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Original Article

Seroepidemiological investigation on hantavirus prevalence in rodent population at international ports in Taiwan, 2007-2009

Yin-Hsin Lee[1], Shu-Fen Chang[2], His-Chieh Wang[2],
Jui-Wei Hsieh[3], Min-Cheng Lin[4] Shin-Yan Yang[5]

1. Department of Agriculture of Changhua County Government
2. Research and Diagnostic Center, Centers for Disease Control, Taiwan
3. Seventh Branch, Centers for Disease Control, Taiwan
4. Third Branch, Centers for Disease Control, Taiwan
5. First Division Center for Disease Control, Taiwan

Abstract

A total of 1,572 rodents consisted of six species in four genera, two families, and two orders have been captured at international ports in Taiwan for the investigation of rodent population and hantavirus seropositive rate during January 2007-December 2009. The majority of the captured rodents were the species of *Rattus norvegicus* (54.77%). The percentage for other species in descending order was 18.64% for *Suncus murinus*, 15.90% for *Rattus losea,* 7.95% for *Bandicota indica,* 2.61% for *Rattus tanezumi,* and 0.13% for *Apodemus agrarius.* The species of *Bandicota indica* was caught only at Taoyuan airport and was the dominant species of the areas, *Rattus losea* was commonly found at Taipei seaport, Kinmen areas, and Taoyuan airport, but the dominant species at other international ports were *Rattus norvegicus* and *Suncus murinus.* By rodent species, the positive rate for hantavirus antibody was highest (19.05%) in *R. norvegicus,* followed by *R. losea* (4.40%), *R. tanezumi* (2.44%), and *S. murinus* (2.39%). The overall average positive rate for hantavirus antibody was 11.64% for the time period between 2007 and 2009, which is approximately equal to that detected in 2005 (11.03%) and in 2006 (11.43%). This indicates that a certain percentage of rodents at international ports in Taiwan has been infected with hantavirus and should not be neglected. The average seropositive rate for hantavirus antibody in rodents captured at international ports during November 2004-December 2009 was 11.56% (4.11% - 25.99%) except four ports detected 0.00%, including Taipei seaport, Songshan airport, Taoyuan airport, and Hualian seaport. The seropositive rate at other international ports in descending order was Keelung (25.99%), Suao (23.17%), Kaohsiung seaport (21.95%), Penghu (21.43%),

Taichung (14.81%), Kaohsiung airport (12.90%), Matsu (8.47%), Kinmen (5.84%), Mailiao (4.11%). The dominant species include *B. indica, R. norvegicus,* and *R. losea* at Taoyuan airport; *R. losea, S. murinus,* and *R. norvegicus* at Kinmen arreas; *R. norvegicus, R. tanezumi, and S. murinus* at Hualian seaport; *R. norvegicus at Suao seaport;* and *R. norvegicus* and *S. murinus* at the rest of the international ports. We suggest that rodent control activities and relevant public health measures should focus on the species specifically presenting in individual port areas. Although the hantavirus seropositive rate in rodent population slightly increased in 2008 but slightly decreased in 2009 during 2007-2009, the rate was still maintained at a certain level. Human might acquire hantavirus infection when in contact with excreta or secretions from infected rodents. Therefore, the threats of hantavirus infection should not be neglected. Furthermore, the competent authorities at international ports should strengthen environmental health in port areas and decrease density of rodent population so that the chance of contact between rodent and human could be reduced and the occurrence of human infection could be eliminated.

Keywords: international ports, hantavirus, antibody positive rate

Introduction

Hantavirus syndrome is an acute viral zoonotic disease caused by hantaviruses, a genus of the family Bunyaviridae. The genus hantavirus includes more than 20 different virus strains that distribute in different geographical regions, and each strain of them has its own specific species of rodent host [1]. Among these strains, some of them are found to be non-pathogenic to humans, others that are pathogenic to humans can be divided into two groups based on the clinical symptoms. The first group mainly causes hemorrhagic fever with renal syndrome (HFRS), mostly exists in Asia and Europe, including Hantaan virus, Seoul virus, Puumala virus, and Dobrava virus. Among these viruses, Hantaan virus and Dobrava virus are two strains that cause the most severe symptoms and a higher fatality rate [1]. The viruses found from rodent animals in Taiwan and Fujian areas are all Seoul virus that usually produces milder symptoms [1]. Viruses in the second group are the causative agents of Hantavirus pulmonary syndrome (HPS), mostly found in America, such as Sin Nombre virus [1-2].

