Epidemiology Investigation of Rodents as Vectors for the Hantavirus in Taiwan's Harbor Areas

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Abstract

During the period from November 2004 to December 2006, a total of 1,446 rodents (52.49% males and 47.51% females) were captured in international and domestic harbors in Taiwan under the investigation of the rodent distribution and the positive antibody rate of the Hantavirus. The rodents can be categorized into 2 orders, 2 families, 4 genus, and 7 species. The Brown rat (*Rattus norvegicus*) takes up 58.44% of the entire captured number. Following are other kinds placed in percentage order: House shrew (*Suncus murinus*) 24.97%, Taiwan bandicoot rat (*Bandicota indica*) 6.92%, Buff-bellied rat (*Rattus flavipectus*) 6.36%, Brown country rat (*Rattus losea*) 2.14%, Black rat (*Rattus rattus*) 1.04%, and the House mouse *(Mus musculus*) 0.14%. Apart from the Taiwan bandicoot rat and Brown country rat found in Taoyuan Airport, Buff-bellied rat and House shrew found in the Kinmen area, and the Brown rat in Su-ao Harbor, the main population of rodents found in other harbor

areas is made up of Brown rats and House shrews. The captured number

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did not differ greatly due to the different seasons. Categorizing by species, the Brown rat showed the highest positive antibody rate (18.82%). Following are Black rat, House shrew, and Buff-bellied rat with positive antibody rates of 6.67%, 6.37%, and 5.43%. The average positive antibody rate is 13.00%, which is slightly higher than results found in previous investigations. This shows that the Hantavirus is still prominent in Taiwan's harbor areas and therefore cannot be ignored. In this investigation, results showed that the average positive antibody rate in domestic harbors is 20.48%. Although the rate for domestic harbors is higher than the rate for international harbors (11.45%), this does not mean that the rate is relatively higher in domestic harbors due to the widely dispersed rate results. With the exception of Taoyuan Airport and Hualien Harbor which showed a 0.00% rate, other international harbors had a rate between 3.16% and 25.64%. From high to low are Su-ao Harbor (25.64%), Kaohsiung Harbor (22.16%), Taichung Harbor (19.28%), Keelung Harbor (15.24%), Kaohsiung Airport (11.54%), Mailiao Harbor (6.38%), and Lienchiang (5.19%), and Kinmen (3.16%). In domestic harbors, the positive rate is between 11.86% and 56.25%. The highest is in Wu-ci Harbor with a 56.25%. The other harbors are as following from high to low: Shuei-di-liao Fishing Harbor (23.81%), Fang-liao Fishing Harbor (15.71%), Dong-gang Fishing Harbor (14.93%), and Ba-dou-zih Fishing Harbor (11.86%).

Key Words: Harbor, Hantavirus, Rodent, Positive Antibody Rate

Introduction

The Hantavirus Syndrome is an acute zoonotic disease that can be transmitted from animals to humans through the means of the Hanta Virus. The Hantan Virus belongs to the Hantavirus of Bunyaviridae. Ever since the

determination of this virus in 1978, there are currently 22 types of the Hantavirus, categorized by different immunities [1]. The symptoms and severity of the infection differs greatly with different Hantaviruses. The symptoms can be categorized mainly into 2 types. The first type causes Hantavirus hemorrhagic fever, also called hemorrhagic fever with renal syndrome (HFRS), which is mainly seen in Asia and Europe. Commonly seen serotypes include Hantaan, Seoul, Puumala and Dobrava, among which the Hantaan is the most deadly to humans with a much higher death rate. Rodents in the Taiwan area infected with the Hantavirus all belong to the Seoul type [1] which causes milder symptoms. The other type causes Hantavirus pulmonary syndrome (HPS) which is mainly seen in America with virus types such as the Sin Nombre virus.

Rodents are the natural carriers of the Hantavirus. Different Hantavirus have different host. However, recent study shows that one type of Hantavirus may infect different hosts [2]. These hosts are not inflicted with the virus yet are capable of spreading the virus amongst their own kind through direct contact (such as fighting) or contact with the feces of the infected animal. Humans are mainly infected through contact with the excretions or secretions from the infected animal such as feces, urine, and saliva.

