requested support and cooperation from 15 organizations related to animal welfare, including the Pet Food Association, to provide protection, food, and proper care for domestic animals in the affected area.

A total of 2,542 animal cages and 56 tents were purchased and delivered to affected local bodies and local bodies that accepted victims of the disaster. These local bodies supported the installation of temporary animal shelters in affected areas during fiscal years 2011 and 2012. Each local body set up animal welfare centers and other systems based on animal welfare laws in order to administer animal accommodation, transfer, and guardian search, and to deal with wandering dogs and dogs whose guardians had lost control over them. In addition, the veterinary associations and animal welfare organizations for each affected area cooperated with local bodies to provide medical attention, food, and temporary stay for affected animals, and collected information about places for pet evacuation. In Iwate, Miyagi,

and Fukushima Prefectures as well as in Sendai city, local bodies supervised administration in cooperation with regional veterinary associations, animal welfare organizations, and animal aid centers for the affected areas.

At least in the entire Iwate Prefecture, many areas in Miyage Prefecture, and municipalities in Fukushima Prefecture, tenants living in temporary housing were allowed to keep their pets. Of the 88 affiliated companies for the Pet Food Association, 39 offered a total of 296 tonnes of pet food.

(3) Aid activities for cats and dogs: timeline.

- March 11th, 2011, 14:46: The Tohoku–Pacific Ocean Earthquake occurred, with the epicenter off the Sanriku coast.
- March 14th: The Japan Society for the Prevention of Cruelty to Animals, Japan Animal Welfare Association, Japan Pet Care Association, and Japan Medical Veterinary Association set up the HRAE to raise funds for donations.
- March 30th: The HRAE held the 2nd special meeting in order to share information regarding the present circumstances and future directions with relevant organizations.
- March 31st: The MOE investigated the possibility to support the set up of temporary accommodation for animals in affected areas during fiscal year 2011.
- April 1st to May 2nd: A staff member from Welfare and Management of Animals Office at the Ministry of the Environment was dispatched to the HRAE.
- April 18th: In the 4th special meeting at the HRAE, rescue or aid of pets at temporary entry to the restricted area was consulted with relevant organizations.
- April 19th: Based on the notification by the Nuclear Emergency Response headquarters, entry was prohibited in the 20-km radius from the Fukushima Daiichi Nuclear Power Plant for the purpose of pet rescue, as published on the web page.
- April 22nd: The Ministry of the Environment and Fukushima Prefecture set up a committee to investigate aid of pets within the exclusion zone.
- April 25th to May 9th: In the special meeting at the HRAE, concrete measures to rescue pets within the exclusion zone were discussed with relevant organizations.
  The first shelter for affected companion animals was opened at Ino, Fukushima city.
- April 28th: Fukushima Prefecture officials started a survey on pets left within the 20-km radius from the Fukushima Daiichi Nuclear Power Plant. On the first day of this survey, i.e., April 28th, two officials from the Ministry of the Environment assisted the survey. The survey was conducted until May 2nd for 5 days.
- May 7th: One official from the Animal Welfare Office at the Ministry of the Environment was dispatched to the local nuclear emergency response headquarters.
  Residents were temporarily allowed to enter the exclusion zone to rescue and protect pets from May 10th, 2011, and the Ministry of the Environment and Fukushima Prefecture gave their full cooperation. With the cooperation of the HRAE, rescued and protected pets were housed at facilities provided by Fukushima Prefecture.
- May 13th: The Ministry of the Environment issued a written request for cooperation in their pet rescue operation to the seven municipalities where residents were allowed temporary entry into the exclusion zone. As a result, 300 dogs and 191 cats were rescued between May 10th and August 26th by the residents and officials from the Ministry of the Environment, and Fukushima Prefecture, along with assistance from other local bodies and the HRAE.

August 26th: 302 dogs and 190 cats were rescued.

- September 1st: Officials from the Ministry of the Environment and Fukushima Prefecture cooperated to launch their campaign to rescue wandering cats and dogs. Ten dogs and 16 cats were rescued in 16 days since September 3rd. The second shelter for affected companion animals was built at Miharu, Tamura-gun, and animals were housed in accommodation administered by Fukushima Prefecture.
- August 31st to October 23rd: Based on information regarding affected dogs and cats provided by residents, an inspection was carried out within the exclusion zone, and 14 dogs and 15 cats were rescued and protected.
- December 5th: The Ministry of the Environment and Fukushima Prefecture established and published guidelines in which standards for entry into the exclusion zone to rescue pets was defined for NGOs.
- December 7th (Wednesday) to December 27th (Tuesday): Based on the guidelines, 16 NGOs, whose rescue plans were approved, conducted rescues in the exclusion zone and saved 34 dogs and 298 cats.
- February 28th, 2012: Officials from the Ministry of the Environment in cooperation with Fukushima Prefecture, officially announced that from March 1st (Thursday) to March 19th (Monday), a focused rescue would be conducted for the following three separated time periods:

  Rescue period no. 1: assisted by Tochigi, Gunma, and Aichi Prefectures, as well as Kawasaki city

  Rescue period no. 2: assisted by Tokyo and Kyoto Regions, Shizuoka and Tottori Prefectures, and Aomori and Yokohama cities

  Rescue period no. 3: assisted by Kanagawa and Tokushima Prefectures.
- March 27th, 2012: The Ministry of the Environment and Fukushima Prefecture published the results from the rescue activities conducted between March 1st–19th: a total of 13 dogs and 93 cats were rescued and kept at the animal care shelter run by Fukushima Prefecture. The rescues were announced on the home page of the Fukushima Prefecture Animal Welfare Division, and a search for their guardians was initiated.
- September 6th, 2012: The Ministry of the Environment and Fukushima Prefecture officially announced that comprehensive rescue activities would be conducted from September 7th to October 2th, taking into account the rescue activities up to date, investigation of the living state of dogs and cats, and surveys of the guardians.

(4) Estimates of the number of companion animals within the 20-km radius from the Fukushima Daiichi Nuclear Power Plant.

According to Fukushima Prefecture records of August 2011, a total of 5,800 dogs had been registered within the exclusion zone. At the time of the earthquake, the total number of cats and dogs in the 20-km radius was therefore estimated to be approximately 10,000. Approximately 26% of them were killed in the tsunami, approximately 300 were evacuated with their guardians, and approximately 2,000 were taken out of the zone by volunteers and others. Among the rest 5,000 animals, 80% starved to death. Furthermore, approximately 600 out of the remaining 1,000 were rescued through administrative efforts; thus, it is estimated that there are still approximately 400 animals in the exclusion zone. The number of animals evacuated with their guardians in Fukushima Prefecture was 304 dogs, 63 cats, and 6 other animals.

(5) Transporting rescued animals to evacuation areas and shelters, and decontamination during transport

There were no cases wherein rescued animals were transported by special vehicles to shelters and refuges. With regard to decontamination, it was initially planned that after the entire body surface of animals were screened using a GM counter, if necessary, they would be washed with shampoo to decontaminate them. However, none of the animals exceeded the reference value for radiation, so this was not performed. Instead, as a precautionary measure, animals with relatively high radiation levels (though still below the reference value) were washed with water (Table 1).

Table 1. Surface dose of rescued animals

Day	Zone	Animal		Surface dose
		Dogs	Cats	
April 28th	Minami soma shi, Katsurao mura	5	1	3,500-3,600cpm
April 29th	Namie machi, Kawauchi mura	5		400-900cpm
April 30th	Futaba machi, Hirono machi	4		500-71,000cpm
May 1st	Okuma machi, Naraha machi	10	1	5,000－9,000cpm
May 2nd	Tomioka machi, Miyakoji machi	3		500-4,000cpm
Sum		27	2	

Day	Zone	Animal		Surface dose
		Dogs	Cats	
May 10th	Kawauchi mura	9	3	500cpm
May 11th	Kawauchi mura	2	2	500cpm
May 13rd	Kawauchi mura, Katsurao mura	0	2	500cpm
May 22nd	Tamura shi	2	8	500cpm
May 23rd	Tamura shi	3	7	500cpm
May 25th	Minami soma shi, Tomioka machi	4	5	
May 26th	Futaba machi, Namie machi	7	3	1,500cpm
Sum		27	30	

May 28, 2011, reported by Fukushima Prefecture

The reference value for decontamination was initially set at 100,000 cpm in compliance with the Veterinary Association guidelines; however, after September 16th, 2011, this was changed to 13,000 cpm. Each NGO took responsibility for the whole body screening of the captured animals. However, no animal had to be decontaminated. The administration was unaware of the number of captured animals, except for those rescued by rescue activities of public entities based on the guidelines enforced since December 2011.

▪The number of rescued animals officially recognized by the administration is as follows:

Rescues by the administration,

(from April 28th, 2011, to October 2nd, 2012): 439 dogs, 456 cats.

(until the end of March 2013): 516 dogs, 478 cats.

Rescues by NGOs

(from December 5th to December 27th, 2012): 34 dogs, 298 cats.

Rescues by residents visiting the exclusion zone

(3–4 visits from January 28th, 2012): 2 dogs, 7 cats (screening was conducted by a person in charge of radiation control at TEPCO based on a manual issued by the administration). Till date, no animal was found to be a target for decontamination.

(6) Evaluation of the internal exposure of rescued animals

The effects of both internal and external radiation exposure in cats and dogs found

wandering within the exclusion zone were concerned. In the nuclear power plant disaster, it was observed that “hot spots” where high air dose rate was detected was dotted. However, according to the observations so far, the highest officially recognized radiation dose rate in an inhabited place was 157 uSv/h in the hotspot at Okuma-machi and the dose rate was measured by an ionization chamber. At this air dose rate, it takes 318 days at this hot spot for a radioactive exposure of 3 Gy, which is the half lethal dose for dogs. It cannot be assumed that wandered dogs and cats have stayed for nearly one year around similar hotspots. Thus, taking into account from the dose rate effect, it is assumed that if animals are not exposed to radiation for a long period, acute radiation damage does not occur. Experiments using mice with similar half lethal dose as that for dogs have shown that exposure to 20 mGy/day for a long period shortens the life of the mice by cancer and other disorders; however, it does not cause acute radiation hazards or death. For example, a one-day stay in a hotspot with a dose rate of 157 Sv/h would result in radiation exposure of 2.4 mGy. Thus, it is assumed that there were no spots that would induce an acute radiation hazard outside the Fukushima Daiichi Nuclear Power Plant.

Furthermore, the internal exposure of radioactive materials in wandered dogs and cats in the exclusion zone is a matter of concern. However, as mentioned above, although it appeared to be extremely unlikely that any of the animals would have been exposed to enough radiation internally to induce any acute radiation damage, it is necessary to evaluate this using whole body counters. No acute radiation damage occurred in wandered dogs and cats. However, it is necessary to continue to monitor the animals for late onset disorders such as cancer.

On the other hand, it is necessary either to return wandered dogs and cats in the exclusion zone to their guardians or to find foster parents. However, since these rescued animals had internally absorbed radioactive materials, the external radiation exposure to guardians by such animals should be considered. Accordingly, it is necessary to estimate the amount of radioactive isotopes in bodies of rescued animals. In general, it is known that after radioactive cesium has been taken into the body it is excreted. However, the emission rate (biological half life) of radioactive cesium in dogs and cats has not been clearly reported. For this reason, we conducted whole body surface measurements for animals in order to measure internal exposure in cats and dogs. Before conducting the examination, we took samples of urine from cats in shelters and measured the concentration of radioactive cesium in the urine over time in order to survey the state of excretion of radioactive cesium.

Three cats rescued from the exclusion zone and fostered in the shelter were used for the examination.

- Cat A: age, five years old; female; body weight, 3.55 kg, surface radiation dose, 180 cpm (background: 140 cpm)
- Cat B: age, 10 years old; male; body weight, 5.2 kg; surface radiation dose, 11000 cpm (background: 140 cpm); radiation was reduced to 200 cpm after decontamination
- Cat C: female; body weight, 4.5 kg; surface radiation dose, 160 cpm (background: 140 cpm)

＊Rearing was started on December 5th, 2012

Fig. 2 shows the change in radioactive cesium concentration (Cs-137) in the urine over

time. Urine samples absorbed into cat litter were squeezed out in a U8 compression vessel and measured with a germanium semi-conductor detector. Because the primitive urine was not measured, and because of the uneven nature of the sample from the cat litter, results were not readily reproducible and there was a high degree of variation in the radioactive cesium concentrations. However, the amount of radioactive cesium in the urine of each cat tended to reduce over time. Although the internal concentration of cesium could not be determined accurately, the excretion of radioactive materials from the body after being fed uncontaminated food could be clearly determined. In addition, we calculated the biological half life for the cesium excreted out of the body by exponential approximation analysis. The half life values were 21.6, 69.7, and 9.2 days for cats A, B, and C, respectively. Although it has been reported that the excretion half-life of cesium from experimental animals is 60–90 days, this time, the excretion half-life of cats was suggested to be shorter than that of experimental animals. However, since the differences between individuals were high, and the urine sample was mixed with cat litter, the measurements were not accurate. It was therefore not possible to come to any definite conclusion using this data alone. More definitive conclusions are anticipated after the whole body counter system has been implemented.

