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Plaza

Integrated pest management and surveillance of West Nile Virus infection in Louisiana, USA

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Abstract

West Nile Virus (WNV) infection is a mosquito-borne disease belonging to the genus Flavivirus, family Flaviviridae and is a causative agent of West Nile fever and West Nile encephalitis. Mosquito bites remain the most common way of spread the virus; however, transmission also appears likely to occur through blood transfusion, organ transplantation, and breast milk. WNV infection has emerged in recent years in the United States with a threat to public and animal health. The most serious consequence of WNV infection is fetal encephalitis in humans and horses, as well as death in certain domestic and wild birds. The Culex species that produced WNV are among the most important WNV infection epizootic or epidemic vectors in the United States. The first appearance of WNV infection with encephalitis reported in humans and horses in the United States was in 1999.

From 2000 to 2001, there were 46 cases of aseptic meningitis or encephalitis due to WNV infection in the 3 states (New York, New Jersey, and Connecticut) areas (19 cases in 2000 and 27 cases in 2001). However, during a record-setting epidemic in 2002, there were 4,156 cases with 284 fatalities. As of October 3, 2003, there have been 6,204 cases WNV infection including 127 fatalities and it has spread throughout the United States. The several routes of WNV infection are reported including mosquito-bite, organ transplantation, blood transfusion, and infant through breast-milk. However, there is no evidence that WNV infection is caused by breast-milk.

The mosquito control programs called Integrated Pest Management (IPM) was introduced and developed in 1964 in New Orleans, LA, U.S.A.. IPM has been the most practical method to prevent mosquito-borne diseases and has been carried out by the New Orleans Mosquito Control Center. The program consists of four components; source reduction, public health education, biological control, and chemical control. In addition, 5 surveillance systems concerning WNV infection are carried out by Louisiana Office of Public Health and are for farm animals, wild birds, sentinel flocks, mosquitoes, and larval mosquitoes. Implementation to the IPM and the 5 surveillance systems reduced the incidence of WNV infection by 80% in LA, U.S.A..

WNV infection is categorized as the fourth level of the New Infectious Diseases Protection Law (1999) in Japan. Vaccination against WNV infection for human is developing and we must decrease the risk for human WNV infection and adapt practical control surveillance systems such as IPM and the 5 surveillance systems used in Louisiana.

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I. Introduction

West Nile Virus (WNV) is a mosquito-borne disease belonging to the genus Flavivirus, family Flaviviridae and is a causative agent of West Nile fever and West Nile encephalitis[1]. WNV is a closely related to the St. Louis encephalitis virus (SLEV) which is found in the United States and also resembles the Japanese encephalitis virus in South East Asia. Mosquito-borne diseases affect millions of people worldwide each year and mosquitoes spread this virus after they feed on infected birds and then bite people, other birds and animals. It is not spread by person-to-person contact and there is no evidence that people can get the virus by handling infected animals, especially birds (crows and blue jays). Since WNV was first isolated in 1937 in Uganda[2], it has been known to cause asymptomatic infection and fever in humans in Africa, West Asia, and the Middle East. Human and animal infections were not documented in the Western Hemisphere until 1999. After introduction to the Western Hemisphere, WNV infection has caused human encephalitis and aseptic meningitis. WNV infection was responsible for 59 human cases requiring hospitalization which included 7 deaths in the New York area in 1999[3].

Most WNV infected humans have no symptoms. A small proportion have mild symptoms such as fever, headache, body aches, skin rash, and swollen lymph glands. Less than 1% of infected people develop more severe illnesses such as meningitis or encephalitis. The symptoms of these illnesses can include headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, and paralysis[4]. Severe illness with encephalitis can cause death, but in less than one out of 1,000 infections.

II. Epidemiology

1) WNV infection outbreak in Louisiana :

There were only 12 cases (human 1, equine 10, avian 1) in 2001 ; however, the number of those had increased to 329 cases in 2002. WNV activity had spread out in Louisiana and led to 25 deaths (Table 1). This statewide outbreak of WNV infection during the summer of 2002 was the cause of extensive mortality among free ranging birds[5),6)]. However, the incidence in 2003 decrease dramatically by 80% to 67 cases which included one death as of October 3, 2003 according to the Center for Disease Controls and Prevention (CDC) (Table 2).

2) Spread to mid-western USA :

From 2000 to 2001 there were 46 cases of aseptic meningitis or encephalitis due to WNV infection in the 3 states (New York, New Jersey, and Connecticut) areas (19 cases in 2000 and 27 cases in 2001). It was identified that the epicenter was Staten Island in 2000 and was indefinable in 2001. The incidence in 2001 occurred nine human cases which included two mild cases is not requiring hospitalization in New York City[5),6)]. In 2001, WNV infection spread dramatically in the United States and was seen in 27 states, There were 66 human cases in 10 states, 737 infected horses, thousands of infected birds, and mosquitoes found as far west as Arkansas and as far south as Florida.