According to statistics by the Department of Health Centers for Diseases Control, in Taiwan, a total of 2 cases of the Hantavirus hemorrhagic fever entered from outside of the country and 8 cases originated locally between the years 1997 and 2006, amongst which 3 of the cases occurred in 2006. In addition, 2 local cases of Hantavirus pulmonary syndrome (HPS) occurred in 2001, suggesting that the disease was not a simple case of oversea infection. Therefore, there is a growing concern in the situation of the Hantavirus in

Taiwan.

According to the studies of Department of Health, among the rodents infected with the Hantavirus in Taiwan, the positive antibody rate was 7.2% in 1995 [3-4] and 10.4% in 1996 [5]. In the same year (1996), another study showed that the rate was 4.0% [6]. In addition, the results for the investigation of captured rodents (from major commercial harbors, fishing harbors, Kinmen County, and Lienchiang County) showed a total positive antibody rate of 9.8% in 2002 [7]. Also, it is noted that the positive antibody rate for the Hantavirus in rodents among international harbors is higher than those in domestic harbors [8]. Therefore, in order to further understand the positive antibody rate and distribution for the Hantavirus in rodents in Taiwan's harbors, this investigation was conducted in hopes of becoming a reference for establishing preventative measures in the future.

Materials and Methods

A. Rodent capture locations and investigation dates

1. International harbors:
   a. Harbor areas: Su-ao Harbor, Keelung Harbor, Taoyuan Airport, Taichung Harbor, Mailiao Harbor, Kaohsiung Harbor, Kaohsiung Airport, Kinmen (Shuei-tou and Liao-luo Harbor) and Lienchiang (Fu-wo Harbor).
   b. Investigation date: November 2004 to December 2006.
2. Domestic Harbors
   a. Harbor areas: Ba-dou-zih Fishing Harbor, Wu-ci Fishing Harbor, Fang-liao Fishing Harbor, Dong-gang Fishing Harbor, and Shuei-di-liao Fishing Harbor.

b. Investigation date: April 2005 to August 2006. No captures were made in Shuei-di-liao Fishing Harbor in 2006.

B. Rodent capture, specimen collecting, and further processing

1. Rodent capturing

a. Once, every month (each time 3 days) in International Harbors, traps (cages) are set in suspected rodent activity areas. At least 20 to 30 traps are set for each harbor area. In domestic harbors, Ba-dou-zih Fishing Harbor, Wu-ci Fishing Harbor, Fang-liao Fishing Harbor, Dong-gang Fishing Harbor, and Shuei-di-liao Fishing Harbor were investigated 17, 14, 5, 7, and 1 times respectively in the investigation period.

b. Different baits are set for different types of rodents.

c. All traps are examined the following morning and the captured rodents (along with the cages) are set in double-lined plastic bags.

2. Specimen collecting and processing

a. Blood samples were taken from all captured rodents.

b. Basic data was collected (including date of capture, species, gender, and capture location).

c. Cover the cage with a transparent net and open the cage door. After transferring the captured rodent into the net, 0.2-0.5 ml of Zoletil 50 anesthetic is administered to the rodent according to its size.

d. After the rodent ceases struggling, it is taken out of the net.

e. The sedated rodent is placed on a clean platform.

f. Blood is collected from the heart with a 2.5 ml syringe until blood can no longer be drawn. The blood is set at room temperature for 1 hour before centrifugally administered with 3,000 rpm for 10 minutes. The

separated serum is then labeled and stored in 20℃ below zero temperatures.

C. Analysis of positive antibody rate in serum

a. Reagents: Hantavirus IgG DxSelect™ (FOCUS Diagnostics): Enzyme-linked Immunosorbent Assay (ELISA) can detect the antibody for Hantaan, Seoul, Puumala, Dobrava, and Sin Nombre virus types.

b. Procedures: According to the IgG DxSelect™ (FOCUS Diagnostics) instructions manual.