Previous studies indicated that the same strain of hantavirus is capable of infecting multiple rodent species. Although the rodent animals infected with viruses are usually asymptomatic, they still can transmit the virus to other rodents through physical contact. Human infection usually occurred through the contact with contaminated excreta or secretions, such as feces, urine, and saliva, deposited by rodent hosts carrying hantaviruses [2-3]. However, hantaviruses cannot infect human through the bites of ectoparasites of rodents, the blood-feeding anthropods, such as flea, tick, and mite.The investigation shows that at least eight different hantavitus hosts have currently been identified among members

of order Rodentia, including *R. norvegicus, R. tanezumi, B. indica, Mus musculus, R. losea, A. agrarius;* and order Insectivora, such as *S. murinus,* in Taiwan [2].

A total of eight cases infected with hantavirus were confirmed during 2004-2009 in Taiwan, including one case each from Taipei City, Taipei County, Taichung City, Pingtung County, Lienchiang County, and Penghu County, respectively, and two cases from Kaohsiung City. No time clustering was noticed from the distribution of the cases by month. The occurrences of the cases in Penghu County, Taipei City, and Kaohsiung City seem to have a geographical relationship between them and harbors [1].

To avoid the introduction of hantavirus from other countries via rodents boarding on international vessels or aircraft, Taiwan CDC has been monitoring the hantavirus antibody prevalence in the rodents caught from international ports. Moreover, Taiwan CDC has been constantly taking various control measures to decrease rodent population in the port areas, to prevent the rodents from importation and exportation, and to raise the country's core ability in controlling vectors and reservoir of infectious diseases in the port areas, so that the conditions of the facilities at the ports are meeting the requirements of the International Health Regulations [4]. In addition, the results obtained from the monitoring are serving as a reference for developing the hantavirus prevention and control strategies for the port areas.

Materials and Methods

A. Places and time period for rodent catching

1. Places of international ports: The posts for rodent catching include the Suao, Keelung, Taipei, Taichung, Mailiao, Kaohsiung, Hualian, Kinmen (Shoeitour and Liaoluo), Matsu (Fwuaw), and Penghu (Magong) seaports and the Songshan, Taoyuan, and Kaohsiung airports.
2. Time period: Rodent catching was conducted during January-December, 2009 in Taipei and Penghu seaport and Songshan airport, and from January 2007-December 2009 in other international ports.

B. Rodent catching, and specimen sampling and treatment

1. Rodent catching
   a. Rodent catching was performed on three consecutive days once a month at ports. At least 20-30 bait trap cages were placed at sites where signs of rodent activities were found or suspicious rodent activities were observed.
   b. Several different baits were prepared for being able to catch different species of rodents.
   c. The trap cages were checked in the next morning after the bait trap cages being placed, and the trap cages along with the rodents caught were placed into double plastic bags.
2. Specimen sampling and treatment
   a. The blood specimen was sampled for all caught rodents.

b. Basic information of the caught rodents was recorded, including date of catch, species and sex of the rodents, and catch locations.

c. With a transparent mesh bag over the opening of the cage, the rodent was tipped into the bag, and, then, the rodent was held and injected with a 0.2-0.5 ml of Zoletil 50 anesthesia, depending on the size of the rodent, from bag outside.

d. When the rodent in the bag no longer reacted to a stimulus, it was taken out of the bag.

e. Then, the anesthetized rodent was placed on a clean laboratory table for taking blood specimen.

f. A 2.5 ml syringe was used for drawing blood by cardiac puncture until no more blood was available. After keeping it at room temperature for one hour, the blood specimen was centrifuged at 3000rpm for 10 minutes, and, then, the serum was collected in a test tube labeled with serial number and kept frozen at -20℃.

C. Testing of hantavirus antibody

1.Reagent: The Hantavirus IgG DxSelectTM (FOCUS Diagnostics) test kits for enzyme-linked immunosorbent assay (ELISA) was used, which can detect antibody to five strains of hantavirus, including Hantaan virus, Seoul virus, Puumala virus, Dobrava virus, and Sin Nombre virus.