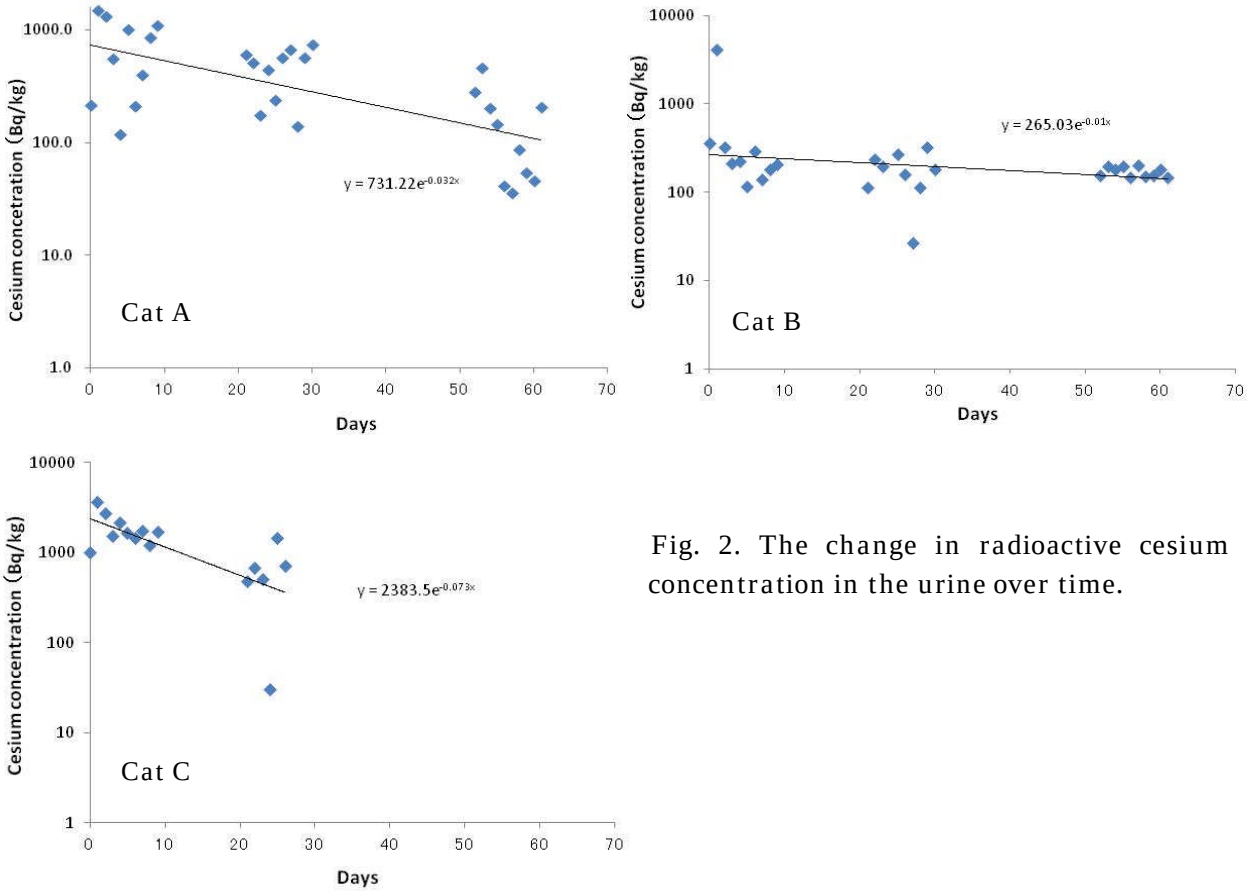


Fig. 2. The change in radioactive cesium concentration in the urine over time.

It has been reported that radioactive cesium is distributed in the muscle and liver in many animals. However, the distribution of radioactive cesium in cats has not yet been reported. In order to make a more detailed analysis of internal radioactive cesium exposure, the distribution of cesium in the body was investigated. Cesium concentrations were

measured in the liver and muscles of rescued cats that died while being reared at the shelter.

- Cat D: age, 3 years old; body weight, 1.95 kg; surface radiation dose, 200 cpm (background: 150 cpm); castrated at the time of transport; looked after from December 6th, 2012; died on December 15th, 2012
- Cat E: age, 3 years old; body weight, 4.3 kg, surface radiation dose, 190 cpm (background:150 cpm); not castrated; reared from September 26th, 2012; died on January 11th, 2013
- Cat F: age, 7 years old; body weight, 3.5 kg, surface radiation dose, 300 cpm (background: 120 cpm); castrated, reared from December 7th, 2012; died on January 9th, 2013

Table 2 shows the cesium concentrations (Bq/kg) in the liver and muscle for each cat. The concentration of cesium in the liver was between 484 and 1,840 Bq/kg, and that in the main muscles was between 533 and 13,100 Bq/kg. Radioactive cesium was detected in each individual, and the concentrations in the muscle were higher than in the liver. It was found that in the cat, the muscle is the main site for accumulation of radioactive cesium.

Table 2. Cesium concentration in the tissues of rescued cats

Cs-137	(Bq/Kg)		
	D	E	F
Liver	1010	484	1840
Masseter	1960	568	1180
Musculus triceps brachii	1770	533	8390
Musculus quadriceps femoris	–	–	13100
Testis	–	390	–
Surface dose	200cpm	190cpm	300cpm
The period for protection	12 days	140 days	30 days

Cat F showed high concentrations of cesium in all internal organs. His surface radiation dose at capture was 300 cpm, higher than that of the other two cats. It is considered that the cat may have been found at a highly contaminated area. Moreover, because radioactive cesium is mainly excreted through the urine, even if it is continuously taken orally, the internal concentration eventually reaches an equilibrium level.

Previous studies have demonstrated that when highly contaminated rice straws were fed to animals for a month, the concentration of radioactive cesium in the internal organs was approximately 5,000 Bq/kg. The equilibrium level for cats therefore appears to be high. It has been reported that the European big cat, which is not a companion animal, caught and ate contaminated reindeer after the Chernobyl disaster and thus showed high concentrations of radioactive cesium in the muscle, the highest level being 15,000 Bq/kg. In the case of cat F, taking into account that 30 days had passed since he was rescued, the internal radioactive cesium concentration on the day of his capture could have been between 15,000 and 20,000 Bq/kg. The domestic cat therefore appears to have a high equilibrium value.

Moreover, cats D and E had similar surface radiation dose on the day of capture, but the number of days that had passed since then was greatly different and this was reflected in the different internal concentrations of radioactive cesium. If the period for protection after the rescue is long, it is assumed that problems of radiation exposure from internal exposure by radioactive cesium and exposure from cats would be reduced since radioactive cesium is excreted from the body.

Furthermore, in order to determine the cause of death of cats, the organs sampled for cesium measurement were dissected and autopsied. Acute radiation damage by radioactive isotopes was not observed as mentioned above. However, in order to evaluate carcinogenesis as a late onset effect by radiation, each organ was examined. No lesions could be found in any of the cats. Leukemia is a typical carcinogenic disease caused by radiation. Although it was unclear whether signs of leukemia were found in cats at the time of autopsy, specific observations of leukemia also were not observed. No other solid cancers were observed. Although parasites were observed in the small intestine, the digestive tract and bladder mucosa showed no noticeable change. Taken together, it can be assumed that no apparent tumor was caused as a result of the nuclear disaster.

In April 2013, we set a whole body counter as a test to monitor the internal radiation exposure of living cats in the shelter. Because of budgetary constraints it was hard to set a lead shield around the measuring chamber; hence, I used a series of poly tanks filled with tap water. The background radiation dose was 200 Bq/kg, indicating that the shielding was inadequate. For further studies, a lead shield will be required.

So far, a few pilot examinations of dogs have been carried out. As aforementioned, urine analysis and results of internal radiation exposure in muscles were conducted, and examination using whole body counter showed high internal contamination levels in animals rescued from high contamination areas. In future, the internal exposure of each individual over time will be monitored, and the radioactive material excretion rates for cats and dogs will be analyzed. We believe that these data can be used as a basis for formulating decontamination procedures and provided safety guidelines to protect guardians when rescued animals are returned or foster parents who rear the animals when rescued animals are fostered.

(7) The number of animals fostered out

Among animals protected by the administration from the disaster in 2011 to October 2nd, 2012, 204 dogs and 53 cats were fostered out. At the end of March 2013, 287 dogs and 156 cats had been fostered. In addition, 90 dogs and 94 cats were returned to their guardians.

Surface contamination inspections were conducted upon a request of the foster parents. So far, no individual was found to have a significant difference compared with the background.

(8) Rearing and state of the rescued animals

Rescued animals were cared for at the shelters, which employed responsible staff including veterinarians, wherein they were provided health check ups everyday and given suitable food and toys based on their species. For daily exercise, dogs spent some time in a fenced-in outdoor playground. Because it is harder to contain cats outside, they were provided with three-dimensional structures in their cages.

(9) Increase and decrease of the number of births in the exclusion zone

Cat breeding was allowed. Cats that were not reared by humans were considered untamed. Many untamed cats were rescued; however, the number of these cats in the exclusion zone was unknown. According to the Natural Environment Research Center, there is a tendency that the number of untamed cats increased, although it did not seem to increase explosively.

(10) Correspondence for movements from the exclusion zone to outside the exclusion zone

By feeding animals inside the exclusion zone, efforts were made to prevent them from moving outside the exclusion zone. Nevertheless, the number of animals moving out of the exclusion zone is unknown.

(11) Confirmed deaths inside the exclusion zone

The Ministry of the Environment has not published any current estimates for the number of cats and dogs that died in the exclusion zone. It is believed that the main cause of death is starvation. However, animals may have also died from infectious diseases and other disorders.

(12) How to deal with confirmed dead animals

Because dead bodies cannot be removed from the exclusion zone, slaked lime is scattered on the sites containing dead bodies.

(13) Similar shelter in the Fukushima Prefecture

An internet search using the keyword “Miharu shelters−address” obtained the shelter of the Fukushima Animal Rescue Headquarters and the “Animal Rescue Nyander Guard,” the latter shelter run by welfare organizations. These two shelters are only 2 km apart. Thus, it is reported that volunteers often come to the private shelter run by welfare groups, mistaking it as the Fukushima Prefecture shelter.

As far as affected animals are efficiently managed and volunteers conduct appropriate rescue operations, no major issues would arise. The Fukushima Animal Rescue shelter set up by the administration has full time veterinarians to conduct healthcare treatment and monitor the health of the animals. The shelter also provides environmental health guidance for volunteers and part-time staff and, it impressed us with its well-organized management systems. In addition, the full-time veterinarians in the facility perform other duties, such as setting up of accommodations for the animals depending on the degree of acclimatization, providing countermeasures for animals exposed to radiation contamination, providing guidance to foster parents, and taking measures to prevent them from further exposure to radiation. The shelter is also evaluated by the Veterinary Association and animal welfare organizations to make sure that it fulfills its official responsibilities.

However, it is inevitable that donations and subsidies will be divided between the two shelters with similar names. For the foster parents and the volunteers to receive the best

support, and for the animals to receive the best care, a centralized system under the auspices of central and local bodies would be preferred.

Reference material 1

Guidelines for rescuing pets from the exclusion zone by non-governmental organizations (NGOs) (excerpt)

Ministry for the Environment Animal Protection Division
Food Health Division, Fukushima Prefecture

1. Objectives
The guidelines state the eligibility and provisions for non-governmental organizations (NGOs) conducting rescue operations of pets and other animals left within the exclusion zone established after the disaster caused by the Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company (TEPCO) from a view of animal welfare under the provisions of Article 28 paragraph 2 of the Nuclear Disaster Special Measures Law, which supersedes the primary legislation (Article 63, paragraph 1 of the Disaster Control Response Act). It would help save the lives of many animals before the climate becomes severely cold.

2. Effective period of these guidelines
Monday, December 5th, 2011, to Tuesday, December 27th, 2011

3. Operation contents
(1) Animals targeted for rescue
As a general rule, animals targeted for rescue by NGOs are restricted to household pets (such as cats and dogs) in cases wherein their owners requested for them to be rescued. However, these provisions allows the rescue of sick or weak animals in an emergency.

(2) Operation
Rescue and associated activities such as provision of food and water may only be carried out for household pets (such as cats and dogs) in the exclusion zone for 5 h between 9:30 am and 3:30 pm.

4. Application procedure for public places
Applications are administered by the relevant city, town, or village council where the public site is situated. However, before applying at the council office, the applicant is required to complete following documentation and bring it or post it to Animal Protection Division at the Ministry of the Environment for approval by the Ministry of the Environment and Fukushima Prefecture offices.
(1) Application period
Tuesday, December 6th, 2011, to Tuesday, December 20th, 2011

(2) Postal address
Food Safety Division, Health and Welfare Department, Fukushima Prefecture, Sugitsuma-cho, 2-16 Fukushima Prefecture 960-8670. (Fukushima Prefectural Headquarters, West Building, 4th floor)

(3) Documentation required

・Power of attorney from the guardian stating the request for rescuing animals (including the name, address, and contact details of the agent, as well as the number and species of the animals to be rescued and the date of rescue).
・A rescue plan [including name, address, contact details, and the representative of organizations, the names, addresses, and contact details for all those who enter the area, the name(s), address(es), and contact details for the animals' guardian(s), the species, color, and size of the animals, the entry point, number of vehicles used, rescue schedule, the rescue facility for animals, method of capture, number of animals contained in the rescue facility, details on the methods used to look after the animals, and a photograph showing the inside and outside of the facility]. Contact details for the organization and the guardian must provide sufficient detail to allow both the Ministry of the Environment and the Fukushima Prefectural office to contact them for further clarification.

・Certificate of corporation which is made within 6 months from the time of application.

Either of the following:
a: Original transcripts or copy of the registry
b: Complete certification

5. Eligibility requirements for NGOs
NGOs must act as corporate entities at the time of application and must meet the eligibility requirements described below.
(1) Administrative authority
Organizations approved by the Ministry of the Environment and the Fukushima Prefectural office and have submitted their rescue plan to the mayor of the relevant territorial authority.

(2) Animal holding facilities
If the guardian of a rescued pet is unable to collect the pet, the NGO will take over its management at the rescue facility. If pets require care for an extended time period, the NGO will take responsibility for their care until they are returned to their guardians.