In 2002, there were 4,156 human cases WNV infection with 284 fatalities in 44 states and the District of Columbia. Another byproduct of WNV infection announced on October 10, 2002 was a polio-like paralysis that had struck two Louisianians.

As of October 3, 2003, It have been reported 6,204 cases WNV infection including 127 fatalities in the entire United States (Table 2).

The transmission appeared likely to occur through blood transfusion, organ transplantation[7)-9)]. Concern about infection from these sources arose. CDC, the

Table 1 WNV Encephalitis Outbreak in Louisiana U.S.A. 2002

Age Group	Cases			Population	Cases /100K	Death	Death /100K	Clinical Classification			ME /100K
	M	F	Total					ME	Fever	Unk	
0-14	3	7	10	864,146	1.2	0	0.0	3	7		0.3
15-29	26	29	55	870,687	6.3	1	0.1	31	24		3.6
30-44	49	28	77	861,068	8.9	1	0.1	35	40	2	4.1
45-59	39	33	72	650,995	11.1	2	0.3	44	28		6.8
60-75	35	23	58	442,076	13.1	3	0.7	40	17	1	9.0
75+	30	27	57	158,517	36.0	18	10.7	51	6		32.2
Undetermined	0	0	0			0		0	0	0	
Total	182	147	329	3,847,488	8.6	25	0.6	204	122	3	5.3

ME=Meningo encephalitis, Unk=Unknown
Source: Louisiana office of Public Health, West Nile Virus Statistics 2002

Table 2 West Nile Virus 2002-2003 Case Count in U.S.A.

State	Laboratory Positive Human		Deaths	
	2002	2003*	2002	2003*
Alabama	49	29	3	3
Arizona		1		
Arkansas	43	11	3	
California	1	0		
Colorado	14	2,090		38
Connecticut	17	9		
Delaware	1	10		1
District of Columbia	34	4	1	
Florida	28	32	2	
Georgia	44	15	7	2
Illinois	884	22	64	
Indiana	293	6	11	
Iowa	54	108	2	4
Kansas	22	44		1
Kentucky	75	10	5	1
Louisiana	329	67	25	1
Maryland	36	21	7	3
Massachusetts	23	10	3	
Michigan	614	1	51	1
Minnesota	48	111		4
Mississippi	192	51	12	1
Missouri	168	38	7	2
Montana	2	207		2
Nebraska	152	999	7	15
Nevada		1		
New Hampshire		2		
New Jersey	24	17		1
New Mexico		179	5	4
New York	82	47		6
North Carolina	2	19		
North Dakota	17	293	2	4
Ohio	441	66	31	3
Oklahoma	21	46	2	
Pennsylvania	62	91	7	1
Rhode Island	1	3		
South Carolina	1	1		
South Dakota	37	840		8
Tennessee	56	8	7	
Texas	202	357	13	13
Utah		1		
Vermont	1	1		
Virginia	29	7	2	
West Virginia	3	0	2	
Wisconsin	52	11	3	
Wyoming	2	315	8	
Total	4,156	6,204	284	127

*October 3, 2003
Source: The Centers for Disease Control and Prevention

Food Drug Administration (FDA), and the Health Resources and Services Administration (HRSA) had investigated WNV infections in recipients of blood transfusion and organ transplantation. The CDC received reports from 10 states of 15 patients with confirmed West Nile meningoencephalitis (WNME) after blood components as of October 2, 2002. It has also been reported that WNV infection in a Michigan woman, who received a blood product later found to have evidence of WNV, and her newborn, were WNV-specific IgM-positive on testing through breast-milk[7)-9)]. However, there is no evidence that WNV infection is transmitted through breast-milk at the present time. The CDC and the Michigan Department of Community Health (MDCH) have continued to investigate this question.

III. WNV infection control measurement

Integrated Pest Management (IPM) in New Orleans, Louisiana

To combat mosquitoes and public health hazards, the New Orleans Mosquito Control Center (NOMCC) was established in 1964. A mosquito control program called Integrated Pest Management (IPM) was introduced and developed. IPM consists of 4 components; source reduction, public health education program, biological control, and chemical control.