2. Steps: The testing procedure followed manufacture's instruction. Steps for analysis were as follows:

a. Dilute all specimens and controls 1:100 with the sample diluent,

b.Wash microtiter plate absorbed with recombinant protein by using the 1X wash buffer solution,

c. Dispense 100 µl of the sample diluent (served as "blank"), and 100 µl of the diluted specimen and control into the wells of the microtiter plate, and incubate for one hour at room temperature (20-25℃),

d. Repeat wash 3 times with 1X wash bsolution,

e. Add 100 µl of IgG conjugate to each well, and incubate for 30 minutes at room temperature,

f. Repeat wash 3 times with 1X wash bsolution,

g. Add 100 µl of substrate reagent to each well, and incubate for 10 minutes at room temperature,

h. Add 100 µl of stop reagent to each well,

i. Measure the optical density (OD) value by using the spectrophotometer with a wavelength of 450 nm.

3. The antibody titer of the tested specimens was determined based on the values obtained from the IgG ELISA test.

D. The analysis of variance (ANOVA) and Tukey's test in the SPSS statistical software were used to analyze the difference across multiple mean values obtained for the rodents. The level of significance (α value) for statistical analysis was set at 0.05.

Results and discussions

A. Species, number, and distribution of rodents caught during 2007-2009

The rodents caught at all ports during investigation period and likely to be a potential host of the hantavirus consisted of six species in four genera, two families, and two orders (Table 1).

A total of 1,572 rodents were captured during the investigation period, which Kinmen Shoeitour and Liaoluo seaports had the highest number of rodents (375, 23.85%), followed by Kaohsiung seaports (257, 16.35%), Taoyuan airport (234, 14.89%), Suao seaport (142, 9.03%), Keelung seaport (122, 7.76%), Matsu Fwuaw seaport (114, 7.25%), Mailiao seaport (104, 6.62%), Hualian seaport (89, 5.06%), Taichung seaport (79, 5.03%), Kaohsiung airport (20, 1.27%), Taipei seaport (15, 0.95%), Penghu Magong seaport (14, 0.89%), and Songshan airport (7, 0.45%) (Table 2).

The species of *R. norvegicus* accounted for the largest number (861, 54.77%) of the caught rodents, followed by species of *S. murinus* (293, 18.64%), *R. losea* (250, 15.90%), *B. indica* (125, 7.95%), *R. tanezumi* (41, 2.61%), and *A. agrarius* (2, 0.13%). The major species of rodents in most of the international ports are very similar, which *R. norvegicus* and *S. murinus* was the dominant species at all international ports, except *B. indica, R. norvegicus, and R. losea* at Taoyuan airport; *R. losea, S. murinus,* and *R. norvegicus* at Kinmen Shoeitour and Liaoluo seaports; *R. norvegicus, R. tanezumi,* and *S. murinus* at

Table 1. Species of rodents caught at ports in Taiwan during 2007-2009

Order	Family	Genus	Species
Rodentia	Muridae	*Rattus*	*R. norvegicus*
			R. tanezumi
			R. losea
		Bandicota	*B. indica*
		Apodemus	*A. agrarius*
Insectivora	Soricidae	*Suncus*	*S. murinus*

Table 2. Species and number of rodents caught at international ports in Taiwan during 2007-2009

Items	R. norvegicus	R. tanezumi	S. murinus	B. indica	A. agrarius	R. losea	Total
Suao	142	0	0	0	0	0	142
Keelung	110	0	12	0	0	0	122
Taipei	0	0	6	0	0	9	15
Kinmen	85	0	104	0	0	186	375
Matsu	64	2	44	0	0	4	114
Songshan	7	0	0	0	0	0	7
Taoyuan	55	2	2	125	2	48	234
Taichung	46	0	30	0	0	3	79
Mailiao	68	3	33	0	0	0	104
Kaohsiung S.*	217	4	36	0	0	0	257
Penghu	10	0	4	0	0	0	14
Kaohsiung A.*	12	4	4	0	0	0	20
Hualian	45	26	18	0	0	0	89
Total	861	41	293	125	2	250	1572
Percentage (%) by species	54.77	2.61	18.64	7.95	0.13	15.90	100.00

*Kaohsiung S. and Kaohsiung A. means Kaohsiung seaport and Kaohsiung airport, respectively

Hualian seaport; and *R. norvegicus* at Suao seaport. The Tukey's multiple comparison test showed that the number of captured *R. norvegicus* was significantly higher than that of other species (p-value <0.05) (Table 2).