(1) Rodent serum and control are diluted with Sample Diluent 1:100 separately.

(2) Wash the microwell plates containing recombinant proteins with 1X Wash Buffer solution.

(3) Diluted serum, control, and specimen diluent (as Blank) are placed in a microwell plate (each well 100ul) and set at room temperature (20-25℃) for 1 hour.

(4) Clean with 1X Wash Buffer solution 3 times.

(5) Add IgG Conjugate 100ul/well and set at room temperature for 30 minutes.

(6) Clean with 1X Wash Buffer solution 3 times.

(7) Add Substrate Reagent 100ul each well and set at room temperature for 10 minutes.

(8) Add Stop Reagent 100ul/well.

(9) Measure the optical density (OD) with 450nm long wave Spectrophotometer.

Results

A. Rodent numbers and distribution

A total of 1,446 rodents (52.49% males and 47.51% females) suspected to be Hantavirus hosts were captured in harbors. 1,197 of these were captured in international harbors and 249 in domestic harbors. These can be categorized into 2 orders, 2 families, 4 genus, and 7 species (Table1). The Brown rat (*Rattus norvegicus*) takes up 58.44% of the entire captured number. Following are other kinds placed in percentage order: House shrew (*Suncus murinus*) 24.97%, Taiwan bandicoot rat (*Bandicota indica*) 6.92%, Buff-bellied rat (*Rattus flavipectus*) 6.36%, Brown country rat (*Rattus losea*) 2.14%, Black rat (*Rattus rattus*) 1.04%, and the House mouse *(Mus musculus*) 0.14%. Of the captured rodents in international harbors, the distribution is as following: Brown rat 57.48%, House shrew 22.89%, Taiwan bandicoot rat 8.35%, Buff-bellied rat 7.69%, Brown country rat 2.59%, Black rat 0.84%, and the House mouse 0.17%. The captured rodent numbers clearly do not differ according to the season ($P>0.05$) (Figure 1). Only the Brown rat, House shrew, and Black rat were captured in domestic harbors, each with a percentage of 63.05%, 34.94%, and 2.01% (Table 2).

The Buff-bellied rat was only captured in the Kinmen area. The rodents captured there were mainly House shrews and Buff-bellied rats. Rodents captured in Taoyuan Airport mainly consisted of the Taiwan bandicoot rat and Brown country rat. In addition, 116 of the 117 captured rodents in Su-ao Harbor were Brown rats. These 3 areas differed from the other areas where the rodents were mainly Brown rats and House shrews.

B. Positive rate for antibodies in Hantavirus serums

Of all the captured rodents, the rodent serum that resulted in positive Hantavirus antibody potential hosts includes the following species: Brown rat, Black rat, House shrew, and Buff-bellied rat with positive antibody rates of 18.82%, 6.67%, 6.37%, and 5.43%. Among the harbors, Su-ao Harbor, Taichung Harbor, Shuei-di-liao Fishing Harbor, and the Lienchiang area had only the Brown rat as the Hantavirus host (Table 3). If we categorize the results into International harbors and domestic harbors, we can see in international harbors there was a 17.15% positive antibody rate in Brown rats, 5.11% in House shrews, and 5.43% in Buff-bellied rats. In domestic harbors, the rate was 26.11% in Brown rats, 20.00% in Black rats, and 10.34% in House shrews (Table 4).

The average positive Hantavirus antibody rate for the captured rodents is 13.00%. The average rate for international harbors is 11.45%. With the exception of Taoyuan Airport and Hualien Harbor which showed a 0.00% rate, other international harbors had a rate between 3.16% and 25.64%. From high to low are Su-ao Harbor (25.64%), Kaohsiung Harbor (22.16%), Taichung Harbor (19.28%), Keelung Harbor (15.24%), Kaohsiung Airport (11.54%), Mailiao Harbor (6.38%), and Lienchiang (5.19%), and Kinmen (3.16%) (Table 5). In domestic harbors, the positive rate is between 11.86% and 56.25% (average 20.48%). The highest is in Wu-ci Harbor with a 56.25%. The other harbors are as following from high to low: Shuei-di-liao Fishing Harbor (23.81%), Fang-liao Fishing Harbor (15.71%), Dong-gang Fishing Harbor (14.93%), and Ba-dou-zih Fishing Harbor (11.86%) (Table 6).

