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OUTBREAK OF FLIES, RATS, AND OTHER PESTS AFTER THE GREAT TSUNAMI IN JAPAN

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Abstract More than a half million ton of frozen fish, fresh fish and processed sea foods were strewed around the Tsunami disaster areas from fishing port and huge freezing storehouses located along the saw-toothed coastline, approximately 35 minutes after the Great East Earthquake on March 11, 2011. Large populations of the black blow fly, *Calliphora nigribarbis* larvae were found under rotten fish in the early May. Adult flies invaded residential areas from the end of May to early June. *Phormia regina* and other blow flies were replaced by the *C. nigribarbis* after middle June. The pest control operators from all over Japan were requested to spray rubble heaps and rotten fish in the affected areas from May to September. Etofenprox emulsion was selected as an insecticide due to its efficacy and low avian toxicity. With integrated efforts of the insecticide spraying, replacement of rubble heaps or dried-up rotten fish, fly population declined from the end of July. In 2012, no fly problem was observed in the Tsunami affected area. Rat infestation became a public health concern as 87% rubble heaps were positive with rats. Since these rats were likely to escape from rubble to residents nearby, we recommend controlling the rats with rodenticides by local administrations and pest control operators in Iwate and Miyagi prefectures.
Key words Tsunami disaster, *Calliphora nigribarbis, Phormia regina,* fly control, *Rattus novegicus.*

INTRODUCTION

The Great Tsunami raided into the saw-toothed coastline in the Northern Pacific Japan in the afternoon of March 11, 2011. The coastline is stretched about 300 km from Miyako-city, Iwate prefecture to Ishinomaki-city, Miyagi prefecture. Along the coastline, fishing ports, seafood processing plants and the freezer warehouses were destroyed. The devastated news suggested that the blow fly problems would occur in the following months. The Annual Marine Industrial Statistic 2010 indicated that approximately 443,000 tons of fish productions were estimated in these areas including cattle fish, salmon, tuna, Pacific saury, mackerel, and bonito. In addition, about 100,000 tons of fish processing products were reported. Almost all of these products were scattered around the affected area immediately after the Great Tsunami. Fishing nets, oyster rafts and scallop breeding nets were also washed up around seashore. We dispatched warning to city offices in the concerned cities, informing that fly problems would be inevitable in the coming warm season. We also advised them that vast fly problem would difficult to control by them, and we could help by inviting pest control operators all over Japan when deemed necessary. Rat survey in rubble heaps was conducted in the following year of the Tsunami (2012). We settled adhesive rat traps, rat cages or bounce traps on the skirts of rubble heaps.

Some parts of these studies were published in the Japanese Journal of Medical Entomology and Zoology in Japanese with English summary (Tabaru et al., 2012; Tabaru et al., 2013). This paper

reports chronologically what happened on the medically important pests in the Tsunami affected area.

SURVEY SITES AND METHODS

Fly survey was carried out at 33 sites (The Northernmost point is N 38, 24',01,88", 141,18',53,75" and the southernmost point is N 39, 41' 45,96, 142,00',39,04") in 5 cities and two towns in two prefectures (Iwate and Miyagi) from early May through November (Figure 1). The survey sites were selected on the basis of rubble heaps, fishing ports, freezer houses, warehouses and residence reporting fly problems. Fly survey were varied such as sweeping collection by nets, sticky papers, and monitoring larvae under rotten fish. The exposure time of