6. Permission requirements for entry
・The permission period is limited to one week. If permission is required for a more than one week, a new application must be submitted to the Food Health Division at the Fukushima Prefecture for approval by the Ministry of the Environment and Fukushima Prefectural offices. In case of a renewal request, a report on the rescue progress (as described in section (7) needs to be attached.
・Rescuers are restricted to the activities described in 3 (2).
・Up to 10 (maximum) approved vehicles per organization may enter.
・Applicants must submit an oath of declaration (form 3), pledging their adherence to section 7 (compliance conditions) of these guidelines. Those who violate the compliance conditions will have their permission rescinded, and no further permission to enter will be granted.

7. Compliance conditions
(1) Important points concerning entry of public services
The relevant territorial authority will gazette all entries as “entries to public sites” in the public notice section of its home page or similar publication.

(2) Compliance of passing entry points

Only the following two points can be used for entering and leaving the evacuation zone. It should be noted that entering and leaving points are always the same.

A: The checkpoint established on Route 6 at 29-1 Numata, Memezawa, Haramachiku, Minamisoma City

B: The checkpoint established on Route 6 at 1 Nakamaru, Yamadaoka, Naraha Town, Futaba Gun

While entering or leaving via any of these points, the vehicles (also the inside of the vehicles) must be checked by officers from the Ministry of the Environment and Fukushima Prefectural offices.

In addition, occupants must also be prepared to answer questions regarding the content of activities by officers from the Ministry of the Environment or from Fukushima Prefectural office, within the evacuation zone.

(3) Marking the vehicles

Vehicles entering the exclusion zone must have a clearly visible yellow ribbon attached to the antenna or a similar structure.

(4) Forbidden activities within the exclusion zone

The following are forbidden within the exclusion zone.

a: Smoking or use of fire in any form

b: Damaging any structure

c: Entering the interior of any building

d: Using any goods or materials in the exclusion zone

e: Removing anything except for domestic animals such as cats and dogs (however, this restriction does not include waste products generated as a results of the rescue)

(5) Limit of personal property into the exclusion zone

Rescuers must not bring in anything except for materials required for the rescue of affected pets.

(6) Reporting requirements

Soon after any rescue activity, the NGO must submit a progress report about their detailed activities to the Food Health Division, Fukushima Prefecture. This shall include the name, address, contact details, and the representative for the task, the names of all those who entered the zone, the name and address of the rescued animals' guardian(s), a detailed description of the rescue area, distinct features of the rescued animals, a digital photograph, and the rescue facility. Furthermore, if requested by the Ministry of the Environment or the Fukushima Prefectural Office during a rescue period, the NGO must immediately report their rescue activities conducted so far.

(7) Care of the rescued animals

All NGOs must take responsibility of looking after their own affected pets, and those requesting the rescue must come to collect their pets as quickly as possible. At the time when each animal is returned to its guardian, the Sousou (Hamadori) Health and Welfare Office must be notified.

The NGOs also must take responsibility for animals rescued under the emergency provisions in section 3 (1). In order to reunite the pets with their guardians, the NGO must make every effort to contact the guardians. This must be done not only by publishing information about the rescued animals on their home pages (including the species of animal, breed, color, sex, place of rescue, and any other descriptions−including a photograph−which would help in identification, as well as information of the place where the animal is being held). This information must also be sent to the Sousou (Hamadori) Health and Welfare Office. The same office needs to be informed once the guardian has collected the animal.

(8) Compliance of environmental protection
The NGOs that are acknowledged to conduct rescue activities must collect any empty food bag and other waste generated during rescue activities by the end of the activities. To protect the environment it is also important to collect any food used by others.

(9) Maintaining order in the exclusion zone
Those who enter the exclusion zone must not violate any ordinances or interfere with the normal activities of businesses, officials, and temporary residents of the zone. They must also not cause any disturbance to other NGOs in the area. In addition, if a case of compensation for damage occurs, the NGO must take a responsibility. Such damage must be reported to the Food Health Division, Fukushima Prefecture.

(10) Procedure for radiation screening
Screening of all vehicles that enter the exclusion zone and all rescued animals at the completion of the activity must be conducted by the NGO.

8. Inspections by the administration
The Ministry of the Environment and the Fukushima Prefectural office will inspect rescues conducted by NGOs. If any violation is detected, the operation will be immediately terminated.

9. Rescinding
If any of the aforementioned conditions are violated, the mayor will rescind permission to enter the exclusion zone, upon the request of the Ministry of the Environment and the Fukushima Prefecture office.

10. Others
NGOs that are acknowledged to conduct rescue activities must carefully conduct their activities and drive within the evacuation zone so that no accident takes place. In case an accident occurs, the NGO must take sole responsibility.

Reference material 2

Effects of radioactive contamination by Fukushima Daiichi Nuclear Power Plant disaster on animals, and corresponding laws (Emergency interim measures)
April 1st, 2011

Preamble is omitted

[Supplementary] Rescue of animals from Fukushima Prefecture

Cats and dogs are monitored to determine the presence of contamination or analyze if decontamination is required.
1. Radiation survey methods (※If there are no radiation meters, such as survey meters, go to section 2, animal decontamination methods)
※Animals being cared for by those who lived or stayed in the evacuation zone when the nuclear power plant disaster occurred have been in an area where the air dose rate was 30 uSv per hour or higher, or in areas suspected to have a high contamination level in the soil and to have unsafe levels of contamination should be treated as follows.
(1) Measurements must be taken while wearing surgical gloves or thin latex gloves with a glass badge or semiconductor-type pocket monitor.
(2) To ensure that the survey meter sensor (GM type: Geiger counter or scintillation counter) does not become contaminated, cover it with clear plastic and perform measurements thoroughly for the entire body surface of the animal.
(3) Since it is not necessary to accurately measure a value of air dose rate, set the time constant (T-const) to 3 seconds. Measure each site on the body for 10 s using the radioactivity measurement mode (cpm) of the survey meter. If the contamination is concentrated in a particular site of the body, such as the thyroid gland in the neck, record the greatest value and the body site where this value was obtained.
(4) In humans, a partial wipe decontamination is required at levels of 13,000−100,000 cpm, and a full body decontamination if the radiation levels exceed 100,000 cpm (400 Bq/cm2). The same standard is therefore applied to decontamination requirements for animals. A level of 100,000 cpm is still lower than that experienced in an X-ray or nuclear medicine scan; thus, it indicates that significant radiation exposure did not occur.
(Note) cpm = counts per minute (number of radiation particles per minute)

2. Methods for decontaminating animals

In general, cleaning procedures for animals is not different from those used otherwise. If cleaning is possible in the animal hospital, it should be performed using an animal shampoo and warm water. (If the contamination level has not been determined and there exists a possibility of contamination, it is recommended to measure the contamination level at the nearest facility either before or after cleaning.
(1) Veterinarians and others who conduct decontamination for the animal must wear thin plastic gloves for surgery and carry a glass badge or semiconductor-type pocket monitor.
(2) Warm water from a bath water container or shower can be used for washing. It is also acceptable to wash in the bath tub. After washing, rub the animals with dry paper towels (Kim towels or kitchen paper). If a bathtub is used, the water needs to be changed for each

animal.
(3) If there is no enough water for washing, use a wet disposable towel (such as Kim towel, kitchen paper, and wet tissues) to wipe the entire animal evenly, including the pads. Used paper towels and plastic gloves must not be reused for other animals.
(4) Collect all the rubbish, such as used towels and gloves, in a plastic bag. If contamination levels are particularly high, they may need to be treated as radioactive waste. If possible, check the radioactivity of the collected waste. If it is <10,000 cpm, it can be treated as general waste. Cloth towels and clothes attached at the time of decontamination can be decontaminated by ordinary washing.
(5) According to expert opinion, if the contamination level of the wastewater is low, it can treated as normal wastewater.

Source： "Disaster Prevention and Nuclear Safety Network for Nuclear Environment" at Ministry of Education, Culture, Sports and Science
Emergency radiation treatment screening (inspections) (Fukushima Prefecture Health and Welfare Department).
Radiation levels in daily life and signs of abnormal levels (source: United Nations Science Committee, National Institute of Radiological Sciences. From the "nuclear power" collection of diagrams, compiled from 2002-2003)

[Corresponding methods for particular cases]

Q. Cats, dogs, and other domesticated animals were rescued from the evacuation zone, which is a 30-km radius from the Fukushima Daiichi Nuclear Power Plant. It is unclear as to where these animals were transported to or what they ate. What should be done for these animals including the sick animals rescued from the disaster?

A. Please screen the entire body surface of these animals with a survey meter. If they are contaminated they need to be decontaminated. Please ensure that they do not get contaminated anymore.

Procedure: ※Using a GM- or scintillation-type survey meter, measure each site on the body surface for approximately 10 s with a total count mode.
1 If any site shows a measurement value of ≥10k cpm, wash the site surface thoroughly and screen again to ensure the value is <10k cpm, which indicates the contamination is negligible.

2 If any sites shows a measurement value of ≥100k cpm, wash the entire body surface thoroughly and screen again to ensure the value is <10k cpm, which indicates the contamination is negligible.

3 If repeated washing and screening still does not reduce the value to <10k cpm, make a note of the sites where high contamination levels are observed. After identifying these sites such as the head, neck, under surface, and limb regions, please concentrate on these regions by shaving them and washing again until the measurement is <10k cpm, which indicates the contamination is negligible.

4. If contamination levels are still above 10k cpm even after washing, shaving, and repeated washing, move away from the animal to check whether there is any other radiation source affecting the measurement. If so, remove the source and repeat the measurement.

5 If after repeating steps 1−4, the measurements is still ≥10k cpm, or does not reduce to <10k cpm, it would be essential to shift the animal to an animal hospital or a similar facility for a night to several days as per the requirement. If this is the case please go through the correspondent veterinarian to contact Natsuhori Masahiro, (at that time) Head of Radiology at the Japan Animal Referral Medical Center, Kuji 2-5-8, Takatsu-Ku, Kawasaki City, Kanagawa Prefecture TEL: 044-850-1280 for further information, (now; Professor of Kitasato University)

Washing methods:
If sufficient water is available, wash the contaminated areas thoroughly. Washing is more effective if an appropriate agent such as shampoo is used.
If there is no sufficient water, use a wet paper towel or a kitchen paper for washing. If the contamination level is high, keep the used towels together.
After washing, check the contamination levels of the person who was in charge of washing the animals as well as that of the animal to ensure that contamination levels are less than the standard.
If possible, record the values (cpm), sites, date, and time (for case references).

3. The situation of affected horses during the disaster

A large number of horses are domesticated in Fukushima Prefecture, especially in Minamisoma City where Soma Nomaoi festival (wild horse chase) is a tradition holding a thousand-year history; horse breeding is still active in this region.

Immediately after the earthquake, supplies of food and water to farms were cut off because of the evacuations. Before the exclusion zone was established, some guardians looked after their horses in stables or took them away from the zone. It was legally restricted to move livestock from the exclusion zone to outside the exclusion zone. However, some guardians ignored the regulations, moved their cattle and horses to pastures outside the exclusion zone, and looked after them. The numbers of these animals is not known. A livestock dealer living in Iidate mura rescued and transported approximately 30 herds of cattle (450 cows), and approximately 20 racehorses in Okuma and Futaba towns before the exclusion zone was established. It is assumed that considerable number of horses was moved out of the exclusion zone by the cooperative effort of many volunteers and those related to the livestock industry.

On April 15th, 2011, volunteer groups entered the exclusion zone and conducted an inspection. At this stage, they found one horse (who was reared for food) who underwent euthanasia and was covered with blue sheets as per the government directives. Dead bodies in farms were still untreated and covered with blue sheets (Photograph 1).

In an interview with this horse farmer, he said that he had to drive a light truck 100 km (one way) to get water for the horses. “When will we have a permission to move?” he complained. After the earthquake, two of his horses were outside his farm and four died because of the tsunami that struck after the earthquake (including death debilitation because of injury by tsunami). Since then, eight horses have died, volunteers have helped move 11 horses, and looks after 18 horses. All horses were not moved because they were weak and there was a possibility that these weak horses would not be able to handle the stress during transport and thus die.

In addition, he said that horses reared for food lost weight due to lack of fodder. Given their condition, it would take a year for them to recover before they can be shipped. Photograph 2 shows the view of the coast from a farm after the tsunami damage. All stables and other buildings were swept away leaving nothing between the farm and sea.

It is prohibited to move horses in the exclusion zone. However, in one exceptional case, 31 horses were transported for Soma Nomaoi festival (wild horse chase) after April 22nd, 2011. None of these horses had surface radiation levels exceeding 100,000 cpm. However, other horses may have been transported from the exclusion zone by volunteer groups and NGOs.

On the other hand, it is acceptable for horses to get stressed due to evacuation, as mentioned in the report stated below, (Imamoto, S., etc. Livestock Evacuation Planning for Natural and Man-made Emergencies, Int. J. Mass Emergency and Disasters, International journal of Mass Emergencies and Disaster, vol. 31, No. 1, March 2013). Simulations like this could be helpful for the movement of animals in natural disasters.

Photograph collections of struck horses

(Photograph 1) Dead body of a horse covered with a sheet

(Photograph 2) Damage to horse stables by the earthquake

(Photograph 3) The farmer in this farm is hard-working, but is unable to provide proper care for his horses because of his financial condition and restricted access. Although these stables were damaged by the earthquake, 3 horses were unharmed in the undamaged stables (next to the stables in Photograph 2). Fifteen horses have also been cared for in other stables. The injured horses have not been able to receive the care they need because the veterinarians cannot gain access to treat them.

(Photograph 4) There are many small -scale stables like this one. Horses can be cared for and kept alive by flexible cooperative arrangements with fellow stable owners whose stables have not been severely damaged like the others. The house next to the stable is damaged, making it inhabitable. The owner has to come to the stable from a great distance to look after the horses.