Discussion

The distribution of the main rodent species is mainly similar in Taiwan's harbors with the exception of Su-ao Harbor, Taoyuan Airport, and the Kinmen area. These are mainly Brown rats and House shrews. Kinmen was the only area in which Buff-bellied rats were found. This is consistent with Chin Chuan et al. findings [4-5]. The Taiwan bandicoot rat and Brown country rat were the main rodent species found in Taoyuan Airport. These are also the main species of rodents found here in previous investigations [4-5]. The Taiwan bandicoot rats captured here took up 96% of the total number of captured Taiwan bandicoot rats. This seems to be related to the trap locations and the species' habitual tendency to live in farm lands and desolated country areas. The rodents captured at Su-ao Harbor were mainly Brown rats, showing a different result from Chin Chuan et al. findings [4-5]. In addition, the Black rats captured only took up 1.04% of the entire number captured. This may have to do with the fact that this investigation is focused on harbors only.

The average positive virus antibody rate is 13.0%. It is slightly higher than the previous investigation results of 9.8% [4], 12.6% [5], and 9.8% [7]. This shows that the Hantavirus is still prominent in Taiwan's harbor areas and therefore cannot be ignored.

Looking at the rodent species, the highest positive antibody rate is in Brown rats with an 18.82%. Although this is higher than Chow Ling *et al*. results (12.0%) in 2002, it is lower than Chin Chuan *et al*. findings in 1995 (20.1%) and 1996 (24.6%). Therefore, Brown rats are the main potential Hantavirus hosts in harbor areas. In addition, House shrews of the Insectivora order had a 6.37% positive antibody rate. Although this is much higher than Chin Chuan *et al*. findings in 1995 (0.2%) and 1996 (1.8%), it does not show

much change in comparison with Chow Ling *et al*. results (7.6%) in 2002. This means that the species is quite stable in terms of positive antibody rate in the harbor area. Noted is another result in which the positive rate for Buff-bellied rats caught in the Kinmen area is 5.43%. This result is higher than those of Chin Chuan *et al.* (1.0% and 0.8%) [4-5] and Chow Ling *et al*. (2.0%) [9]. Only the prior study captured rodents in the Kinmen area, whereas this investigation only conducted trapping in harbors in the Kinmen area (Shuei-tou and Liao-luo Harbor). The positive antibody rate for the species there has indeed risen. In addition, the rate is higher in harbor areas than those areas which do not neighbor the sea [10]. This may also be due to other factors which need further investigation.

Although the positive antibody rate for domestic harbors (20.48%) is higher than the rate for international harbors (11.45%), this does not mean that the rate is relatively higher in domestic harbors. This is due to the fact that the differences between the international harbors' rate is quite great. In addition, the 56.25% of the Wu-ci harbor had also influenced the result. According to Chow Ling *et al*. results [7], the infectious rate of the Brown rat differs greatly according to the difference in location and season. Some harbors may reach a rate of 50%, such as the Wu-ci Harbor (October ~ December, 2002), Nan-liao Fishing Harbor (February and September, 2002), and Pei-shih-liao Fishing Harbor (August and September 2002). The causes of the high rate in Wu-ci Harbor are still in need of future investigation in whether they are environmental or other causes. However, the Wu-ci fishing harbor is classified as the first class fishing harbor in fishing development. Its fish sales center is also a main tourist attraction. Therefore, it is strongly advised that measures in reducing rodent population should be enhanced in order to reduce

the health threat it imposes on the working people and tourists in the Wu-ci Harbor. The positive rate for Taoyuan Airport is 0.00%, similar to the Chin Chuan *et al.* results of 1995 (0.0%) and 1996 (0.5%). This means that this harbor has a stable and extremely low rate of rodents infected with the virus. On the other hand, although Hualien Harbor also had a rate of 0.00%, this may be due to the smaller number of rodents captured. Therefore it is more difficult to reflect the actual positive virus antibody rate of the area. In addition, the 3.8% of 1995 and 4.0% of 1996 (Chin Chuan *et al*.) has risen to 25.64% in Su-ao Harbor. This has placed a red light on the infection of rodents with the Hantavirus situation on the area.