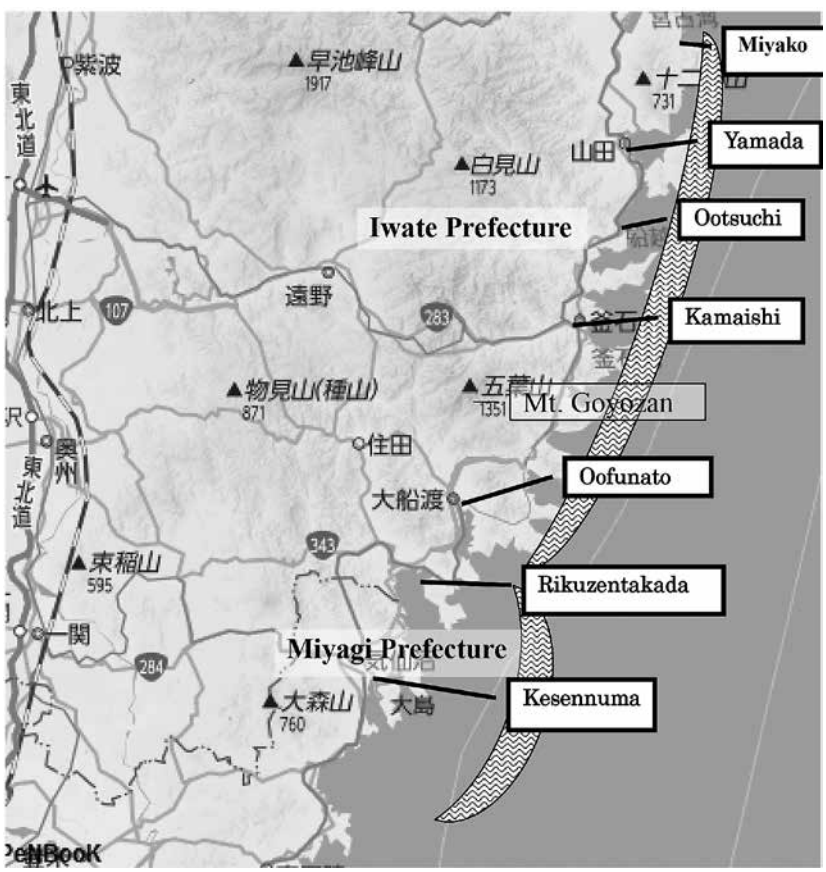

Figure 1. Fly survey sites (Cities and towns) in Iwate and Miyagi Prefecture, 2011

traps was depended on fly numbers in view; 20 min. in case of big number without bait and 24 hrs in small number with baits. The collected flies were identified. Fly control was carried out by the employee of the members of the Japan Pest Control Association. We selected Etofenprox emulsion according to the efficacy, avian low toxicity and low fish toxicity as insecticides, and some places with Fenitrothion EC. Fly survey was also carried out in the following year (2012) in the limited sites. Rat survey was also conducted at the same places except limited in the rubble heaps using adhesive rat traps, rat cages or bounce traps. There were no rat problems in the previous year of 2011. The captured rats were examined pathogen.

Figure 2. Larvae of Calliphora nigribarbis developed in a damaged food freezer in May in Ootuchi town.

Figure 3. Adult Phormia regina captured in 24 h. Sticky paper (44 mm x 32 cm) and bottles with attractants mixed with vinegar, sugar and rice wine.

RESULTS AND DISCUSSION

Fly Condition in Early May, 2011

We surveyed medical important flies in the Tsunami affected area in May 5 through 8, 2011; just 55 days after the catastrophe. Fly larvae were wriggled in mess under strewed rotten fish at that time; outside temperature was below 14°C (abb. C.) in day time (Figure 2). The larvae were developed to the final stage, and the larvae were identified as *Calliphora nigribarbis*. This large blow fly is common in the early spring and late autumn in Japan. Adult flies were a few at early spring. Takei (1964) reported that the blow flies deposit their eggs in eyes, gills, and anal organ of dead fish from the following day of their death. Outdoor temperature in early spring in Kesennuma city varied as 1.6°C. (March), 8.2°C. (April) and 13.5 C. (May) by the Sendai Meteorological Station in 2011. Other micro-diptera, such as seaweed fly, *Coelopa frigid* and *Coproica vagans*, manure fly, *Leptocera fuscipennis*, and seashore fly, *Fucellia apicalis* were observed in washed up algae on sea-food breeding nets. However, these flies do not invade human residents. In late May the Tsunami affected area was infested with fly larvae around destroyed warehouses, freezers (Figure 3), food processing plants and residential area. Housewives frightened watching fly larvae invading their yards one after another. We felt that fly outbreaks were coming instantaneously.

Fly Condition in Early June, 2011

The adult flies invaded residents nearby with great numbers. The city offices received telephone calls every minute from morning to evening by residents, informing fly infestations and asked to control them. Housewives could not open windows and entrances were surrounded by the extraordinary number of swarming flies. Figure 4 shows adult flies on sticky paper in a day at a resident in the Kesennuma city, where rice fields spread in front of the house, leaving rotten fish in the fields. Rotten fish were washed from freezing plants located 2 km away from seashore. Housewives used plastic bottles to collect flies with attractants; mixed with vinegar, sugar, and rice wine in it. From late June *Phormia regina* was replaced by *C. nigribarbis*. We encountered crowded flies like carpets in a fishery village while driving in Ootsuchi-town

Figure 4. Swarming of Phormia regina on a street in Ootsuchi town, July 2011.

Figure 5. Insecticide spraying on rubble heaps, July 2011.

in June 12 (Figure 4). These flies developed in destroyed freezers nearby. Table 1 shows the flys captured in 20 minutes on the surface of sticky traps in a several locations, July, 2011. *P. regina* was the major, followed by *Musca domestica,* and *C. nigribarbis* was few. *P. regina* was captured 2,564 individuals in the fishing port of Kesennuma city and 2,364 flies in the fish processing plant in Ootsuchi town. In middle September *P. regina* and *C. nigribarbis* were quite a few. Fly emergence might have been enhanced by washed away natural enemies such as small birds, reptiles, and predatory insects by the Tsunami.