1) Source Reduction:

Source reduction, or elimination of breeding areas, is a major part of NOMCC control efforts and public health education program informs both adults and school children in the communities by using media forms. This includes filing, draining, dredging, or in some way altering the habitat so that it is no longer suitable for mosquito larval development. This program represents a long-term commitment, as community education and participation are needed for a successful program. Information is required from the Louisiana Office of Public Health (OPH) and communities for different types of control measures. In the United States, urban mosquitoes, especially Aedes mosquitoes are usually the problem as they can breed in containers and do not need large amounts of water. Also, artificial containers are free of predators. Backyard containers and old tires are often found in urban areas, and represent ideal breeding places for mosquito larvae. Larval control involves applying a physiological or physical insecticide to the larval habitat or introducing a parasite or predator into the habitat to reduce larval populations.

2) Public Health Education Program:

Public understanding of the problems caused by mosquitoes has helped in the elimination of container breeding and is the goal of the public health education

program. Community-based control efforts with local participation can help to eliminate container for breeding mosquitoes. The NOMCC has used many media forms such as videotapes, radio, television, and insert to educate and provide public service announcements for the people in community about the mosquito educational programs. Training mosquito control personnel is also a part of the public health education program, which advises the people on how to avoid mosquito bites during feeding hours. It is a sound way to utilize local capacity without being resource intensive.

3) Biological Control :

Biological control is being used and developed at the NOMCC. NOMCC is using existing biological controls, as well as developing new technologies for the future. These basic biological methods are supported by adult mosquito density surveys, rainfall information, larval surveys, encephalitis surveillance and other operations for controlling mosquitoes, and protecting the people in New Orleans, LA. There are numerous biological control agents such as: 1) Mosquito fish otherwise known as a top minnow (*Gambusia affinis*). This small larvivorous fish is a surface feeder, and provides the best mosquito reduction in water with little vegetation to provide larval refuges. It is most efficient in clean water and can be introduced periodically along the shore of a body of water.

2) Turtles eat larvae even in polluted water such as settlement ponds from cattle and pigs farms, where fish cannot survive. 3) Copepods are microcrustaceans that are often found in the same habitats as mosquito larvae. Several species are predators and are capable of surviving in diluted sewage effluent while preying on mosquito larvae. Copepods are sprayed and provided high larvae mortality in container habitats. 4) Toxorhynchites amboinensis adult mosquitoes feed only on nectar and are reared and released to control container-breeding mosquitoes because larvae of Toxorhynchites spp. mosquitoes prey upon other mosquito larvae. Because the adult female seeks containers in which to oviposit, they naturally disperse to habitats that are difficult for humans to find and treat. Larvae are often spread by spoonfuls of water to container habitats, and adult females are simply released in an area with several containers. Successful implementation of biological control requires that many ecological and economic factors be taken into consideration.

4) Chemical Control :

The basic methods of chemical control (larvacides and adulticides) are guided by a continuing surveillance program to define the problem according to the type of mosquito and location. This includes toxins and oil. When thin layers of oil are applied to small surfaces of water, mosquito larvae are prevented from reaching the water surface to breathe, and therefore die. Controlling the number of the mosquito adults consists of applying physiological insecticides to the habitat in which mosquito adults fly or rest. Controlled the number of the mosquito adults is achieved by numerous methods such as UV traps, light traps, dry ice/CO_2/vacuum traps, duplex cone traps, and truck mounted traps at dawn and dusk when mosquitoes are most active.

After collecting mosquito, the effect of insecticides on the mosquitoes is tested by NOMCC. Susceptibility testing to determine the concentration of insecticide needed to kill 50%-90% of the mosquito population is carried out and the level of resistance in field populations is also determined. Spraying of insecticides is effective but expensive: however, it is the only method of disease outbreak control and can be carried out by trucks or airplanes. Large scale of application of pesticides is economically not feasible for developing countries. Generally, pesticides are the last measure used if other control measures have failed. Pyrethrum is preferred to Malathion because of its toxicity and lack of human skin penetration. It breaks down almost immediately when exposed to sunlight it is sprayed after dusk. Malathion is slightly but when used appropriately, it is non-toxic for humans and animals. DEET is the only repellent that works at keeping mosquitoes away, generally lasting longer than other repellents. Mosquitoes are attracted to dark colors, CO_2 in human breath, body odor, sweat, and warm body temperature. Cloth treated with quick-acting insecticides such as permethrin is effective.

IV. Surveillance System of WNV infection

The 5 surveillance systems in the Louisiana OPH are as follows;

1) Veterinary Surveillance :

Veterinarians will monitor horses, dogs, and cats for clinical signs of neurological disease and conduct laboratory testing. The number of reported WNV cases in horses peaked and persisted after human cases in 2002. This fact could indicate that the horse was not a sensitive sentinel for the prediction of human illness. However, further study is needed.