Conclusion and Suggestions

According to investigation results, there are many Hantavirus potential hosts in harbor areas. This includes the Brown rat (58.44%), Black rat (1.04%), House shrew (24.97%), and Taiwan bandicoot rat (6.92%), Buff-bellied rat (6.36%), Brown country rat (2.14%), and the House mouse (0.14%). Apart from Taoyuan Airport, Su-ao Harbor, and Kinmen area, most of the rodents are mainly Brown rats and House shrews. Preventative measures can be made focusing on the main rodent species habits in the future.

The positive antibody rate of the Hantavirus in rodents is slightly higher than the results in previous years. Due to the fact that transmission can occur through the contact of humans with rodent excretions, the threat of the Hantavirus in harbors cannot be ignored. Harbor management are strongly advised in enforcing the environmental sanitation in reducing the density of rodent numbers; thus reducing the chances of contact and infection.

Note of Appreciation

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Table 1. Categories of Captured Rodents in Investigation Areas, November 2004 ~ December 2006

Order	Family	Genus	Species
Rodentia	Muridae	Rattus	Brown rat
			R. norvegicus
			Black rat
			R. rattus
			Buff-bellied rat
			R. flavipectus
			Brown country rat
			R. losea
		Mus	House mouse
			M. musculus
		Bandicota	Taiwan bandicoot rat
			B. indica
Insectivora	Soricidae	Suncus	House shrew
			S. murinus

Table 2. Captured Rodent Species in International and Domestic Harbors in Taiwan

Harbor		Brown rat	Black rat	House shrew	Taiwan bandicoot rat	Buff-bellied rat	Brown country rat	House mouse	Total
International Harbors (IH)	Su-ao	116	1	0	0	0	0	0	117
	Keelung	84	0	21	0	0	0	0	105
	Kinmen	0	0	97	0	92	1	0	190
	Lienchiang	41	0	35	0	0	1	0	77
	Taoyuan Airport	4	0	0	96	0	25	0	125
	Taichung	61	0	22	0	0	0	0	83
	Mailiao	153	1	28	1	0	4	1	188
	Kaohsiung	168	5	12	0	0	0	0	185
	Kaohsiung Airport	44	2	57	0	0	0	1	104
	Hualien	17	1	2	3	0	0	0	23
	IH total	688	10	274	100	92	31	2	1,197
	Percentage	57.48	0.84	22.89	8.35	7.69	2.59	0.17	100.00
Domestic Harbors (DH)	Ba-dou-zih	18	0	41	0	0	0	0	59
	Wu-ci	31	0	1	0	0	0	0	32
	Fang-liao	43	0	27	0	0	0	0	70
	Dong-gang	50	4	13	0	0	0	0	67
	Shuei-di-liao	15	1	5	0	0	0	0	21
	DH total	157	5	87	0	0	0	0	249
	Percentage	63.05	2.01	34.94	0.00	0.00	0.00	0.00	100.00
Total count		845	15	361	100	92	31	2	1,446
Percentage		58.44	1.04	24.97	6.92	6.36	2.14	0.14	100.00

