Experimental Studies on Comparison of the Potential Vector Competence of Four Species of Culex Mosquitoes in China to Transmit West Nile Virus

SHU-FANG JIANG,1,2 YING-MEI ZHANG,1 XIAO-XIA GUO,1 YAN-DE DONG,1 DAN XING,1 RUI-DE XUE,3 AND TONG-YAN ZHAO1,4


ABSTRACT To assess the risk that indigenous mosquitoes in China are capable of transmitting and sustaining West Nile virus (WNV), four important Culex mosquito species, Culex tritaeniorhynchus, Culex modestus, Culex pipiens pallens, and Culex pipiens quinquefasciatus, were allowed to feed on the artificial infectious blood meal with WNV dose of 10^6.8 plaque-forming unit/ml and tested 2 wk later to determine infection and transmission rates. The results indicated that four Culex mosquitoes were competent laboratory vectors of WNV. The infection rates and transmission rates were statistical differences among different species of mosquito (χ² = 20.620, P = 0.000; χ² = 15.020, P = 0.005, respectively). The highest infection rate and transmission rate were obtained with Cx. tritaeniorhynchus (87.5 and 74.2%, respectively).

KEY WORDS West Nile virus, Culex, infection, transmission

West Nile virus (WNV), a member of the Japanese encephalitis virus (JEV) serogroup in the genus Flavivirus, family Flaviviridae, can cause fever, headache, myalgia, and sometimes fatal illnesses in humans (Hubelek et al. 1999). The virus is historically enzootic in Africa, Asia, and southern-central Europe. The outbreak of WNV fever or encephalitis in New York City represented the first introduction of WNV into the New World (Lanciotti et al. 1999).

Since the outbreaks of WNV in the New World, almost 75 species of mosquito were regarded as the vector mosquitoes (Higgs et al. 2004). The different mosquito species were recognized as the primary vectors in the different prevalence areas. In Africa and the Middle East, WNV had been most frequently isolated from Culex univittatus (McIntosh et al. 1976). In central Asia, Culex quinquefasciatus, Culex tritaeniorhynchus, and Culex vishnui were found to be the primary vectors (Akhter et al. 1982). In Europe, Culex pipiens, Culex modestus, and Coquillettidia richardi were identified as principal vectors (Hayes 1989). Cx. pipiens complex, Culex tarsalis, and Cx. quinquefasciatus are implicated as the predominant vectors in different parts of America (Kramer and Ebel 2003, Turell et al. 2000, 2005).

Materials and Methods

Mosquito Strain. Mosquitoes tested were drawn from established laboratory colonies. These included Cx. tritaeniorhynchus (Yunnan strain), Cx. modestus (Beijing strain), Cx. pipiens pallens (Beijing strain), and Cx. pipiens quinquefasciatus (Guangdong strain). All mosquitoes were maintained at 26 ± 1°C (Cx. tritaeniorhynchus at 29 ± 1°C) and 75 ± 5% RH under a 14:10, LD photoperiod.

Virus and Virus Assay. The WNV strain granted was preserved in the Microbial Culture Collection Center of Beijing Institute of Microbiology and Epidemiology. Its gene sequenced (Genbank AY490240) was homologous with Eg101 strain. The WNV stock (virus in infected mouse brain tissues) was titered by plaque assay in six-well tissue culture plates (Costar, Corning, NY) (Jiang et al. 2006a). All samples were detected for virus by reverse-transcriptase polymerase chain reac-

1 State Key Laboratory of Pathogen and Biosecurity, Institute of Microbiology and Epidemiology, Beijing, 100071, China.
2 Chinese People’s Liberation Army General Hospital, Beijing, 100853, China.
3 Anastasia Mosquito Control District, Augustine, FL 32085.
4 Corresponding author: No. 20 Dongdajie, Fengtai, Beijing, China (e-mail address: Aedes@263.net).
Table 1. Infection and transmission rate for mosquitoes infected with West Nile virus

<table>
<thead>
<tr>
<th>Species</th>
<th>Infection rate (%)</th>
<th>Transmission rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cx. tritaeniorhynchus</em></td>
<td>87.5 (32/38)</td>
<td>74.2 (23/31)</td>
</tr>
<tr>
<td><em>Cx. modestus</em></td>
<td>42.3 (11/26)</td>
<td>35.0 (7/20)</td>
</tr>
<tr>
<td><em>Cx. pipiens pallens</em></td>
<td>55.3 (21/36)</td>
<td>48.4 (15/31)</td>
</tr>
<tr>
<td><em>Cx. pipiens quinquefasciatus</em></td>
<td>40.5 (15/37)</td>
<td>36.7 (11/30)</td>
</tr>
</tbody>
</table>

Discussion

Among species of mosquitoes tested in our study, *Cx. tritaeniorhynchus* was the most susceptible and ready to transmit WNV by biting. The highest rates of infection and transmission were obtained with *Cx. tritaeniorhynchus* under the laboratory condition. In China, *Cx. tritaeniorhynchus* was distributed widely in the rice culture region, and recognized as the primary vector of the JEV (Li et al. 1998). Even though it fed primarily on swine that was the amplifying host of JEV, it fed on humans and birds also. Hence, it was suggested that *Cx. tritaeniorhynchus* would play an important role in the possible outbreak of WNV in the future based on its extremely extensive distribution and highest infection and transmission rates.

*Cx. pipiens quinquefasciatus* and *Cx. pipiens pallens* are members of *Cx. pipiens* complex, which distributes widely in the south and north of China, respectively. Both of them feed readily on avian and human. The results showed that *Cx. pipiens quinquefasciatus* and *Cx. pipiens pallens* were susceptible to WNV and able to transmit WNV under experimental conditions; they would be important potential vectors of WNV, based on their distribution and bloodfeeding behavior in China. *Cx. modestus* was listed in the species of arthropods in which WNV had been detected (Higgs et al. 2004). It was one of the principal vectors of WNV in Europe (Hubalek et al. 1999). *Cx. modestus* was a dominant mosquito species in marshy fields and reedy lakes in north part of China; the species fed on birds, human, swine, and horses. It was confirmed that *Cx. modestus* may play a role in transmission cycle of WNV, especially in the natural cycle in China.

Acknowledgments

We thank Professor Zhang Hailin (Yunnan Endemic Disease Control Institute) for *Cx. tritaeniorhynchus* (Yunnan strain). This work was supported by Nature Science Foundation of China (30371256) and Ministry of Science and Technology of the People’s Republic of China (2003BA712A09-02).

References Cited


Received 10 December 2008; accepted 19 April 2010.