4. The situation of animals used as food (e.g., cattle, pigs, and chicken) during the disaster

(1) Summary

The title states the effects of the Fukushima Daiichi Nuclear Power Plant disaster on animals. However, it is not sufficient to merely consider the effect especially on livestock (cattle, pigs, and chicken) by the accident as a sole cause. In fact, it is assumed that following three factors complexly effect the situation.

Effect of the Great East Japan Earthquake (the earthquake itself and the tsunami).

Effect of evacuation directives after the Fukushima Daiichi Nuclear Power Plant accident (within the exclusion zone).

Effects of diffusion of radioactive materials (outside the exclusion zone)

The breeding situation before the earthquake is shown in Table 1. In the Sousou area (the exclusion zone): milk cows, 2748 (1474); breeding beef cattle, 4474 (2239); fattening beef cattle, 10,473 (5551); horses, 425 (127); pigs, 40,874 (34,292); sheep, 32; goats, 41 (20); layers, 1,343,000 (71,000); and broilers, 576,000 (111,000). In the planned evacuation zone (the emergency evacuation preparation zone): cattle, 9300 (7500); pigs, 10,000 (13,000); chicken, 910,000 (1,079,000); and horses, 40 (150).

The Sousou district has two cities, seven towns, and three villages in the region along the sea of Fukushima Prefecture, and it has all the exclusion zone of the nuclear accident

Table 1. Breeding situation (H21.2.1.)

	Milk cows		Beef cattle				Horses		Pig	
			Breeding		Fattening					
	Households	Heads	Households	Heads	Households	Heads	Households	Heads	Households	Heads
Sousou area	87	2748	726	4474	79	10473	169	425	23	40874
Exclusion zone	43	1474	312	2239	27	5551	43	127	14	34292

	Sheep		Goats		Chicken			
					Layers		Broilers	
	Households	Heads	Households	Heads	Households	Heads	Households	Heads
Sousou area	4	32	11	41	57	1343000	15	576000
Exclusion zone			5	20	55	714000	4	111000

	Cows		Pigs		Chicken		Houses	
	Households	Heads	Households	Heads	Households	Heads	Households	Heads
Planned evacuation zone	410	9300	10	10000	25	910000	5	40
Emergency evacuation zone	260	7500	5	13000	5	1079	80	150

*Sousou area: Futaba machi, Okuma machi, Namie machi, Tomioka machi, Naraha machi, Hirono machi, Katsurao machi, Kawauchi mura Minami soma shi, Soma shi, Iidate mura, Shinchi machi

(2) Effects of the Great East Japan Earthquake (including the tsunami) on industry animals

1) Direct damage

There was no direct damage to cattle caused by the earthquake or tsunami. Pig stalls were swept away by the tsunami, and some pigs went feral. Thus, it was assumed that pigs suffered from the tsunami damage. However, the number of pigs affected is unknown.

2) Indirect damage

There was few direct damage to stalls mentioned above. On the other hand, the earthquake cut

down on major resources (electricity, gas, and water) to the environment of stalls, which destroyed production activity. Moreover, fodder factories, milk processing factories, markets and farm buildings were damaged, and the supply of raw materials and the shipments of products were cut off. Furthermore, the damage of fuel factory led to fuel shortages and a paralysis of commodity distribution. The above stopped general production activity. In Fukushima Prefecture except for the evacuation zone, it took three to four days for lifeline to recover, and around two to three weeks for delivery of fodder and other supplies to return to normal.

(3) Effects of evacuation directives by the Fukushima Daiichi Nuclear Power Plant disaster on industry animals

1) Damage of animal husbandry by the evacuation of caretakers

1)-1. Cattle

As shown in Table 2, most caretakers who evacuated following the directives, still kept feeding and caring for their animals from places of refuge. However, since the exclusion zone was designated on April 22nd, caretakers who could not get to their barns were forced to abandon their animals, either neglecting them or putting them out to graze. Photographs 1−10 and 11–18 show the state in the evacuation zone on April 15th, 2011, and June 25th, 2011, respectively.

Caretakers in the planned evacuation zone managed to continue to care for their animals during the primary evacuation (photographs 19–20) of livestock. However, by May 30th, humans and livestock were permitted to move out of the planned evacuation zone in order to transfer and trade livestock. Sale and transfer of cattle was limited within Fukushima Prefecture, and depended on the result of radioactive surface contamination inspections of the livestock. Moving into the evacuation zone was entrusted to livestock dealers brokering the previous deal. Except for during the chaotic period immediately after the earthquake, inspections of surface dose levels were conducted before transport. None of the animals had surface dose over 100,000 cpm, indicating no contamination.

Table 2. Directives of evacuation

Day	time	Directives of evacuation
May 11st	14:46	Earthquake
		Directive of evacuation in the 3 km zone
May 12th		Directive of evacuation in the 10 km zone (5:44), 20 km zone (18:25)
May 15th	11:00	Directive of indoor evacuation in the 20 - 30 km zone
April 22nd	0:00	Design of exclusion zone in the 20 km zone
	9:44	Design of the planned evacuation zone and the emergency evacuation zone
June 16th		Design of a specific spot recommended for evacuation

1)-2. Pigs and chicken

Due to the cutoff of supplies of fodder, most pigs and chicken-especially the latter, which succumbed early (photographs 21–30)-starved to death, while others were killed by their caretakers immediately before the evacuation.

Few pigs went feral after the tsunami and have been living in and around damaged houses in the exclusion zone (photographs 31–56).

(4) Effects of the diffusion of radioactive materials

There are two separate issues regarding the diffusion of radioactive materials: the environmental radioactive materials that affects living conditions and the radioactive contamination of food. Environmental radioactive materials is measured and reported on a daily basis, and progress is also being made on inspections for food contamination. A provisional standard value for food safety was proposed; however, this did not address the perception of risk from the food. The standard has therefore been tightened and results disseminated. Nonetheless, at present, damage to the reputation of food safety persists.

Decontamination for agricultural production is in progress at the same time just like decontamination of living conditions. In particular, livestock production can be affected by contamination of products such as rice straw and sawdust. Standardized monitoring of these products is in progress.

(5) Changes of legal restriction

1) Orders for preventing raw milk shipments

・On March 17th, the Ministry of Health, Labour and Welfare instituted provisional standards under the Food Sanitation Act (Tables 3 and 4).

Table 3. Provisional standard by Food Sanitation Act.

	Radioiodine
Drinking water	300Bq/kg
Milk, mill-based drinks	
Vegetables	200Bq/kg
Seafood	

Table 4. Provisional standard by Food Sanitation Act.

	Radioactive cesium
Drinking water	200Bq/kg
Milk, Milk-based drinks	
Vegetable	500Bq/kg
Grains	
Meat, Egg, Seafood	

・On March 19th, radioactive materials exceeding the standard were detected in raw milk from Fukushima Prefecture and spinach from Ibaraki Prefecture, leading to ordinances restricting their shipment (Table 5).

Table 5. Changes of legal restriction of raw milk

Day	Event	Association and milk factory
May 11th	Earthquake	
May 18th		Resuming of milk factory (51t)
May 19th	Radioactive materials exceeding the standard were detected in raw milk from Yamakiya	Treatment of raw milk (52t) and self-radioactivity inspection
May 20th	Fukushima Prefecture request self-restraint of raw milk shipment	Prohibition of collecting raw milk in the Fukushima prefecture
May21st	Government direct shipment restriction of raw milk	
May 23rd		Collecting raw milk in the Imate prefecture (31t)
April 4th		Conference of monitoring test due to resuming shipment of raw milk
April 7th		The first monitoring test of raw milk
April 8th	Lifting restriction of raw milk in Aizu	Resuming collecting of raw milk on April 11st
April 12th		The second monitoring test of raw milk
April 16th	Lifting restriction of raw milk in Naka-dori and Iwaki	Resuming collecting of raw milk on April 18th
April 21st	Lifting restriction of raw milk in Soma-shi and Sinchi-machi	Resuming collecting of raw milk on April 23rd
April 25th		The forth monitoring test of raw milk
April 27th		Resuming sale of milk as product of Fukushima prefecture
May 1st	Lifting restriction of raw milk in Minamisoma-shi and Kawamata-machi, except for exclusion zone	Resuming shipment of raw milk, except for exclusion zone

2) Changes in dairy products (Tables 6 and 7)

Until April 21st, evacuation was at the discretion of the owners. Some owners traded independently, while others commuted to their barns, remained on their farms, or abandoned their animals.

From indoor areas between 20 and 30 km, unproductive heifers could only be moved to two designated shelters secured by the union. Those within 20 km were excluded.

April 22nd: The designated zone for movement control was announced.

May 9th: Consultations on the prefectural Dairy Cow Movement Act were held on the subject of heifers, milking cows, dry cows, and prematurely born cows. Inspection procedures were determined based on product safety.

Most pastoral farms ceased trading. Of the 36 herds within the exclusion zone and 32 relocated in the planned evacuation zone and only two herds were relocated to a new pasture.

Table 6.Breedin and dairy farmers situation in the evacuation

	Households	Milk yield per day (t)	Heads			
			Delivered cows	Heifers	Fatting cows	Sum
Exclusion zone	26	13.5	644	132	149	925
Planned evacuation zone	32	18.9	680	94	216	990
Emergency evacuation zone	13	6.2	291	40	65	396
Sum	71	38.6	1615	266	430	2311

Table 7.Transfer of cows in the planned evacuation zone

		Kawamat-machi Yamakiya	Iidate-mura	Namie-machi Tsushima
Evacuation of heifers and fatting cows		5/10	5/10	5/19
The first monitoring test due to transfer of cows		5/11	5/11	5/30
The second monitoring test due to transfer of cows		5/17	5/17	6/6
The third monitoring test due to transfer of cows		5/23	5/23	6/13
Lifting transfer restriction of cows due to milking		5/25	5/25	6/15
Transfer and sale of delivered cows		6/4	6/1	6/27
Sale of evacuation fatting cows	Specially market	6/29	6/29	6/29
Sake of evacuation heifers	Mediation of sale	7/8	7/8	7/8

(6) The number of industry animals evacuated by private and public organizations

1) In the evacuation zone

In general, no movement, with no rescue activity of livestock (cattle, pigs, and others) out of the

exclusion zone, has been acknowledged. However, one exceptional case that cannot be assumed to have anything to do with food has been reported in Fukushima Prefectural records (Table 8).

Table 8. Exceptional case for transfer

Animal	Head	Purpose
Houses	31	Soma-nomaoi as festival
Cows	130-150	Experiment of Kitasato university
Pigs	26	Experiment of Tokyo university

2) In the planned evacuation area

According to public organizations, no evacuation took place. The initial policy was for the designated area to have the same movement restrictions as the exclusion zone. However, because of the huge damage to production, it was decided to acknowledge a primary evacuation period. People evacuating during this period up until the end of May were permitted to move their cattle. In the disaster preparedness zone at the time of the disaster, the controls on raw milk shipments continued, and cattle could not be moved due to the evacuation. Public organizations were required to conduct surface body screening of cattle for the purpose of movement and to monitor productivity at their new location. Systems to ensure food safety were put into place.

Private organizations (such as agricultural cooperative) conducted quarantine procedures during and after transport to ensure the safety of the primary evacuation destination of the livestock, as well as repairing, cleaning, and disinfecting farm buildings.

After the designation of the planned evacuation zone, temporary livestock was returned to a productive state. The sale of cattle and the shipment of meat to processing plants for the purposes of re-establishing production in new places or ceasing business were allowed to continue until the May deadline. However, since it was not completed within May, it went on till July.

The re-establishment of beef cattle in group housing also continued, but the details of such operations remain unclear.

In addition, as for the transport in the planned evacuation zone, since it was permitted to kill cattle with risk to onset diseases before moving, very few cattle with disease onset were observed after moving (only one with downer syndrome). After moving to the primary place of refuge, since cattle were vaccinated and treated for external parasites, no clear noticeable effects were observed.

(7) Care and condition of animals left behind in the exclusion zone

The number of breeding animals used for production in the evacuation zone before the earthquake is as follows table1. After the earthquake in the exclusion zone, it is assumed that only industry animals were left behind (table 1).

On May 12th, 2011, a directive from the Prime Minister, in his role as Nuclear Disaster Response Director to the governor of Fukushima Prefecture required that all livestock within the exclusion zone be humanely killed. By the end of January 2012, this killing had been proceeded, as shown below. However this mass killing required to get the farmers' consent to ensure that there were adequate

burial grounds. The evacuees (farmers) also needed time to come to cope with their own emotions.

・Confirmed deaths in the evacuation zone
[Emergency treatment of dead farm animals from April 13th–15th, 2011]
50 cattle, 7,100 pigs, and 800,000 chicken
[Animals killed up to January 31st, 2012]
1,142 cattle, 5,616 pigs, and 81,454 chicken

※The Ministry of Agriculture, Forestry and Fisheries reported the following number of industry animals killed in the tsunami:
Death of cattle (milk cows and beef cattle): 11 (due to lack of food and similar conditions)
Death of pigs (breeding pigs and pigs used for meat): 1,463 (due to lack of food and similar conditions)
Death of chicken: 2,885 (due to power failure)

(8) Countermeasures for dead animals

Twenty-four months after the disaster, BSE inspections became mandatory, though special exemptions have been applied. In addition, as specified in paragraph 2, article 2 of the Chemical field regulations, after getting approval from the responsible health center or Prefectural Institute of Health and Welfare, anyone wanting to bury a dead animal must submit an application for a license for off-site handling of dead livestock.

The special exemptions to the mandatory BSE inspection for those treating dead bodies are covered by the law governing rendering plants and similar industries (1948, law no. 140) and the law governing waste treatment (1970, law no. 137).

However, other exceptions can be made for dead bodies in the exclusion zone. Under article 20, section 3, paragraph 3 of the Nuclear Disaster Special Measures law (199, Act no. 156), dead bodies are considered as radioactive waste, and depending on the results, are not buried, but instead left at the site where they died. On June 23rd, the Ministry of the Environment issued the Disaster Waste Treatment Policy for Fukushima Prefecture, which established temporary burial sites in consultation with those concerned. Before that, slaked lime was scattered and blue sheets were used to cover the dead animals.