The data indicated that *R. norvegicus* was the species with a higher number of captures than other species at all international ports except Kinmen Shoeitour and Liaoluo seaports and Taoyuan airport. The majority of rodents captured at Taoyuan airport belonged to *B. indica,* and *R. losea,* which *B. indica* was the species caught only at the Taoyuan airport. The *B. indica* usually inhabits in wild areas, especially farm field in use and abandoned farm field with weeds or wild grasses. Therefore, we speculated the capture of *B. indica* only at Taoyuan airport might be associated with the spots chosen for trapping. Suao seaport was the only one port where the *R. norvegicus* was caught. The number of species of *R. tanezumi* captured from various ports (including Matsu Fwuaw, Mailiao, and Hualian seaports; and Taoyuan and Kaohsiung airports) accounted for only 2.61% of the total number of the trapped rodents. The results might be caused by the fact that the spots for investigation had less habitats for the species, such as roof-ceiling system, closet or cabinets, gaps between walls, and forests. Both species of *A. agrarius* and *B. indica* belong to wild species living in the field were captured only at Taoyuan international airport, and accounted for only 0.13% of the total number of the trapped rodents.

To suit needs for national development policy, officials from Taiwan CDC were deployed to Taipei seaport, Songshan airport, and Penghu Magong seaport, and conducted monitoring of rodent population starting in 2009. Therefore, the number of rodents trapped in these ports was less than that in other international ports.

B. Seropositive rate for hantavirus antibody in rodents caught during 2007-2009

The overall average positive rate for hantavirus antibody across species of rodents captured at international ports was 11.64% (183/1572) between 2007 and 2009, and the seropositive rate by rodent species was 10.43% (164/1572) in *R. norvegicus,* 0.06% (1/1572) in *R. tanezumi*, 0.45% (7/1572) in *S. murinus,* and 0.70% (11/1572) in *R. losea*. The potential hosts that were seropositive for hantavirus antibody consisted of four species, the *R. norvegicus, R. tanezumi*, *S. murinus,* and *R. losea,* which species-specific seropositive rates were 19.05% (164/861), 2.44% (1/41), 2.39% (7/293), 4.40% (11/250), respectively. None from the species of *B. indica* and *A. agrarius* was identified to be positive for hantavirus antibody. The seropositive percentage of a species to the total number of seropositive individuals across species were 89.62% (164/183) for *R. norvegicus,*the highest; 0.55% (1/183) for *R. tanezumi,* 3.83% (7/183) for *S. murinus,* and 6.01% (11/183) for *R. losea*., (Table 3).

Table 3. Analysis of hantavirus seropositive rate by species of rodents in Taiwan during 2007-2009

Items	R. norvegicus	R. tanezumi	S. murinus	B. indica	A. agrarius	R. losea	Total
No. of captures	861	41	293	125	2	250	1572
Percentage (%)	54.77	2.61	18.64	7.95	0.13	15.90	100.00
No. of seropositive individuals	164	1	7	0	0	11	183
Species-specific seropositive rate	19.05%	2.44%	2.39%	0.00%	0.00%	4.40%	
Percentage of seropositive individuals	89.62%	0.55%	3.83%	0.00%	0.00%	6.01%	
Overall seropositive rate	10.43%	0.06%	0.45%	0.00%	0.00%	0.70%	

The finding that the *R. norvegicus* has the highest species-specific seropositive rate, 19.05%, among the species of rodents caught during 2007-2009 is consistent with the results conducted during November 2004-December 2006 [5]. The Tukey's multiple comparison test showed that the seropositive rate of the *R. norvegicus* was significantly higher ($p<0.05$) than those of other species. This indicates that the *R. norvegicus* was the major population among the potential hantavirus reservoir hosts and should be considered as the target species to be controlled at international ports.