Table 1. Results of sticky trap (44 cm x 22 cm, no attractant) collection for 20 min in mid July and September.

Survey sites Pref.		Fly species					
		Mid July			Sept.		
		M. domestica	*P. regina*	*Calliphora spp*	*Spaerocerdae*	*Coleopidae*	*Calliphora spp*
Ootsuchi A	Iwate	304	2,364	0	0	0	3
Miyako B	Iwate	78	7	0	25	0	0
Yamada B	Iwate	14	98	0	7	1	0
Oosawa C	Iwate	0	61	0	169	0	11
Oofunato D	Iwate	41	135	0	140	0	2
Rikuzen D	Iwate	29	24	0	34	0	3
Rikuzen D	Iwate	141	154	0	7	0	0
Kesennma B	Miyagi	252	2,564	0	175	0	0
Kesennma A	Miyagi	60	401	0	128	0	7

Fly Control Activities

In the Tsunami affected public municipalities, there were no insecticides and spray equipment at the time. The Japanese Pest Control Association (Headquartered in Tokyo) invited pest control operators from all

over Japan. The operators began to spray garbage, rotten fish, warehouses and residential areas from early June. Each pest control team was consisted of 2 people and the spray machine was laden in track with wide range nozzle, 1000 little tank and 100 m long hose. The total man-day was tallied up to 2,500 man-days from late May to mid September (Figure 5). The most important issue was how to obtain fresh water for dilution. After spraying in freezers, fish processing plants, rubble heaps and residences dead flies were accumulated in mess. However, new borne flies flocked in residences within short days for a while.
Fly population dramatically declined at the end of August due to fly control, removed rubble, and dry-up rotten fish. Table 2 shows the fly condition at October in the Tsunami affected area. The medical important flies; *C. nigribarbis, P. regina M. domestica or Fannia* were a few in comparison with fly condition in July.

Table 2. Fly numbers collected by sticky traps baited with fish and sugar for 24 hours in October.

Prefecture	Sites	Baits	*Calliphora nigribarbis*	Other Calliphoridae	House fly	*Hydrotaea ignava*	Fannia sp.
Iwate	Osabe resident	Fish	1		1		
		Sugar			3		
	Osabe warf	Fish		1	2		
		Sugar	1	1	2		2
Miyagi	Benten-cho, freezing plant	Fish	0	6	1	15	
		Sugar				2	2
	Asahi-cho, grain warehouse	Fish					
		Sugar	3		7	5	6
	Fureai wafr	Fish	1			4	
		Sugar					
	Hajikami residence	Fish					
		Sugar					
	Akaiwa Plastic plant	Fish	1		2	1	
		Sugar					
	Restaurant	Fish					
		Sugar	3	1	3	0	

Table 3. Fly reduction rate in 5 hr and 24 hr after the application of three insecticide formulation in rubble heaps; reduction rate (%) = 100 (fly numbers in post treatment / fly numbers pre) x 100. Spray area varied from 800 to 10,000 square meters. Numbers in parenthesis in 24 h.

Insecticides	Mean reduction (%)		Research sites
	House fly	Blow fly	
Fenitrothion EC	43.8	69.9	12
	(33.1)	(78.6)	
Etofenprox EC	58.5	75.8	22
	(67.6)	(84.5)	
Propetamphos EC	76.3	86.7	16
	(77.3)	(95.5)	

We tried to collect the late autumn *C. nigribarbis* colonies, because the female of this species comes back to lowlands for winter hibernation from highland places where they spent the summer season (Arakawa, et al., 1991). But we failed to collect them in the late November in the Tsunami affected area. The fact indicates us that *C. nigribarbis* did no reach mountains nearby in the summer of 2011 due to control activities.

Fly Condition in 2012

Fly survey was conducted in the following year of the Tsunami in 20 sites in the two prefectures. Most of survey sites were the same as 2011. Fly numbers were very small even though the sticky traps were set for 24 hours with baits on them. The medically important flies might control in 2011, and rotten fish and fresh rubble were removed in 2011. Fly problems in residence were almost absent in 2012.

Table 4. Captured rats in September in Iwate and Miyagi prefectures.