※According to Fukushima Prefectural authorities, from April 15th to May 10th, treatment included scattering slaked lime over the dead bodies as an emergency sanitation measure and the provision of first aid to dying and injured livestock.

The policy of the Nuclear Disaster Response Headquarters at May 23rd, 2011, is outlined below.
<Treatment of livestock in the exclusion zone>
・As an interim measure, taking into account the need to continue safe practices in productive regions, the following policy concerning livestock will be put in place in the exclusion zone.

1. Livestock living in the exclusion zone may not be transported out of the area.

2. Livestock housed indoors may be killed by national or prefectural authorities after obtaining consent from the person in charge.
3. Giving effect to the interim provisions prohibiting movement and treatment of dead bodies, any dead bodies in the exclusion zone are to be treated as waste products, and to be left in place. They are to be sprinkled with lime and covered in a blue sheet.
4. Any animals that escape from indoor housing and are roaming loose, depending on ease of herding, are to be herded to a designated area and, with the consent of the person in charge, may be killed by national or prefectural authorities.
5. Any personnel working in the exclusion zone must manage their radiation exposure by wearing a half face mask and a tyvek suits and carrying a portable radiation counter. At the completion of the work, personnel and vehicles are to be subjected to screening.

(9) Increase and decrease of population within the exclusion zone

According to data from December 2009, there were 9,264 cattle. If the 11 killed by the tsunami, 50 treated dead bodies, and 1,142 that were killed are subtracted, that still leaves 8,000 cattle remaining. Ten months on, around 1,000 cattle remain that have had no interventions.

According to the personal identification (ear tag) records for October 5th, 2,560 cattle and calves were found living in the 20-km exclusion zone around March 31st, 2012.

(10) Impact on domestic animals used for food

When considering animals raised for food, the situation is easier to understand if the total time since the disaster is broken down into 3 shorter periods. The first period is the time immediately after the disaster until April 22nd; the second period is from April 23rd to August or September; and the third period is from the end of the second period until the present. During the first stage, including the earthquake and the nuclear accident, the priority was to save human lives through evacuation measures. Livestock keepers differed from normal evacuees in that they rescued or provided aid to animals under very chaotic conditions. The national authorities responded quickly, putting evacuation measures in place to protect against external radiation exposure and prevent shipment of foods and agricultural products to protect against internal exposure.

The second period is characterized by regulations for evacuees wanting to enter the exclusion zone and continue to care for animals. National authorities provided animal keepers with two choices for their livestock: death by starvation or euthanasia. The euthanasia option did not progress smoothly, and more animals were left to die of starvation.

The reasons behind were not simply that people were letting the animals go free for animal welfare reasons or a lack of effort in implementing the euthanasia. A major factor was the lack of legislation allowing euthanasia to proceed without permission of the person in charge of the animal. In accordance with the laws governing nuclear disasters, livestock were left unburied, making it difficult to get guardians' consent to kill the animals. As a result, the world was shocked to discover the rise in the number of neglected and released animals starving to death.

Some farmers wanted another choice apart for euthanasia or starvation: the chance for the animals to have some value as subjects for scientific research. There were also those who wanted to see the animals that had survived the disaster set up in pasture as a living monument, an educational

subject to teach respect for life or to commemorate the disaster. However, it was not possible to move the animals because of radiation contamination. One example of animals that were used for research was a group of pigs (including breeding boars and sows) that were moved to the farm of Tokyo University.

Contamination was also found in rice straws used for cattle feed even from farms far away from Fukushima Prefecture, and cesium contamination in beef cattle drew world attention. According to the report of the TEPCO Fukushima Nuclear Power Plant Accident Inspection Committee, on July 8th, 2011, cesium levels in excess of the allowed standard value were detected in beef raised from cattle in Minamisoma city in Fukushima Prefecture and processed in Tokyo. The cause was found to be contaminated rice straw that had been fed to the cattle. Screening inspections for animal food had not been considered.

On March 19th, 2011 the Ministry of Agriculture, Forestry and Fisheries quickly issued a directive titled "Management of Livestock feeding in the light of the nuclear power plant accident," instructing farmers not to provide grass and hay that had been kept indoors after the accident. However, simply following this ordinance was not enough. It has been reported that 4,700 cattle distributed around the entire country, with the exception of Okinawa, have been fed the contaminated rice straw.

The national authorities determined that the time to consider the compensation for farmers as a matter of national policy. In the light of the unexpected problems such as the contaminated rice straw, a radiation monitoring program was put in place between August and September 2011.

Because beef distribution was stopped, people connected to farming (veterinarians, artificial insemination nurses, hoof cutters, and those working in the pharmaceutical, transport, and fodder industries) were facing unemployment. With no relief in sight, many of these people changed their jobs, which may have had an effect on the re-establishment of the animal agriculture industry.

The main issue for the third period up to the present day is roaming livestock in the exclusion zone. Roaming bulls can breed and lead to a population increase. To cope with this problem, the Japanese Veterinary Association has set up organizations to castrate and enclose livestock. Whether all livestock need to be controlled, with the help of local authorities, is something that remains to be seen. People living within the exclusion zone continue to look after the enclosed animals. There is also a demand for animals to be used for non-lethal research, but this has yet to be realized.

In any case, there has been a major setback to animal production within the exclusion zone. An early mass scale evacuation similar to that conducted after Chernobyl was required to reduce internal exposure of humans. After nuclear disasters, human wellbeing must be taken into account, but the area also needs to be protected through appropriate screening. If a similar disaster should happen in the future, the views of residents and those who are concerned need to be respected.

Photograph collection of cattle, pigs, and chicken

(Photograph 1) Since these cattle were allowed to graze, most of them survived. They are thin, but they ventured the surrounding area to check for the presence of humans. If humans stay at such locations for too long, they will be surrounded by cattle, making it dangerous for general public to enter for after a while. There are also some calves. They are a little thin, but their gait is steady. Since the fence surrounding the paddock was damaged the cattle are mixed with those from surrounding areas. Thus, it is unclear as to how many of them were there.

(Photograph 2) Four dead cattle have been gathered together in one place but have not been buried. Cracks and subsidence caused by the earthquake were observed in the pasture. The time of death of these cattle is not known.

(Photograph 3) Only one cow survived in this block, and this cow was unable to stand. Twenty-eight cows were dead.

(Photograph 4) Cows went outside and grazed. Although they were thin, their gait was steady. Some of them tried eating plastic or strings. These cows were released by volunteers without their keepers' permission. People who do not belong to the farms released farm animals in many places.

(Photograph 5) There is an evidence that somebody released these cows from their enclosing

fence and fed them. Water was supplied from a nearby river.

(Photograph 6) Bloating from internal fermentation (possibly occurring after death) was observed in some dead cows. It appears that these cows died a while back.

(Photograph 7) All cows were thin and they dead in the fence. On April 10th, it was confirmed that some cows survived; however, all cows enclosed by the fence were dead.

(Photograph 8) This cow has weakened and could not stand on its feet. We found 72 cows in this place and the number of cows that survived including weakened ones was 27. Forty-five cows died.

(Photograph 9) The cow in the center was unable to stand, but could eat and drink if food or water was provided. Many volunteers have come here for animal welfare purposes but, in my opinion, their nutritional management was inadequate. Sometimes they fed only grass. and at other times only the concentrated feed. Thus, their feeding pattern was uneven. Some of these cows were suffering from diarrhea, though the cause for the same was unknown.

(Photograph 10) Three of cows fell into the ditch. According to reports at the stage of April 16th, one of the cows in the ditch was unable to stand and could eat the grass by lifting her head out of the ditch. However, this cow ate up almost all grass.

(Photograph 11) The photo was taken on April 14th. Three cows survived in the gutter.

(Photograph 12) The photo was taken on June 25th at the same site as Photograph 11. The three cows that fell into the gutter died there itself. The other cows also succumbed.

(Photograph 13) The photo was taken on April 15th

(Photograph 14) The photo was taken on June 25th at the same site as Photograph 13. The bones of three cows were observed in the ditch. The bones of two other cows were visible in other places in the same ditch. It is believed they fell into the ditch after April 15th and died. The building materials scattered around the site were thrown into the river by animal welfare volunteers.

(Photograph 15) The photo was taken on April 15th. The cow in the center has become severely emaciated over the course of two months

(Photograph 16) The photo was taken at the same site on June 25th. A large number of flies are observed around the dead bodies. All animals have

died, and the air was putrid . Maggots have infested the areas where liquid has accumulated.

(Photograph 17) The photo was taken on April 15th

(Photograph 18) The photo was taken at the same site as Photograph 17, on June 25th. The same cows, two months later.

(Photograph 19) Evacuation areas with abandoned pasture and feeding stalls

(Photograph 20) Evacuation area with abandoned farm and free stalls

(Photograph 21) Top left tier: 9 living hens and 41 dead hens. Bottom left tier: 7 living hens and 44 dead hens. Top right tier: 6 living hens and 46 dead hens. Bottom right tier: 3 living hens and 48 dead hens.

(Photograph 22) Hens that could go outside were probably attacked by a predator. Six hens were found dead outside.

(Photograph 23) Dead hens.

(Photograph 24) In some places the survival rate was remarkably low. As in Photograph 29, all hens were found dead in this spot.

(Photograph 25) This hen facility was inclined by the earthquake. Nine hens survived, 63 hens died, and 9 hens escaped.

(Photograph 26) Water supply was cut off. In this hen house, hens were kept in upper and lower left and right tiers. Upper left tier: 27 survived hens and 20 dead hens. Lower left tier: 16 survived hens and 16 dead hens. Upper right tier: 27 survived hens and 45 dead hens. Lower right tier: 11 survived hens and 63 dead hens. A few hens were so weak that they could not eat food that was put in front of them. There was evidence that food was provided to these hens, probably after the disaster.

(Photograph 27) Upper tier: 8 survived hens and 72 dead hens. Lower tier: 6 survived hens and 68 dead hens.

(Photograph 28) This hen facility had totally collapsed; therefore, only a brief inspection was possible. The cackling of hens could not be heard in collapsed facilities like this one.

(Photograph 29) The buildings on the right and center of this photo had collapsed. Nobody has entered the hen house at the rear because it was dangerous.

(Photograph 30) This hen house was about to collapse. Crows could no longer be heard in this area.

(Photograph 31) The pig in the middle was alive but could not drink by himself. The pig on the left was alive but could barely breathe. Since this stall was located at side from a road, namely, this stall was difficult to find, it was assumed that it was left behind after the earthquake.

(Photograph 32) Almost all rooms of these stalls were occupied with 20 pigs. However, almost all died. Out of an estimated 400 pigs, 6 pigs survived.

(Photograph 33) Within the fence we found surviving pigs and a dead pig (lower left) that

assumed to have been cannibalized. The standing pig was the only one among the six surviving ones, which was able to stand.

(Photograph 34) Changes observed in parts of the skin.

(Photograph 35) Within the fence where pigs showed the same skin changes as observed in Photograph 34, some survived pigs were observed. It was assumed that survived pigs bite the dead one for food.

(Photograph 36) The dead body under the surviving pig from Photograph 31 indicated the same skin changes as that in Photograph 34. It was assumed that the surviving pig probably bite at the dead pig for food.

(Photograph 37) A surviving pig was observed near the dead pigs, which showed the same skin changes.

(Photograph 38) In the place where all pigs died, such dead pigs did not show peeling skin. It might be that some groups of pigs died without cannibalism.

(Photograph 39) Mummified dead bodies were observed.

(Photograph 40) The dead swine that escaped from the fence to the outside. The front part of the body seemed to have been bitten by something.

(Photograph 43) A part of the floor was damaged by the earthquake. Although it was not possible to count the accurate number of dead pigs, over 400 bodies were found.

(Photograph 41) On the same passage where the half-eaten body was found, another dead body showed no evidence of damage. It has unclear as to how they escaped through the fence.

(Photograph 44) Many dead bodies were found in the next stall. No surviving pigs were observed.

(Photograph 42) Some dead pigs with black liquid oozing from their mouth were found. It looked like blood, but the cause has been remained unclear.

(Photograph 45) It was unclear as to how the pigs managed to escape from the stalls. In another stall, no surviving pigs were found. Approximately 300 pigs died. So far, two stalls have been checked, and six surviving and 700 dead pigs were observed.

(Photograph 46) Four pigs outside the stalls. They ran away as soon as they saw humans; thus, it was not possible to approach them. They appeared to be well nourished.

(Photograph 49) It was observed that a pig got out through a gap in the damaged fence. You can see that a pig is getting out through a gap in the damaged fence in the upper right of the photograph.

(Photograph 47) A pig stall in the same site, but at a distance. Here many pigs survived. It is not quite clear as to how they survived. Behind this notice board, there is a stainless steel food container; thus, the pigs may have been able to get food from the food container.

(Photograph 50) The surviving pigs are healthy. The floor is clean with no sign of fecal matter.

(Photograph 48) The container with food is showed in the foreground. The variety of pigs in this photograph is different from ones in the other stalls.

(Photograph 51) The whiteboard shows the results of survival checks from stalls in photographs 41–44. Seventy-seven pigs survived out of a total of 120. All the surviving pigs were provided with food and water.

(Photograph 52) A dead pig in an isolated stall. No surviving pigs were observed. There was no written record of why this pig was isolated. Estimated deaths were approximately 200.

(Photograph 53) It was found that two pigs that got out were dead in this water trough.

(Photograph 54) Species of this pig was the same as one with high surviving rate in the pig pen. It was assumed that this pig escaped through a gap in the fence.

(Photograph 55) In pig stalls, which were closed from the outside, more than 200 pigs were dead and only 4 pigs survived. In this case, there was no stainless steel food containers like the one in the pig pen with the high survival rate. With regard to the type of pigs, at this stage, there were 10 surviving pigs out of 1000 pigs.