Among the international ports, the *R. norvegicus* captured at Keelung seaport has the highest hantavirus seropositive rate (37.27%), followed by Kaohsiung airport (33.33%), Kaohsiung seaport (25.81%), Suao seaport (21.13%), Penghu Magong seaport (20.00%), Taichung seaport (17.39%), Matsu Fwuaw seaport (17.19%), and Kinmen Shoeitour and Liaoluo seaport (14.12%). However, no hantavirus antibody was detected from *R. norvegicus* at Taipei seaport, Songshan airport, Taoyuan airport, Mailiao seaport, and Hualian seaport (Table 4). In

Table 4. Hantavirus seropositive rate by species of rodents captured at international ports in Taiwan during 2007-2009

species of rodent	Items	Suao	Keelung	Taipei	Kinmen	Matsu	Songshan	Taoyuan	Taichung	Mailiao	Kaohsiung S.	Penghu	Kaohsiung A.*	Hualian
R. norvegicus	No. of rodent	142	110	0	85	64	7	55	46	68	217	10	12	45
	No. of seropositive rodent	30	41	0	12	11	0	0	8	0	56	2	4	0
	rate of seropositive rodent	21.13%	37.27%	0.00%	14.12%	17.19%	0.00%	0.00%	17.39%	0.00%	25.81%	20.00%	33.33%	0.00%
R. tanezumi	No. of rodent	0	0	0	0	2	0	2	0	3	4	0	4	26
	No. of seropositive rodent	0	0	0	0	1	0	0	0	0	0	0	0	0
	rate of seropositive rodent	0.00%	0.00%	0.00%	0.00%	50.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
S. murinus	No. of rodent	0	12	6	104	44	0	2	30	33	36	4	4	18
	No. of seropositive rodent	0	2	0	4	0	0	0	0	0	0	1	0	0
	rate of seropositive rodent	0.00%	16.67%	0.00%	3.85%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	25.00%	0.00%	0.00%
B. indica	No. of rodent	0	0	0	0	0	0	125	0	0	0	0	0	0
	No. of seropositive rodent	0	0	0	0	0	0	0	0	0	0	0	0	0
	rate of seropositive rodent	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
A. agrarius	No. of rodent	0	0	0	0	0	0	2	0	0	0	0	0	0
	No. of seropositive rodent	0	0	0	0	0	0	0	0	0	0	0	0	0
	rate of seropositive rodent	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
R. losea	No. of rodent	0	0	9	186	4	0	48	3	0	0	0	0	0
	No. of seropositive rodent	0	0	0	11	0	0	0	0	0	0	0	0	0
	rate of seropositive rodent	0.00%	0.00%	0.00%	5.91%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
total No. of rodent		142	122	15	375	114	7	234	79	104	257	14	20	89
total No. seropositive rodent		30	43	0	27	12	0	0	8	0	56	3	4	0
rate of seropositive rodent		21.13%	35.25%	0.00%	7.20%	10.53%	0.00%	0.00%	10.13%	0.00%	21.79%	21.43%	20.00%	0.00%

*Kaohsiung S. and Kaohsiung A. means Kaohsiung seaport and Kaohsiung airport, respectively

addition, although the hantavirus seropositive rate of the *R. norvegicus* from Penghu Magong seaport and Kaohsiung airport appeared slightly higher, the result might be unable to reflect the real picture because the number of captures was a bit low.

The hantavirus seropositive rate of 2.39% (7/293) found in *S. murinus* (Table 3) was lower than that (5.11%) obtained during November 2004-December 2006 [5]. The hantavirus seropositive rate for *R. losea* was 4.40% (11/250), which is higher than that (0.00%) found during November 2004-December 2006 and only found among those caught at Kinmen Shoeitour and Liaoluo seaport (Table 4). Whether it is related to the frequent contact with mainland China or other factors need to be further investigated.

The hantavirus seropositive rate for *R. tanezumi* was 2.44% (1/41) (Table 3). In contrast, no hantavirus antibody in *R. tanezumi* was identified during November 2004-December 2006 [5]. The only one hantavirus-seropositive identified in 2009 was captured at Matsu Fwuaw seaport. Furthermore, the number of *R. tanezumi* captured at international ports other than Matsu was low and none was identified as positive. Again, whether it is related to the geographical association between Matsu and mainland China needs to be continually monitored.

No hantavirus antibody was detected in *B. indica* caught during 2007-2009, the same was found during November 2004-December 2006 [5].