Prefecture	Positive sites/ Survey sites	Captured rats/ Trap Nos.	Species	
			R. norveigicus	***R. rattus***
Iwate	9/10 (90%)	19/38(50%)	12	7
Miyagi	6/6(100%)	13/25(52%)	12	1

Rat Problem in 2012

Yabe and Ishikawa (2012) could not detect rat evidence in the rubble heaps in the year of 2011 in Tsunami affected area. However, some rat infestation evidences; such as feces, fur or foot prints were found on the surface of adhesive rat traps set around skirts of the rubble heaps and an abandoned school in May, 2012, but no rats were captured. Rat collections by sticky traps might be unsuccessful due to wet rat bodies. Sixteen Norway rats (*Rattus norveigicus)* and three roof rats *Rattus rattus* were captured by rat cages or bounce traps in the heaps of the Tsunami affected areas in the following year of the tsunami in the beginning of July, 2012. Nine rubble heaps out of 13 heaps were positive with Norway rats and a roof rat was captured in grass field of an abandoned school and two of rubble heaps in Rikuzentakada city. On the September survey, rat infestation was higher compared with the survey of July; 14 rubble heaps out of 16 were positive with rats, and 23 Norway rats and 8 roof rats were captured in 60 trap cages (Table 4). Sun flower seeds in road sides were eaten by roof rats in Oofunato city. The rats have tendency to break loose from the rubble heaps at the time of removing or collecting the refuse. Thus, we recommend controlling the rats with rodenticides by local administrations and pest control operators. The captured 32 rats were immediately killed by CO_2 and kept in dry ice. All captured rats were examined for micro pathogens in the National Institute of Public Health, but no evidence obtained. In the Tsunami affected zone no infectious disease was reported in the following 3 years.

Present Situation

Adults of *Calliphora nigribarbis* were collected at a mountain lodge (1,351 m sea level) located 12 km away from nearest coastline of Oofunato city in June 7, 2013. This indicates us the natural environment

in the fishing ports recovered as a normal condition. However, fly problem in the Tsunami affected area did not occurred in 2013. By the end of 2013, 90% of rubble heaps were removed in Iwate and Miyagi prefectures and this condition resulted rat free environment. But, in the Fukushima prefecture rat problem are still serious due to keeping away from their residents. A scientist commented that roof rats (*Rattus rattus*) are abundant in vacant houses in Fukushima prefecture. Looking back on the fly control activities in 2011, fast response and mobility brought success.

ENTOMOLOGICAL INVESTIGATIONS

Field Evaluation of Pesticides

In the middle of July field evaluation of pesticides were carried out in the rubble heaps in Rikuzentakada city with area of 800 m^2 to 10,000 m^2 where fly numbers were abundant. At first we located sticky paper (22 cm x 22 cm) without baits for 20 minutes in rubble heaps, then we sprayed pesticide as 200 liter per 100 m^2 in 200 times dilution each of three insecticides; Fenitrothion 10% EC, Etofenprox 7% EC, or Propetamphos 5% EC in the different rubble heaps. In 5 and 24 hrs after spraying, we tried again fly collection by the same method. The test was carried out in 12 to 22 sites. The results are shown in Table 3. The reduction of blow flies was superior in Propetamfos EC, followed by Etofenprox EC and Fenitrothion EC. The effect against house fly showed inferior, especially with Fenitrothion EC. According to the fly species; dominant is *P. regina* in rubble heats, we recommend using Etofenprox EC.

Susceptibility Test

Susceptible tests were carried out in a rural vacant house in Rikuzentakada city, after collecting flies with sweeping nets from rubble heaps. In this test three insecticides were approved: Fenitothion 10% EC, Etofenprox 7% EC and Propetamphos 5% EC. We released them in cages (30 cm x 30 cm x 30 cm). Then, we put approximately 20 flies in a 500 ml plastic bottle with insecticide impregnated filter paper (4 cm x 14 cm), and counted mortality after 24 hours. All of the tested blow fly were dead at low concentrations 0.0125% (a.i.) of each insecticides. A few number of the house fly survived. The tests were repeated 4 times in each pesticide. The fact that the blow flies were very susceptible to any pesticides used resulted in excellent control in the field.

Repellent Test

Repellent test was conducted in fish processing plants where *P. regina* and *M. domestica* were observed. The filter papers (9 cm diameter) were absorbed in the insecticide solution (1% a.i.) of three different chemicals for 5 min. and dried. Then the paper was put on the center of a sticky paper (22 cm x 44 cm), and the sticky paper was placed on rubble heaps where fly activities observed for 20 min. Ikeda (1961) reported that repellent activity of the house fly could analyze using insecticide impregnated filter paper. The result indicated that these three insecticides did not show repellency against blow flies. Flies landed on the sticky papers located insecticide impregnated filter papers in the center of sticky papers. .

CONCLUSION

Fly problems after Great Tsunami occur even in developed countries. The fly problem is liable on depending to industries in relation with organic materials and residence nearby. Scientific pest surveys in early stage after the Tsunami helped following activities. The success of fly control could support recovery in the affected area. It is no doubt that fast response and mobility must have brought success in fly control. Rats invaded rubble heaps the following year and invaded residents. Microbe investigation of captured pests will be essential to prevent infectious disease around affected area.

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