(Photograph 56) The skin of surviving pigs was partially peeled away. It was assumed that cannibalism was the only way to avoid starvation.

5. The situation of animals reared in schools during the disaster

On March 12th, 2011, the area within a 20-km radius of the Fukushima Daiichi Nuclear Power Plant was designated as an evacuation zone. However, animals reared in schools were not considered a priority. While companion animals and livestock were often taken care of after the evacuation, care for animals reared in schools was a group effort, and it was unclear as to who should take a responsibility for them. As a result, their feeding was largely neglected. Since most of these animals were reared in elementary schools, a survey of these schools in the exclusion zone was conducted in July 2011.

The main animals reared in most schools were rabbits and chickens, but other animals such as mandarin ducks were also reared in some schools. During our inspection, there were no people in any of the elementary and junior high schools. In many of the animal housing facilities, dead bodies of animals were found, which we assumed could have been due to starvation. However, in some schools there were signs that volunteers had opened the doors and, in some cases, released the animals. Specific elementary schools and the situation of reared animals therein are given below.

<Tomioka-machi>
① Tomioka second elementary school
Three dead rabbits were found; the probable cause of death was starvation.

②Tomioka first elementary school
One dead chicken and three dead rabbits were found; the probable cause of death was starvation.

<Naraha-machi>
③ Naraha North elementary school
The door of the animal house was left open, and no animals were found. According to the situation, it was assumed that this house was for chickens and birds. The animals were probably released by volunteers.

④Nahara South elementary school
The wire mesh surrounding the animal house was cut using some tool, and no animals were found. According to the situation, it was assumed that this house was for rabbits. The animals were probably released by volunteers.

<Okuma-machi>
⑤ Kumamachi elementary school
The door of the animal house was left open, and no animals were found. The animals were probably released by volunteers.

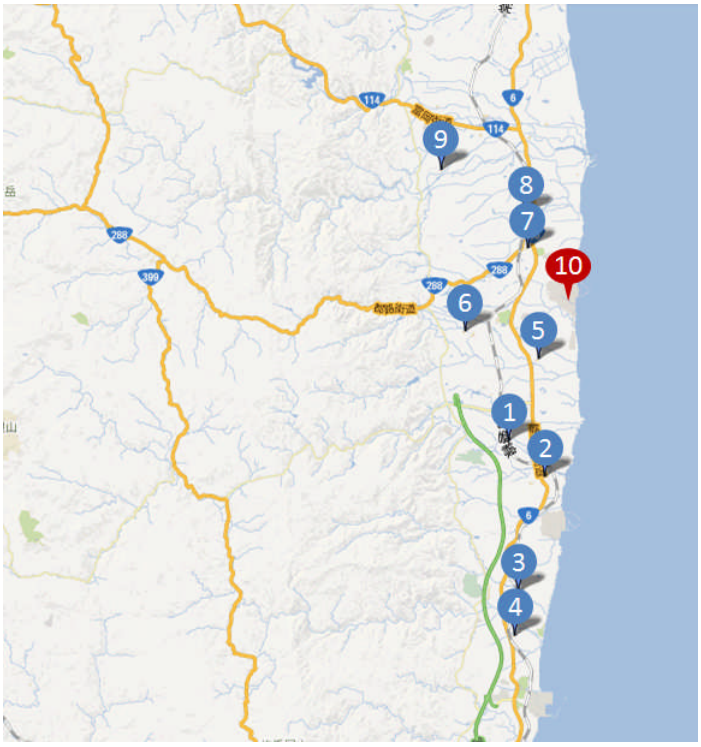
⑥Ohno elementary school
Five dead rabbits were found. The probable cause of death was starvation.

<Futaba-machi>
⑦ Futaba South elementary school
No animals were found in the animal house. It was assumed that the animals were released by volunteers. However, the species of animals was unclear.

⑧Futaba North elementary school
One dead rabbit and two dead mandarin ducks were found. It was assumed that the cause of death was starvation.

<Namie machi>
⑨Ohori elementary school
No animal house was found. We assume that the school did not rear domestic animals.
It is clear that the care of animals reared in schools was neglected because nobody was clear as to who was responsible for their care.

Those who are involved with school education should bear in mind that animals are kept in schools to provide moral education to children. Hence, systems should be established to clear responsibilities during natural disasters, thereby enabling proper feeding, protection, and screening of these animals.



Map of elementary school

①Tomioka second elementary school
②Tomioka first elementary school
③Naraha North elementary school
④Nahara South elementary school
⑤Kumamachi elementary school
⑥Ohno elementary school
⑦Futaba South elementary school
⑧Futaba North elementary school
⑨Ohori elementary school
⑩Fukushima Daiichi Nuclear Power Plant

Photograph collections of animals reared in the school

(Photograph 1) Tomioka second elementary school

(Photograph 3) Naraha North elementary school

(Photograph 2) Tomioka first elementary school

(Photograph 4) Naraha South elementary school

(Photograph 5) Kumamachi elementary school

(Photograph 6) Ohno elementary school

(Photograph 7) Futaba South elementary school

(Photograph 8) Futaba North elementary school

6. The situation of wild animals during the disaster

(1) Existing radiation contamination in the Fukushima Prefecture and in wild animals

The effects of the Fukushima Daiichi nuclear power plant disaster and the Great East Japan Earthquake on wild animals were not confined to radiation exposure. The release of cattle and pigs in the exclusion zone during the evacuation process had three major effects, as discussed below.

Most people would imagine that the main effect of radiation exposure would be an increase in mutation rates and birth defects. In this chapter, the effects on wild animals after the Fukushima nuclear disaster is described and compared with the case of the Chernobyl explosion.

According to Tetsuji Imanaka at Kyoto University Research Reactor Institute, the Fukushima disaster emitted 20%–40% of 137Cs (half-life, 30.08 years), but twofold of 133Xe (half-life, 5.234 days), a huge quantity, was emitted by the Chernobyl explosion. A small amount of contamination by 90Sr and the plutonium isotopes 239Pu and 240Pu, which are highly carcinogenic, have been reported (Table 1). Given these estimates, the greatest long-term effect of the Fukushima Daiichi nuclear disaster will be exposure to 137Cs.

However, even before the Fukushima Daiichi nuclear disaster, the United States, the former Soviet Union, the Great Britain, France and China conducted atmospheric nuclear tests (Table 2). From these tests and the Chernobyl accident, it was found that ^{137}Cs can produce contaminating fission products (Fig. 1).

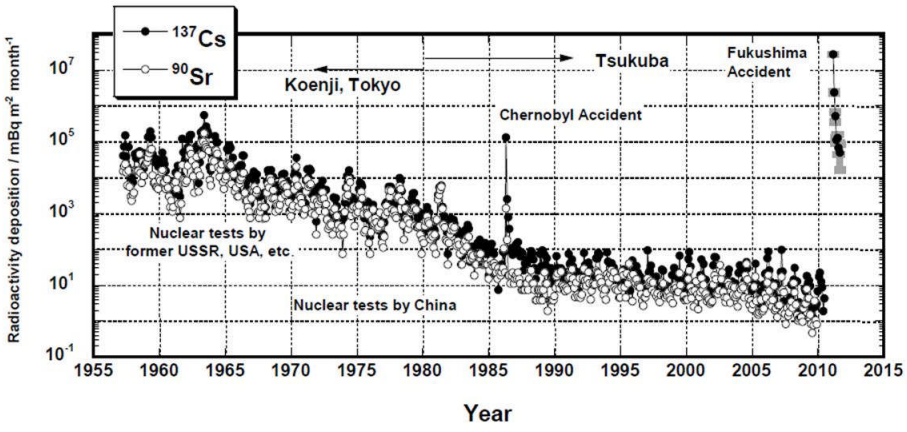


Fig. 1. Monthly deposition time series for ^{90}Sr and ^{137}Cs at the Meteorological Research Institute since 1957 to 2011.

(Cited from "Artificial Radionuclides in the Environment 2011." Geochemical Research Department and Atmospheric Environment and Applied Meteorology Research Department, Meteorological Research Institute, Japan)

Radioactive isotopes may move into forests through mass transfer. In particular, the transfer of ^{137}Cs is dynamic because it has the same alkalinity as the essential plant element potassium (K) (Schell, W. R., 1996).

After settling on the tree canopy, ^{137}Cs is washed into the forest floor by the rain,

together with the leaf litter. The upper layers of leaf litter are broken down, and as ^{137}Cs leaches from the litter, it moves to the lower part of the organic layer of the soil. It finally accumulates in comparatively shallow places in the soil, in contact with the organic layer, where it can stay for a long period. Thus, distribution of ^{137}Cs in forests is determined by the nutrient cycle of the forest ecosystem, i.e., ^{137}Cs in the soil is absorbed into the roots and stems of the plants, through which it reaches the leaves. When these leaves fall, ^{137}Cs returns to the forest floor with the leaf litter and leaching. Because it is continually cycled, it can remain in the forest for a long time. During the cycle, ^{137}Cs remains in a bioavailable state (that plants can use) and is maintained in high concentrations in plants and in fungi that feed on the dead trees (Yoshida, S., 2004). The veterinary radiation laboratory at Kitasato university has collected samples of edible fungi and edible wild plants from the mountains of Aomori Prefecture before the great earthquake and found that ^{137}Cs concentrations exceeded 100 Bq/kg in many samples, indicating that a large amount of ^{137}Cs has remained in Japan. Some researchers have insisted that the half-life of cesium isotopes in the forest environment is the same as the physical half-life. Accordingly, it is necessary to concentrate on the evaluation of wildlife and compare the results with those from past nuclear testing (the background level).

For example, according to government publications, although the ^{137}Cs concentration was 20.5 Bq/kg in wild boars from Shimogo town in Minami-aizu, the ^{134}Cs concentration was below the limit of detection (6.7 Bq/kg). Two years after the disaster, the concentration of ^{134}Cs with a physical half-life of 2 years, should be half of that of ^{137}Cs, or approximately 10 Bq/kg. These results show that the effect of past contamination from atmospheric nuclear testing including nuclear testing in China and at Chernobyl cannot be discounted. Therefore, it should be noted that the results are cumulative from both past contamination and those from the Fukushima Daiichi nuclear plant.

Because ^{137}Cs remains in the forest environment for a long time, its contaminating effects on wildlife are also considered to be long term. Wild boar and rodents are omnivores, and one of their characteristics is that their territorial area is small. If their living environment or food becomes contaminated, they may be exposed to high levels of radiation. After the Chernobyl nuclear disaster, numerous studies were performed on the effects of contamination on wild boars, deer, and other wild animals across Europe. However, thus far, there have been no reports of harmful genetic changes.

Since the great earthquake, data of wild boars in Fukushima have been accumulated, which show a strong correlation between the radioactive concentration in the muscles of wild boars and the air radiation levels in their habitats (Figs. 2, 3, 4). The omnivorous wild boar is therefore a live monitoring system, demonstrating the state of contamination of its habitat and showing that wild boars have been exposed to high levels of radiation from the accident. In Germany, it was reported that among the stomach microflora of wild boars, one fungus (the deer Truffle) was found to have the highest levels of radioactivity (Fig. 5). When capturing wild animals, it is necessary to measure internal radioactive concentration as well as conduct a histopathological examination and consider which food may have caused high levels of radioactivity.

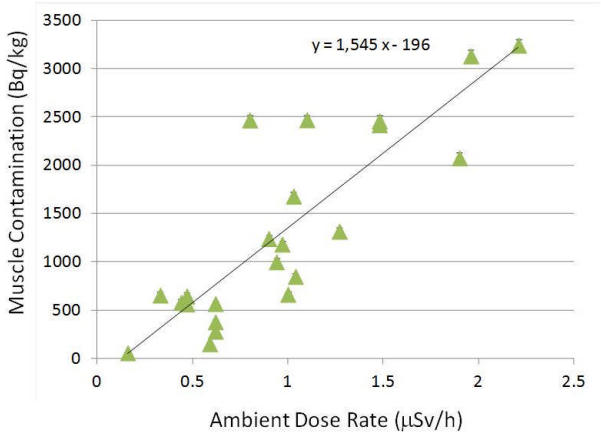


Fig. 2. A correlation between ambient dose rates of habitat and total radioactive cesium (^{137}Cs and ^{134}Cs) contamination in quadriceps femoris muscles of wild boars.

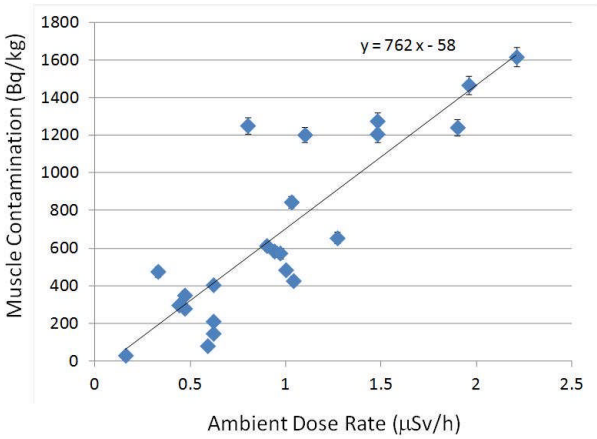


Fig. 3. A correlation between ambient dose rates of habitat and ^{137}Cs contamination in quadriceps femoris muscles of wild boars.