2) Wild Bird Surveillance :

Surveillance participants will monitor WNV activity in wild birds. Surveillance for dead crows in particular is a sensitive means to detect the presence of WNV in an area. There was a geographic expansion of WNV infected wild birds and the WNV affected area consisted of parts of New Orleans and other parish in Louisiana in 2002. Shortly afterward, the WNV affected area stretched from New Orleans to Mississippi.

3) Sentinel Flock Surveillance:

Surveillance participants will monitor WNV activity

in sentinel chicken flocks.

4) Mosquito Surveillance :

Surveillance participants will monitor WNV activity in collected mosquitoes. Surveillance of mosquito populations will be used to detect WNV to help identify potential mosquito vectors in a particular area in New Orleans and monitor population densities of those vectors.

5) Larval Mosquito Surveillance :

This is to select the appropriate control measure for a given mosquito species. Larval Control involves applying a physiological or physical insecticide to the larval habit or introducing a parasite or predator into the habitat to reduce larval populations.

The WNV infection Surveillance System is intended to monitor the geographic and temporal spread of WNV infection over the contiguous the United States, to develop further national public health strategies for WNV infection surveillance, prevention, and control, to develop a more complete regional picture of the geographic distribution and incidence of similar viruses, and to provide national and regional information to public health officials, elected government officials, and the public. Surveillance participants will also monitor virus activity in sentinel chicken flocks.

V. Conclusion

Although the outbreak of WNV infection in Louisiana was 329 cases in 2002, the incidence in 2003 decreased dramatically by 80% to 67 cases, including one death as of October 3, 2003. In contrast, the nationwide incidence in 2003 of WNV infection 6,204 cases exceeds the 2002 number 4,156 cases. It might be said that the IPM and 5 surveillance systems implemented by the NOMCC and Louisiana OPH have been estimably effective in preventing and controlling mosquitoes against WNV infection.

Japan may encounter WNV infection. WNV infection has categorized in the fourth level of the New Infectious Diseases Protection Law in Japan (1999). Vaccination against WNV infection for human is under developing at the present time, therefore, it is indispensable to take preventive measures and practical controls against WNV infection. The fact the IPM and 5 surveillance systems in Louisiana succeeded in preventing and controlling mosquitoes suggests that they might be adapted to new measures in Japan for preventing and controlling of WNV infection.

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米国ルイジアナ州におけるウエストナイルウイルス感染症の総合的対策とサーベイランス

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【要旨】 1999年8月、米国ニューヨークで突如急性脳炎患者が群発し、その病原体がウエストナイルウイルス (West Nile Virus: 以下WNウイルス) であることが解明された事件は、専門家をはじめ多くの人々に大きな衝撃を与えた。その後、米国に定着したWNウイルスは、2002年には米国及びカナダにおいて、4156名の感染者と284名の死亡者をもたらす大流行を、2003年は10月2日現在6204名の感染者と127名の死亡者の大流行を引き起こしている。

WNウイルスは、近代ウイルス学の分類では黄熱ウイルスを代表とするフラビウイルス科・フラビウイルス属であり、抗原的には日本脳炎ウイルス亜群に属している。

WNウイルスはCulexなど複数種の蚊によって媒介され、媒介蚊の中には日本にも生息しているものがあり、媒介蚊の感染源となる増幅動物は、主に鳥類 (カラス、アオカケイ) である。

また、ウイルス保有蚊に刺咬される通常の感染ルート以外に、① 臓器移植、② 輸血によるWNウイルス感染が米国で報告され、更に母乳にWNウイルス遺伝子が検出されたことから、母乳が母親から乳児への感染源となる可能性が指摘されているが、現在のところ確証は得られていない。

このような2002年のウエストナイルウイルス感染症の大流行に対して、New Orleans Mosquito Control Center (NOMCC) は、4つの総合的対策 (IPM) (① 蚊の発生源をなくす、② 住民教育・啓蒙活動、③ 生物学的コントロール、④ 化学的コントロール) を、またLouisiana Office of Public Health (OPH) は5つのサーベイランス (① 牛・馬等獣医学的、② 野鳥 (カラス・アオカケイ) 、③ ヒツジ・ヤギ・アヒルの群れ、④ 蚊、⑤ ボウフラ) を施行した。

その結果2003年度ルイジアナ州のウエストナイルウイルス感染症患者数と死亡者数は著明に減少した。

ウエストナイルウイルス感染症は日本においては感染症予防法 (1999年) の第4類感染症に分類される。しかしながら、ヒトに対するウエストナイルウイルス感染症のワクチンは未だ開発されておらず、今後の予防対策としてルイジアナ州で成功を収めたIPM及び5つのサーベイランスのような有効なシステム確立が日本にも参考となるかもしれない。

〈**Key words**〉 ウエストナイルウイルス感染症、ルイジアナ州、IPM、サーベイランス