The average seropositive rate for hantavirus antibody in rodents captured at ports during November 2004-December 2009 was 11.56%, ranging between 4.11% and 25.99%, except negative was detected from four ports, including Taipei seaport, Songshan airport, Taoyuan airport, and Hualian seaport. The seropositive rate at other ports in descending order was Keelung (25.99%), Suao (23.17%), Kaohsiung seaport (21.95%), Penghu (21.43%), Taichung (14.81%), Kaohsiung airport (12.90%), Matsu (8.47%), Kinmen (5.84%), Mailiao (4.11%) (Table 5). During November 2004-December 2006, the average seropositive rate for hantavirus antibody was 13.00% in rodents captured at international ports [5], 11.85% in 2007, 14.34% in 2008, and 8.93% in 2009, respectively. This data indicate that a certain percentage of rodent population at international ports in Taiwan has been infected with hantavirus. Therefore, the monitoring and control of rodent activities should be continued to assure the environmental health in port areas.

The Council of Agriculture, Executive Yuan, has begun granting on fishing activities between Taiwan Strait in recent years, for example, the fishing boats in Taiwan were allowed to land on mainland China to pick up hired fishing workers and to move live fish. In order to maintain the environmental health and to control vectors of infectious diseases at the fishing ports in this country, the Taiwan CDC, in cooperation with local governments, has launched the Domestic Port Health Management Program since 2008. Some important tasks in this program include monitoring of rodent activities, control of rodent population, removal of mosquito breeding sites, health improvement of the coastal settlement or transitional housing boats for fishing workers from foreign countries, and health education

Table 5. Hantavirus seropositive rate in rodents captured at international ports in Taiwan during November 2004-December 2009

Years	Items	Name of international ports: Suao	Keelung	Taipei	Kinmen	Matsu	Songshan	Taoyuan	Taichung	Mailiao	Kaohsiung S.*	Kaohsiung A.*	Penghu	Hualian	Total
Nov.-Dec. 2004	No. of rodent	9	9	0	10	6	0	23	18	11	21	7	0	6	120
	No. of seropositive rodent	4	2	0	0	0	0	0	5	0	4	1	0	0	16
	rate of seropositive rodent	44.44 %	22.22 %	0.00 %	0.00 %	0.00 %	0.00 %	0.00 %	27.78 %	0.00 %	19.05 %	14.29 %	0.00 %	0.00 %	13.33 %
2005	No. of rodent	51	46	0	80	19	0	31	30	101	93	63	0	12	526
	No. of seropositive rodent	9	4	0	5	0	0	0	5	2	23	10	0	0	58
	rate of seropositive rodent	17.65 %	8.70 %	0.00 %	6.25 %	0.00 %	0.00 %	0.00 %	16.67 %	1.98 %	24.73 %	15.87 %	0.00 %	0.00 %	11.03 %
2006	No. of rodent	57	50	0	100	52	0	71	35	76	71	34	0	5	551
	No. of seropositive rodent	17	10	0	1	4	0	0	6	10	14	1	0	0	63
	rate of seropositive rodent	29.82 %	20.00 %	0.00 %	1.00 %	7.69 %	0.00 %	0.00 %	17.14 %	13.16 %	19.72 %	2.94 %	0.00 %	0.00 %	11.43 %
2007	No. of rodent	54	28	0	84	42	0	81	32	51	87	0	0	22	481
	No. of seropositive rodent	19	6	0	1	1	0	0	7	0	23	0	0	0	57
	rate of seropositive rodent	35.19 %	21.43 %	0.00 %	1.19 %	2.38 %	0.00 %	0.00 %	21.88 %	0.00 %	26.44 %	0.00 %	0.00 %	0.00 %	11.85 %
2008	No. of rodent	51	38	0	138	35	0	74	31	26	98	12	0	27	530
	No. of seropositive rodent	11	12	0	26	5	0	0	1	0	17	4	0	0	76
	rate of seropositive rodent	21.57 %	31.58 %	0.00 %	18.84 %	14.29 %	0.00 %	0.00 %	3.23 %	0.00 %	17.35 %	33.33 %	0.00 %	0.00 %	14.34 %
2009	No. of rodent	37	56	15	153	35	7	80	16	27	72	8	14	40	560
	No. of seropositive rodent	0	25	0	0	6	0	0	0	0	16	0	3	0	50
	rate of seropositive rodent	0.00 %	44.64 %	0.00 %	0.00 %	17.14 %	0.00 %	0.00 %	0.00 %	0.00 %	22.22 %	0.00 %	21.43 %	0.00 %	8.93 %
Nov. 2004-Dec. 2009	No. of rodent	259	227	15	565	189	7	360	162	292	442	124	14	112	2768
	No. of seropositive rodent	60	59	0	33	16	0	0	24	12	97	16	3	0	320
	rate of seropositive rodent	23.17 %	25.99 %	0.00 %	5.84 %	8.47 %	0.00 %	0.00 %	14.81 %	4.11%	21.95 %	12.90 %	21.43 %	0.00 %	11.56 %