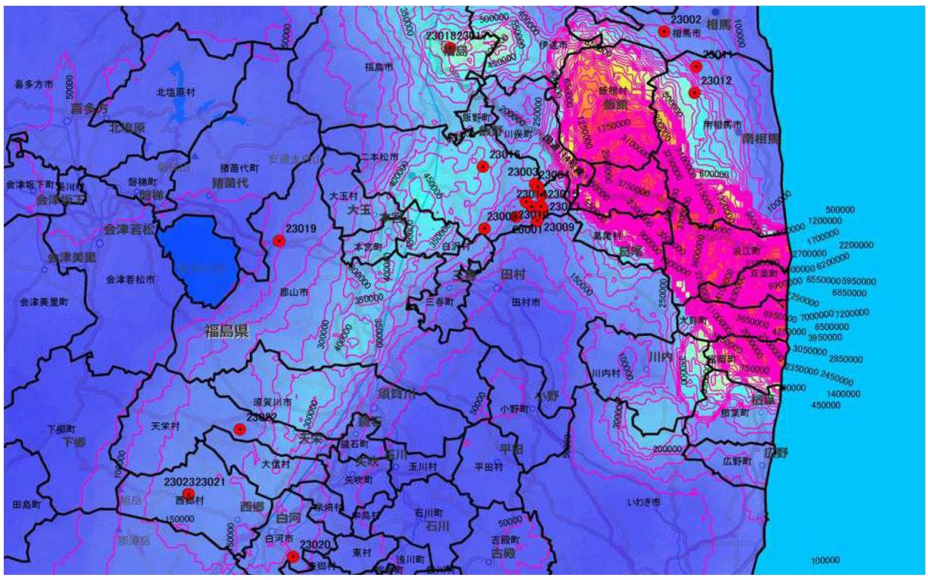


Fig. 4. Capture places of wild boars (red circle).

In the two years since the earthquake, sighting of wild animals, such as wild boars in the exclusion zone appears to have gradually declined. In the coastal areas, in Fukushima Prefecture, where both the Daiichi and Daini (no. 1 and 2) nuclear power plants are located, the areas support high numbers of paddy fields, and rice production is thriving. For a while after the earthquake, the Japanese macaques and other wild animals came into houses and fed on abandoned crops, ensuring a steady supply of food. In the coastal areas, including Okuma, the winter climate is mild enough for kiwifruit orchards to be cultivated However, after a year, when the harvest failed because of lack of pollination, the fields were overpopulated with goldenrod and were devastated (Fig. 6). Therefore, the favorite food of the local wild animals is becoming scarce, forcing them to move to other agricultural areas. The territorial authorities around the exclusion zone are concerned about the fate of the specialty, persimmons, from the Date region of Fukushima. After shipment was stopped, the ripe persimmons on the tree or the harvested piles of persimmons were abandoned, which

have become food for the monkeys and wild boars.

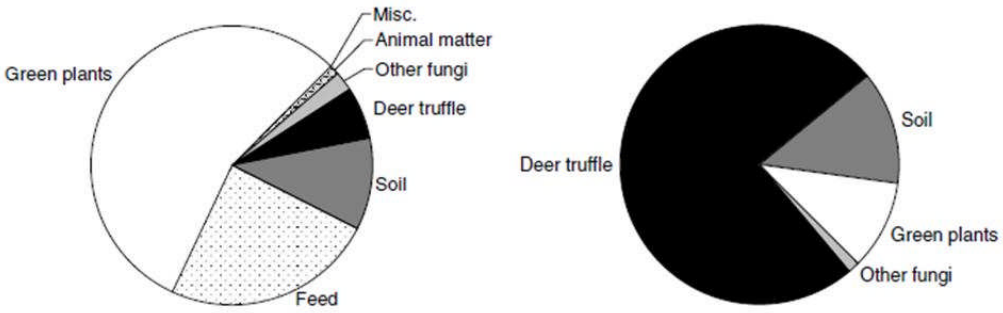


Fig. 5. Diet composition of wild boars shot between May 2002 and June 2003 (40 stomachs) according to weight (left) and radiocaesium intake (right).
(M. Steiner, 2009)

As a result, it is not only in the exclusion zone that wild animals may be a nuisance. The number of wild animals outside the exclusion zone has also drastically increased since the nuclear disaster at the nuclear reactor. The number of wild boars was controlled through hunting; however, with the negative perception of game meat, hunting within the Fukushima Prefecture has reduced. The Fukushima hunting register shows that the number of hunters declined from 3,542 in 2010 before the earthquake (among the top seven in the country), to 2,586 (among the top 19 in the country) in 2011, a drop of 956 (27%) (Dai-Nihon hunting association). This includes those who were forced to evacuate because of the earthquake.

Unless investigations on the effects of radiation exposure on wild animals are continued, it has not been possible to conclude whether the effects have been positive or negative. The data on the internal exposure levels are available, but there are no reports on the effects of the internal exposure. Together with reports on the increase of feral farm animals after the withdrawal from village-vicinity mountain, territorial authorities have published values on internal contamination levels in wild animals from radioactive materials originating from the nuclear power plant accident. This has been combined with our own survey results to produce a combined report.

(2) The potential effects of radiation exposure on wild animals

First, it should be noted that mutations also occur in nature. According to the prolific work by Moeller *et al.* regarding swallows after the Chernobyl nuclear accident, it has been reported that abnormal hatching and development were observed (Moeller 2001, 2005, 2007). There are also a large number of groups studying swallows in the exclusion zone after this great earthquake, starting with the National Institute of Radiological Science.

Swallows build their nests using mud and rice straw. Because the entire country was extremely dry after the nuclear accident, any straw harvested was highly contaminated. We have confirmed contamination levels of 100,000 Bq/kg (the highest value being 190158 Bq/kg) from rice straw collected at sites 30 km from the Daiichi nuclear power plant. Cesium is known to migrate into the soil extremely slowly. For example, samples from multiple sites in Swedish grasslands have shown that cesium penetrated the soil to a depth of 0.5–1.0 cm in the first year. In subsequent years, the penetration rate was even slower, from 0.2–0.6 cm per year (Rosén K, 1999). This means that the swallow nests, made from mud from the surface layer, would be highly contaminated with radioactive cesium. It has been reported by the Ministry of the Environment that at present (September 2012) preliminary research showed that the levels of ^{137}Cs contamination in swallow nests from inside the exclusion zone ranged from 1,500 Bq/kg to 880,000 Bq/kg. There is a report regarding the air dose rate in the surrounding areas; however, the effects on the swallows of exposure to these levels outside of the exclusion zone have not been studied. EURATOM developed a simple tool for evaluating exposure levels in the environment [Environmental Risk from Ionizing Contaminants: Assessment and Management (ERICA)] (Larsson, C. M. 2008). However, in the case of cesium, the results are inaccurate by an order of magnitude (EURATOM 2010, Tsukada, H. 1998). To obtain accurate data for wildlife exposure, it is necessary to use methods that require intensive labor, such as the Monte Carlo computer simulation. The disadvantage of these results is that they are not available immediately.

To gain insight into the effects of the nuclear accident on wild animals, research is underway not only on wild boars, deer, and swallows but also on numerous other species; these include various species of mice, frogs, newts, silver carp loaches, killifish, honey bees, butterflies, earthworms, and other insects. At present, there have been no changes in these species due to the radiation, but ongoing investigations are required.

(3) Humans evacuated from wildlife habitats

As mentioned, in the Chernobyl nuclear disaster, there was no direct effect of the radiation on swallows. However, the removal of humans from the area may result in greater exposure to birds of prey and other animals, which could stress existing wildlife. The effects of reduced interference from humans must therefore be taken into account.

Fukushima is a strongly agricultural prefecture. Before the earthquake, in 2010, the total cultivated area was 121,488 ha, the 6th biggest in Japan (World agriculture and forestry census). The human population at that time was the 18th largest in Japan, which would account for the preponderance of agriculture. The total area of Fukushima Prefecture is 13,780 km^2, or 1,378,000 ha, and approximately 10% of it is cultivated land. Of the remainder, 70% is forest; and 80% of the land area is managed as agriculture or forests. Because of the accident, humans have left many wildlife habitats, and numbers hunting or other interferences with wildlife have drastically declined. According to a report by the Fukushima Prefecture Conservation Division, the amount of radioactive cesium in eight species of wild animals used for food (wild boars, black bears, two species of pheasant,

spot-billed duck, mallard duck, Japanese deer, and hare) exceeded the standards stipulated by food safety laws (100 Bq/kg). This is one reason why hunting has declined and the number of wild boars and bears are increasing. The possibility that these species may damage crops and harm humans has been raised. Commensal species living within human habitats are also being affected by other wild animals

(4) Effects of feral farm animals on wild animals

Of all the farm animals left behind in the exclusion zone, pigs and cattle had a high impact on natural environments. Chickens mostly perished in their cages, and horses were considered to be domestic animals, and consequently many were rescued. The numbers are not huge; however, it was also observed that an ostrich escaped at the time of the earthquake (Fig. 7). It was captured and was brought back to the farm. There was also a soft-shelled turtle farm, but all the turtles in that facility died and subsequently decomposed in the pool.

Many pigs and cattle starved to death where they were abandoned. Some cattle were enclosed in a locked-linked fence by an animal welfare group, making it difficult for them to obtain food and leading to their early deaths. There are various causes including damaged pasture fences by the earthquake and released fences by farmers and animal welfare groups. However, some cattle and pigs escaped from confinement and became feral (Fig. 6). Measures should be considered for this concern.

There are no wild cattle in Honshu of Japan, but the cattle liberated by the earthquake have now established a colony of black-haired Japanese and Holstein cows and their mixed breeds. Breeding cattle mate around 14–15 months after birth, and the gestation period is 280 days; thus, some of the feral cattle will have reached the age of two years. Calves are then born every year. In addition, in the coastal areas of Fukushima, according to reports from 2008, snow fell for only 15 days, and there was little snow on the ground. The winters are warm and thus grass would be available all year round, and cattle would therefore not have suffered from a lack of food. Thus, the increase in the number of cattle is dependent on the availability of cattle.

Because the fields in the exclusion zone have been abandoned and overgrown with tall foliage, cattle can hide from humans in the lush growth and in the forests that constitute 70% of the Fukushima Prefecture. It is therefore not possible to estimate the number of feral cattle.

Feral pigs may mate with wild boars. Wild boars and domestic pigs are usually distinguished by genetic tests. According to Fukushima Prefectural officials, contact with wild boars in the exclusion zone may have occurred even before the earthquake, and more so after a number of pigs from a major pig farm escaped, many of which would have been newly born. Cross-breeding is only one aspect of contact between the two types of pigs. The main concern is the transfer of infectious diseases and the danger of infected domestic pigs spreading the infection outside the exclusion zone.

Another possible vector for infectious diseases is rodents, whose numbers are also increasing. There is a concern that rodents from the forest areas will transfer viruses and bacteria, which until now were restricted to the forests. The farm and companion animals

exposed to these pathogens will therefore have no immunity, and the infection could spread quickly. These infectious agents could even ultimately be transmitted to humans. It is also possible that opportunist infections will spread among wild animals because their immune systems have been compromised through radiation exposure. It is therefore necessary to consider the effects of humans and animals coming in contact with dead wild animals.

Even now, nearly two years after the earthquake, there are approximately 850 cattle in the exclusion zone belonging to farmers who did not consent to slaughter their animals. For the Japanese, cattle are historically creatures who labor in the fields alongside the farmers as fellow workers. Many Japanese may not subscribe to the western way of thinking that views cattle simply as a commodity to be utilized for milk and meat. Animal rights and welfare groups are promoting a society where humans and cattle can live together in harmony. In an effort to improve the quality of life of cattle, the Livestock and Farmland Management Research Board was established in August 2012. It is expected that this group will make at least some contribution towards improving the welfare of feral cattle.

However, the problems associated with feral pigs are likely to take longer to solve. Gun control regulations in Japan are strict and the shooting of cattle and pigs is prohibited because they are not considered to be wild animals. The national and prefectural authorities do appear to have a master plan for livestock in the exclusion zone. However, its implementation would require a large amount of time and money. It would be desirable to prohibit the uncontrolled release of livestock in the event of future disasters, both in Japan and in other countries.

(5) References

Imanaka, T. 2011. A comparative study of radiation emission and contamination in the Fukushima and Chernobyl nuclear accidents. Japan Radiation Response Society 54th annual general meeting (17 November 2011)

Larsson, CM. 2008. An overview of the ERICA Integrated Approach to the assessment and management of environmental risks from ionising contaminants. J. Environ. Radioact. 99: 1364-70.

Møller, AP. 2001. The effect of dairy farming on barn swallow Hirundo rustica. Abundance, distribution and reproduction. J. Appl. Ecol. 38: 378-389.

Møller, AP, Mousseau, TA, Milinevsky, G, Peklo, A, Pysanets, E., Sze´p, T. 2005. Condition, reproduction and survival of barn swallows from Chernobyl. J. Anim. Ecol. 74: 1102-1111.

Møller, AP, Mousseau, TA, de Lope, F, Saino, N. 2007. Elevated frequency of abnormalities in barn swallows from Chernobyl. Biol. Lett. 3: 414-7.

Rosén K, Öbornb I, Lönsjöa H. 1999. Migration of radiocaesium in Swedish soil profiles after the Chernobyl accident, 1987–1995. J. Environ. Radioact. 46: 45-66.

Schell WR, Linkov I, Myttenaere C, Morel B. 1996. A dynamic model for evaluating radionuclide distribution in forests from nuclear accidents. Health Phys. 70: 318-35.

Steiner M, Fielitz U. 2009. Deer truffles - the dominant source of radiocaesium contamination of wild boar. Radioprotect. 44: 585-88.

Tsukada H, Shibata H, Sugiyama H. 1998. Transfer of radiocaesium and stable caesium from substrata to mushrooms in a pine forest in Rokkasho-mura, Aomori, Japan - The Transfer of Radionuclides through

Nordic Ecosystems to Man. J. Environ. Radioact. 39: 149-60.

World Census of Agriculture and Forestry and Report of Statistics on Forestry Income Produced , Statistics Department, Ministry of Source 2010. Agriculture, Forestry and Fisheries. Statistical Handbook of Forest and Forestry, Forestry Agency, Ministry of Agriculture, Forestry and Fisheries.