Table 3. Hantavirus Positive Antibody Rate in Rodent of Harbors in Taiwan

Listing		Su-ao	Keelung	Kin-men	Lien-chiang	Taoyuan Airport	Taichung	Mailiao	Kaohsiung	Kaohsiung Airport	Hualien	Ba-dou-zih	Wu-ci	Fang-liao	Dong-gang	Shuei-di-liao	Total
Brown rat	Caught number	116	84	0	41	4	61	153	168	44	17	18	31	43	50	15	845
	Positive number	30	11	0	4	0	16	10	40	7	0	1	17	10	8	5	159
	Positive rate, %	25.86	13.10	-	9.76	0.00	26.23	6.54	23.81	15.91	0.00	5.56	54.84	23.26	16.00	33.33	18.82
Black rat	Caught number	1	0	0	0	0	0	1	5	2	1	0	0	0	4	1	15
	Positive number	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Positive rate, %	0.00	-	-	-	-	-	0.00	0.00	0.00	0.00	-	-	-	25.00	0.00	6.67
House shrew	Caught number	0	21	97	35	0	22	28	12	57	2	41	1	27	13	5	361
	Positive number	0	5	1	0	0	0	2	1	5	0	6	1	1	1	0	23
	Positive rate, %	-	23.81	1.03	0.00	-	0.00	7.14	8.33	8.77	0.00	14.63	100.00	3.70	7.69	0.00	6.37
Taiwan bandicoot rat	Caught number	0	0	0	0	96	0	1	0	0	3	0	0	0	0	0	100
	Positive number	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Positive rate, %	-	-	-	-	0.00	-	0.00	-	-	0.00	-	-	-	-	-	0.00
Buff-bellied rat	Caught number	0	0	92	0	0	0	0	0	0	0	0	0	0	0	0	92
	Positive number	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5
	Positive rate, %	-	-	5.43	-	-	-	-	-	-	-	-	-	-	-	-	5.43
Brown country rat	Caught number	0	0	1	1	25	0	4	0	0	0	0	0	0	0	0	31
	Positive number	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Positive rate, %	-	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-	-	-	0.00
House mouse	Caught number	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	2
	Positive number	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Positive rate, %	-	-	-	-	-	-	0.00	-	0.00	-	-	-	-	-	-	0.00
Total caught rodents		117	105	190	77	125	83	188	185	104	23	59	32	70	67	21	1,446
Average positive rate, %		25.64	15.24	3.16	5.19	0.00	19.28	6.38	22.16	11.54	0.00	11.86	56.25	15.71	14.93	23.81	13.00

Table 4. Positive Hantavirus Antibody Rate in Different Species of Rodents Captured in Taiwan's Harbor Areas

Listing		Brown rat	Black rat	House shrew	Taiwan bandicoot rat	Buff-bellied rat	Brown country rat	House mouse	Total
International Harbors	Caught number	688	10	274	100	92	31	2	1197
	Species %	57.48	0.84	22.89	8.35	7.69	2.59	0.17	100.00
	Positive Hanta number	118	0	14	0	5	0	0	137
	Species positive rate, %	17.15	0.00	5.11	0.00	5.43	0.00	0.00	11.45
Domestic Harbors	Caught number	157	5	87	0	0	0	0	249
	Species %	63.05	2.01	34.94	0.00	0.00	0.00	0.00	100.00
	Positive Hanta number	41	1	9	0	0	0	0	51
	Species positive rate, %	26.11	20.00	10.34	0.00	0.00	0.00	0.00	20.48
All Harbors	Caught number	845	15	361	100	92	31	2	1,446
	Species %	58.44	1.04	24.97	6.92	6.36	2.14	0.14	100.00
	Positive Hanta number	159	1	23	0	5	0	0	188
	Species positive rate, %	18.82	6.67	6.37	0.00	5.43	0.00	0.00	13.00

Table 5. Hantavirus Positive Antibody Rate of Rodent Caught in International Harbors in Taiwan