*Kaohsiung S. and Kaohsiung A. means Kaohsiung seaport and Kaohsiung airport, respectively

of fishing workers. Three governments, including Ilan City, Hsinchu City, Pingtung County, took part in the program in 2008. The number of local governments in this program increased to seven in 2009 and to thirteen in 2010. The newly participating governments was Keelung City, Tainan County, Kaohsiung County, and Lienchiang County in 2009, and Miaoli County, Yunlin County, Jiayi County, Tainan City, Hualian County, and Kinmen County in 2010. A total number of 540 rodents was captured during 2008-2009, and 33 (27 in 2008 and 6 in 2009) of them were positive for hantavirus antibodies. The average seropositive rate was 6.11% (33/540) during 2008-2009, by year, it was 16.07% (27/168) in 2008 and 1.61% (6/372) in 2009. These

results indicate that the hantavirus seropositive rate in rodent population seems to have been in a declining trends after pushing through environmental reforms and strengthening the activities of rodent control. However, in consideration of the increasing contact between the two sides of Taiwan Strait, local governments should continue the implementation of monitoring to update relevant information, to assure the control of infectious disease and national security, and to effectively respond to emergency events.

C. Rodent activities at international ports (refer to Table 2-Table 5)

1. A large number of *R. norvegicus* was captured at each of the international ports during the investigation period. Previous reports indicated that the species of *R. norvegicus* distributes island-wide in Taiwan and mainly inhabits within the sewage system or waste piles [6-8]. Since they needs more water for drinking than other species, they usually live in an environment near a water source. The high level of hantavirus seropositive rate in *R. norvegicus* at international ports suggests that they should be the target species of rodents to be controlled.
2. The species of *B. indica* was captured only at Taoyuan airport and the species of *R. losea* was trapped only at Kinmen areas, Taoyuan airport, and Taipei seaport. Based on previous reports, *B. indica* distributes in farm field and weedy sites located at low, medium altitude all over the Taiwan island, especially in cane field in middle and southern Taiwan areas, and usually inhabits in field with wet and soft soil [6-8]. The species of *R. losea* distributes island-wide in weedy sites, abandoned farm field with weeds, and farm field in use, and mainly inhabits within farm field. Therefore, we speculate that lacking habitats due to the high development at most ports is the reason why the two species of rodents were not captured. To effectively control the rodents, the control activities should be implemented not only within the port areas but also their surrounding farm fields through the cooperation with relevant authorities.
3. The previous reports [6-8] indicates that *R. tanezumi* distributes in areas all over the island and inhabits in roof-ceiling system, closet or cabinet, gaps between walls or buildings, and places filled with waste piles. Only 41 *R. tanezumi* were captured during 2007-2009. The small number of captures might result from lack of environment suitable for rodents to inhabit at these ports or the factor that most of the baited trap cages were placed on the ground [6].
4. The information provided by the Council of Agriculture [9] shows that *S. murinus* mainly inhabits in areas within or near houses, such as kitchen, drainage ditch, or wet, dark places, and generally distributes in human residential areas at low altitude. The number and percentage of captured *S. murinus* were relatively low in some international ports, including Suao, Keelung, Songshan, Taoyuan, and Hualian. To improve the low number of captures, the investigation could be conducted focusing on areas where they are frequently active, as mentioned previously, so that we could know more better about the population fluctuation and hantavirus seropositive rate in *S. murinus*. In addition, since

poisonous baits are less effective in controlling population of *S. murinus,* other tools, such as glue boards and snap trap, can be the options for control over them.