Yoshida S, Muramatsu Y. Dvornik AM, Zhuchenko TA, Linkov I. 2004. Equilibrium of radiocesium with stable cesium within the biological cycle of contaminated forest ecosystems. J. Environ. Radioact. 75: 301-13

Web:EURATOM; Environmental Risk from Ionising Contaminants: Assessment and Management web sites [online].

http://www.erica-project.org/ Natural resources Defense Council: The NRDC's Nuclear Data, Table of Known Nuclear Tests Worldwide 1945-1996. http://www.nrdc.org/nrdcpro/nudb/datab15.html

Japan Society of Soil Science and Plant Nutrition, Effects of nuclear accidents on soil and crops WG “Nuclear accident related information (6)：Radio active cesium (Cs) in forest ecosystems. Dynamics and transfer into mushrooms.”http://jssspn.jp/info/nuclear/cs-2.html

Table 1

Comparison of accidental atmospheric releases of fission products from a nuclear plants in Chernobyl and Fukushima-Daiichi.

	Chernobyl	Fukushima-Daiichi		
Unit PBq=1 x 10^5 Bq	Chernobyl Forum	NSC	NISA	Stohl et. al.
	(2005)	Apr. 12, 2011	May 16, 2011	ACPD 2011
Xe-133	6,500 (100%)	-	11,000 (97%)	16,700
I-131	1,760 (55%)	150	160 (2.5%)	-
Cs-137	85 (30%)	12	15 (2.6%)	35.8
Sr-90	10 (5%)	-	0.14 (0.003%)	-
Pu-239, 240	0.03 (1.5%)	-	0.0000064 (0.0002%)	-

(%): emission ratio from inventories of nuclear plants

NSC: Nuclear Safety Commission, Japan

NISA: Nuclear and Industrial Safety Agency, Japan

Table 2

Table of Known Nuclear Tests Worldwide: 1945-1996

Year	United States		Soviet Union		United Kingdom		France		China		Total
	A	U	A	U	A	U	A	U	A	U	
	A = atmospheric; U = underground										
1945	1	0	0	0	0	0	0	0	0	0	1
1946	2	0	0	0	0	0	0	0	0	0	2
1947	0	0	0	0	0	0	0	0	0	0	0
1948	3	0	0	0	0	0	0	0	0	0	3
1949	0	0	1	0	0	0	0	0	0	0	1
1950	0	0	0	0	0	0	0	0	0	0	0
1951	15	1	2	0	0	0	0	0	0	0	18
1952	10	0	0	0	1	0	0	0	0	0	11
1953	11	0	5	0	2	0	0	0	0	0	18
1954	6	0	10	0	0	0	0	0	0	0	16
1955	17	1	6	0	0	0	0	0	0	0	24
1956	18	0	9	0	6	0	0	0	0	0	33
1957	27	5	16	0	7	0	0	0	0	0	55
1958	62	15	34	0	5	0	0	0	0	0	116
1959	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	3	0	0	0	3
1961	0	9/1*	58	1	0	0	1	1	0	0	71
1962	39	55/2	78	1	0	2**	0	1	0	0	178
1963	4	41/2	0	0	0	0	0	3	0	0	50
1964	0	39/6	0	9	0	2	0	3	1	0	60
1965	0	37/1	0	14	0	1	0	4	1	0	58
1966	0	44/4	0	18	0	0	5/1*	1	3	0	76
1967	0	39/3	0	17	0	0	3	0	2	0	64
1968	0	52/4	0	17	0	0	5	0	1	0	79
1969	0	45/1	0	19	0	0	0	0	1	1	67

1970	0	38/1	0	16	0	0	8	0	1	0	64
1971	0	23/1	0	23	0	0	5	0	1	0	53
1972	0	27	0	24	0	0	3/1	0	2	0	57
1973	0	23/1	0	17	0	0	5/1	0	1	0	48
1974	0	22	0	21	0	1	7/2	0	1	0	54
1975	0	22	0	19	0	0	0	2	0	1	44
1976	0	20	0	21	0	1	0	4/1	3	1	51
1977	0	20	0	24	0	0	0	7/2	1	0	54
1978	0	19	0	31	0	2	0	10/1	2	1	66
1979	0	15	0	31	0	1	0	10	1	0	58
1980	0	14	0	24	0	3	0	11/1	1	0	54
1981	0	16	0	21	0	1	0	12	0	0	50
1982	0	18	0	19	0	1	0	9/1	0	1	49
1983	0	18	0	25	0	1	0	9	0	2	55
1984	0	18	0	27	0	2	0	8	0	2	57
1985	0	17	0	10	0	1	0	8	0	0	36
1986	0	14	0	0	0	1	0	8	0	0	23
1987	0	14	0	23	0	1	0	8	0	1	47
1988	0	15	0	16	0	0	0	8	0	1	40
1989	0	11	0	7	0	1	0	8/1	0	0	28
1990	0	8	0	1	0	1	0	6	0	2	18
1991	0	7	0	0	0	1	0	6	0	0	14
1992	0	6	0	0	0	0	0	0	0	2	8
1993	0	0	0	0	0	0	0	0	0	1	1
1994	0	0	0	0	0	0	0	0	0	2	2
1995	0	0	0	0	0	0	0	5	0	2	7
1996	0	0	0	0	0	0	0	1	0	2	3
Total	**215**	**815**	**219**	**496**	**21**	**24**	**50**	**160**	**23**	**22**	**2046#**
	1030		**715**		**45**		**210**		**45**		

* Number after / beginning in 1961 in the U.S. column represents PNEs. In the French column number after / represents safety tests.
** All UK underground tests were conducted in the U.S.
# Grand total includes one underground explosion by India conducted on May 18, 1974. No tests by these nations occurred from 1997-2002. For Indian and Pakistani tests see accompanying table.

Fig.6 The escaping beef cattle hides oneself in the goldenrod that grows thickly.

Fig.7 The gate of ostrich farm that was named Ostrich Paradise.

7. Summary

The tsunami that occurred on March 11, 2011, as a result of the Great East Japan Earthquake, was not anticipated by the power company or the government. It caused immense damage and claimed the lives of humans and animals. There was a loss of AC electrical power supply to the Fukushima Daiichi nuclear power plant. On March 12, 2011, a meltdown of the nuclear reactor caused a hydrogen explosion that scattered large amounts of radiation. The explosion at the Fukushima Daiichi nuclear power plant was the worst nuclear catastrophe since the Chernobyl accident. Evacuation was arranged in the zone within 20 km of the nuclear reactor building soon after the hydrogen explosion occurred. However, since the explosion spread radiation far and wide and damage was not restricted to the area close to the reactor, elevated air dose rate in other parts of Fukushima Prefecture were immediately observed. On March 25, 2011, evacuation was extended to inhabitants within a 30-km radius zone and on April 22, 2011, the area within 20 km was designated as an exclusion zone; entry into this zone was strictly controlled.

This investigation confirmed that a large number of animals within the exclusion zone had died. The direct cause of death was not the radiation (acute radiation damage). The major cause of death was the tsunami, and because it became difficult for the keepers to enter the exclusion zone, they died of hunger and thirst. Even after the hydrogen explosion in the reactor building, many residents near the Fukushima Daiichi nuclear power plant assumed that the evacuation would be temporary and they would soon be able to return and thus left their animals behind. It is estimated that only approximately 0.3% of evacuees brought their animals with them. However, after the exclusion zone had been designated, even the movement of residents back into the zone was restricted and care of the animals was neglected. As a result, chained dogs and animals fenced in farms starved to death, and animals that escaped by themselves, or were freed by people, are still wandering in the exclusion zone. Therefore, in the case of similar nuclear disaster where entry should be strictly restricted, it would be best for the evacuees to take their animals with them. Although this could have been arranged, there were few shelters where evacuees could live with their animals. For this reason, the administrators need to stock animal cages or establish a system that will allow these cages to be set up outside the affected area during an emergency. Shortly after the earthquake, on March 14, 2011, the “Headquarters for the Relief of Animals in Emergencies” was established, with a mandate to aid companion animals. However, after the nuclear disaster, although there were many cases of animals left behind in the exclusion zone, rescue activities started only two months after the earthquake. One cannot help but think that more could have been achieved with an earlier start.

The rescue activity of abandoned animals is ongoing. Rescued animals are being cared for at shelters and reunited with their guardians or fostered out. However, these animals have been living in the exclusion zone for a long time and are contaminated with radioactive isotopes. Some of this radioactivity will inevitably be passed to the guardians through excreta. Thus, whole body counters for animals are being proposed, which will be operational from April 2013. It is believed that these counters would solve the problem of

radiation exposure from animals to humans. In addition, because the excretion rate of radioactive cesium from animals is not known, this should contribute to our scientific knowledge. This whole body count inspection is ongoing, and results will be made public. Because the outbreak of cancer as a late onset effect of radiation cannot be eliminated, such investigations need to be continued.

The situation of animals in schools was found to be disastrous, with almost all animals dying of starvation. They appear to have been completely neglected, most likely because their keepers could not be identified. It is absolutely crucial that the administration understands the needs of animals in schools when access to the exclusion zone is restricted, makes an effort to rescue them, and transports them to shelters as done for domestic animals.

Many farm cattle, pigs, and chickens were found to be dead from starvation due to neglect, similar to domestic and school animals. This was particularly evident in pigs and chickens. Because these animals are considered as mere commodities for food and milk, they were not allowed to move outside the exclusion zone. For this reason, on May 12, 2011, the government issued a directive that all animals should be euthanized.

However, although some animals were euthanized, many others are still alive because no provisions were made for disposal of the dead bodies and the keepers were against the slaughter of their animals. Some animals are being reared in farms for research purposes and others have been released, causing road accidents and nuisance to residents. Because cattle and pigs freely reproduce, fewer people think of them as merely food producers. Moreover, projects that protect and breed such animals for a long time have been initiated to contribute to medical research and evaluate environmental effects.

In Japan, horses are generally treated as industry animals. However, in Fukushima, particularly in the Soma region, many are used in rites and festivals and for riding; therefore, they are treated more as companion animals. For this reason, it is necessary to arrange a system throughout the country to enable evacuees to take their horses with them, as is the case for companion animals. The administration needs to cooperate with keepers and horse-related organizations to take measures for horses different from animals reared for foods.

No decline in the number of wild animals due to radiation has been observed; on the contrary, because there is now less friction with humans, an increase is expected. As mentioned above, uncontrolled cattle that breed in the wild also lead to an increase in their numbers. Therefore, in places where access is strictly restricted, such as the exclusion zone, it is necessary to practice appropriate management of livestock while prohibiting the release of animals into the wild.

In forests, where many wild animals live, the contamination from radioactive cesium is particularly evident because of its slow decay rate. This means that both the internal and external radiation exposure rates are high not only in wild animals but also in mammals, birds, and invertebrates, as shown by research. The effects of radiation from the Chernobyl explosion on swallows were highlighted, but in order to show other effects, a complex research program on swallows has been conducted. It may take a considerable time before

any conclusions can be drawn, but this is important research that has attracted public funding, and results are expected after continuous research.

Feral pigs have crossed with wild boars to produce hybrid species. However, it is very difficult to prevent such hybridization. Because of the radiation contamination, hunting of wild boar has decreased and because there are fewer encounters with humans, the number of feral pigs and wild boars is predicted to rise.

These pigs not only damage crops but also transfer infectious diseases to domestic farm animals through contact with wild animals; this could be a serious concern and perhaps draw our attention to focus on ways to prevent infections. Because wild rodent populations are also predicted to increase, we need to be aware of the resulting possible unpredictable outbreaks of infectious diseases in livestock and companion animals.

The Fukushima Daiichi nuclear power plant disaster by the earthquake caused immense damage that was not anticipated by the government, and animals also suffered greatly. It cannot be denied that with regard to animal care, society as a whole took a reactive rather than a proactive approach to this unexpected catastrophe. A lesson needs to be drawn from this disaster so that we can reconsider necessary measures for animals in future disasters and accordingly prepare to ensure the safety of animals, including appropriate legal structures.

Research on the cattle in the exclusion zone has revealed that cattle are highly contaminated with radioactive cesium. If their rearing environment is continually cleaned, they can excrete the radioactive material relatively quickly. Accordingly, the administration should isolate the animals during the period of confusion, and once the situation has been controlled, resume farming and consider options other than euthanasia. Such a system would be beneficial for the welfare of the animals while ensuring food safety.

On August 2012, we visited Chernobyl to conduct interviews on the conditions of companion animals at the time of the accident. Many animals used for food had been moved outside the exclusion zone, but dogs had not been allowed to move out. It appeared that they had been inside the exclusion zone for a long period, being fed by military personnel and eventually shot dead. In Japan, the age has changed and the condition of cats and dogs has improved. However, because the nuclear disaster was unexpected, everyone was caught off-guard with regard to the treatment of the animals. As a result, animals were treated in a manner that was even more atrocious than death by shooting.

We hope that animal welfare groups in other countries will learn from this report and from our mistakes to ensure that the miseries endured by animals in Japan are not repeated.

Nobuhiko Ito, DVM, PhD, Vice-President,
Kitasato University

The Study on the Impact of the Fukushima Nuclear Accident on Animals

---

June 14th 2013

Issue: Laboratory of Veterinary Radiology and Radiation Biology, School of Veterinary Medicine, Kitasato University
35-1, Higashi 23 banntyo, Towada, Aomori Pref. , 034-8628 Japan
Tel: +81 176 23 4371 Fax: +81 176 23 8703

Translation: Crimson Interactive Pvt. Ltd.
1001, 10th Floor, Techniplex - II
Veer Savarkar Flyover, S. V. Road
Goregaon (W), Mumbai 400062, India
Tel: +91 22 6193 5000
Fax (Tokyo) : +3 4496 4934, Fax (India): +91 22 6193 5050