Year	Item	Harbor										Total
		Su-ao	Keelung	Kinmen	Lienchiang	Taoyuan Airport	Taichung	Mailiao	Kaohsiung	Kaohsiung Airport	Hualien	
2004 (Nov, Dec)	Caught number	9	9	10	6	23	18	11	21	7	6	120
	Positive number	4	2	0	0	0	5	0	4	1	0	16
	Positive rate, %	44.44	22.22	0.00	0.00	0.00	27.78	0.00	19.05	14.29	0.00	13.33
2005	Caught number	51	46	80	19	31	30	101	93	63	12	526
	Positive number	9	4	5	0	0	5	2	23	10	0	58
	Positive rate, %	17.65	8.70	6.25	0.00	0.00	16.67	1.98	24.73	15.87	0.00	11.03
2006	Caught number	57	50	100	52	71	35	76	71	34	5	551
	Positive number	17	10	1	4	0	6	10	14	1	0	63
	Positive rate, %	29.82	20.00	1.00	7.69	0.00	17.14	13.16	19.72	2.94	0.00	11.43
2004～ 2006	Caught number	117	105	190	77	125	83	188	185	104	23	1,197
	Positive number	30	16	6	4	0	16	12	41	12	0	137
	Positive rate, %	25.64	15.24	3.16	5.19	0.00	19.28	6.38	22.16	11.54	0.00	11.45

Table 6. Hantavirus Positive Antibody Rate of Rodent Caught in Domestic Harbors in Taiwan

Year*	Item	Harbor					Total
		Ba-dou-zih	Wu-ci	Fang-liao	Dong-gang	Shuei-di-liao	
2005	Caught number	31	13	51	53	21	169
	Positive number	2	8	8	7	5	30
	Positive rate, %	6.45	61.54	15.69	13.21	23.81	17.75
2006**	Caught number	28	19	19	14	0	80
	Positive number	5	10	3	3	0	21
	Positive rate, %	17.86	52.63	15.79	21.43	-	26.25
2005～2006	Caught number	59	32	70	67	21	249
	Positive number	7	18	11	10	5	51
	Positive rate, %	11.86	56.25	15.71	14.93	23.81	20.48

* Rodents caught between April 2005 and August 2006, once a month for 17, 14, 5, 7, and 1 times.

** No rodent capture was conducted in 2006 in Shuei-di-liao Fishing Harbor.

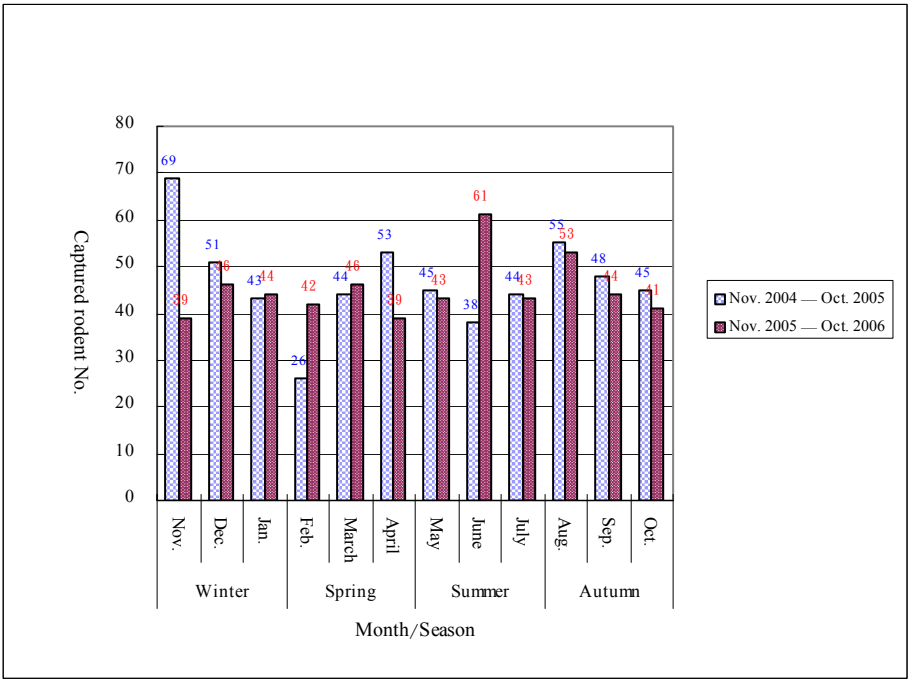

Figure 1. Numbers of Rodents Caught between November 2004 and October 2006 in Taiwan's International Harbors (Months/Seasons)