5. The number of captured rodents and the positive rate for hantavirus antibody in rodents (*R. norvegicus*) at Suao, Keelung, and Kaohsiung seaport maintain in a constant and high level. Therefore, the monitoring should be continued and the control activities should be improved to update and understand the relevant information.
6. The hantavirus seropositive rate in 2008 was significantly higher than those in other years in Kinmen and Matsu areas. Although the positive rate for hantavirus antibody in Kinmen has declined to 0% in 2009, the number of captured rodents still kept in a high level. Therefore, except that the monitoring should be continued, the control activities should be conducted in cooperation with other units in Kinmen Shoeitour and Liaoluo seaport areas to reach fully control of rodent population. In addition, the continually increasing hantavirus seropositive rate from 2008 to 2009 in Matsu emphasizes that the cleaning and disinfection of environment in areas where the rodents appeared frequently should be conducted, and the control measures should be improved to decrease the rodent population and to reduce the opportunities of contacts between human and rodents.
7. The number of captured rodents was maintained at a stable level and no hantavirus antibody in rodents were identified at Taoyuan airport and Hualian seaport. We, therefore, suggest that more baited trap cages may need to be used and alternative sites can be chosen for the cages.
8. Although the number of trapped rodents in Taichung and Mailiao seaports maintains in stable level and the decreased seropositive rate was found in 2008, the monitoring and control to rodents still need to be continually implemented to assure that the seropositive rate will not go up again. The baited trap cages can be placed at sites where a better chance that the rodents will be captured, to understand the changes in their seropositive rates.
9. The observation that some specific species of rodents were captured only at some certain ports might be associated with the environments of the ports and their surrounding areas. Of course, the spots chosen for placement of trap cages were also one of the significantly associated factors. Except that the trap cages should be placed at sites where the rodents present frequently, the communication and cooperation with other units at port areas should be improved at the usual time to fully understand the possible hiding place of the rodents. The spots for trap cage placement should not be limited at some fixed locations so that the species and number of rodents fully reflecting the whole picture of rodent population at the ports could be obtained.

Conclusions

The investigation conducted during 2007-2009 shows that several species of rodents having the potential of being hantavirus reservoir host have existed at international ports in Taiwan. These species include *B. indica, R. norvegicus,* and *R. losea* at Taoyuan airport; *R.*

losea, S. murinus, and *R. norvegicus* at Kinmen arreas; *R. norvegicus, R. tanezumi, and S. murinus* at Hualian seaport; *R. norvegicus at Suao seaport;* and *R. norvegicus* and *S. murinus* at the rest of the international ports. We suggest that rodent control activities and relevant public health measures could be conducted focusing on the species specifically presenting in individual port areas.

Although the hantavirus seropositive rate in rodent population slightly increased in 2008 but slightly decreased in 2009 during 2007-2009, the rate was still maintained at a certain level. Human might acquire infection of hantavirus when they contact excreta or secretions from infected rodents. Therefore, the threats of hantavirus infection to human should not be neglected. Furthermore, the competent authorities at international ports should strengthen environmental health in port areas and decrease density of rodent population so that the chance of contact between rodent and human could be reduced and the occurrence of human infection could be eliminated.

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Outbreak Investigation Express

Investigation of an Imported Measles Case in North Taiwan in March, 2012

Ming-Chu Tai, Chia-Ping Su, Tzu-Yun Huang

Second Branch, Centers for Disease Control, Taiwan

Abstract

Taiwan has been actively promoting the four stages program for eradication of poliomyelitis, neonatal tetanus, congenital rubella syndrome and measles for nearly two decades. The immunization completion rate of MMR (measles, mumps, and rubella) for eligible children in Taiwan has reached more than 95%, and indigenous cases barely occurred. Nevertheless, the secondary infection from imported cases occasionally caused local outbreaks. This article reports the investigation of a measles case imported to North Taiwan in 2012. Based on the 2009 revised "Standard operating manual for measles control", control measures such as risk assessment of contacts, levels of prevention, and health management for focal population were implemented, no further transmission was detectable thereafter. It demonstrated an effective blockade on domestic transmission. This experience may provide a reference for health organizations to deal with similar epidemic situations in the future.

Keywords: measles; eradication of poliomyelitis, congenital rubella syndrome, neonatal tetanus and measles; MMR (measles, mumps, and rubella) vaccine

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