2005 National Conference on West Nile Virus in the United States

Mosquito field infection rates and transmission risk are related to avian and mosquito host competence

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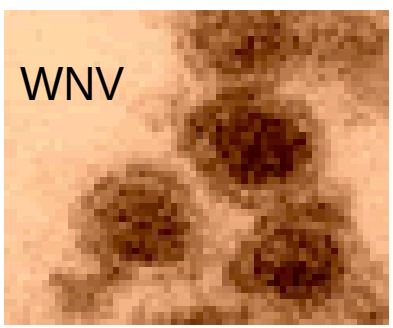


Support for research in California

- National Institutes of Allergy and Infectious Diseases, NIH
- Centers for Disease Control and Prevention
- Office of Global Programs, NOAA
- California Department of Health Services
- University-wide Mosquito Research Program
- Coachella Valley MVCD
- Greater Los Angeles Co VCD
- Sacramento/Yolo MVCD
- Kern MVCD

Feb 2004

Missing: Marc Kennsington [COAV], Scott Hallam & Leah Korserof [Kern]; Aaron Brault, Chris Barker and Bruce Eldridge [Davis], Scripps Group, UC San Diego

Talk Content

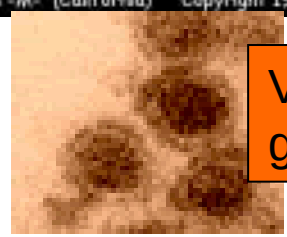
- Mosquito species infected in nature
- Mosquito vector competence
- Avian host competence
- Incidence of human infection

Gonotrophic cycle and biological WN virus transmission

TRANSMISSION??

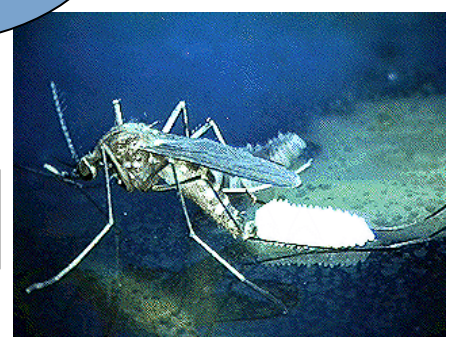
HOST-SEEK

HOST-SEEK



Virus growth

OVIPOSIT



TEMPERATURE

BLOOD FEED

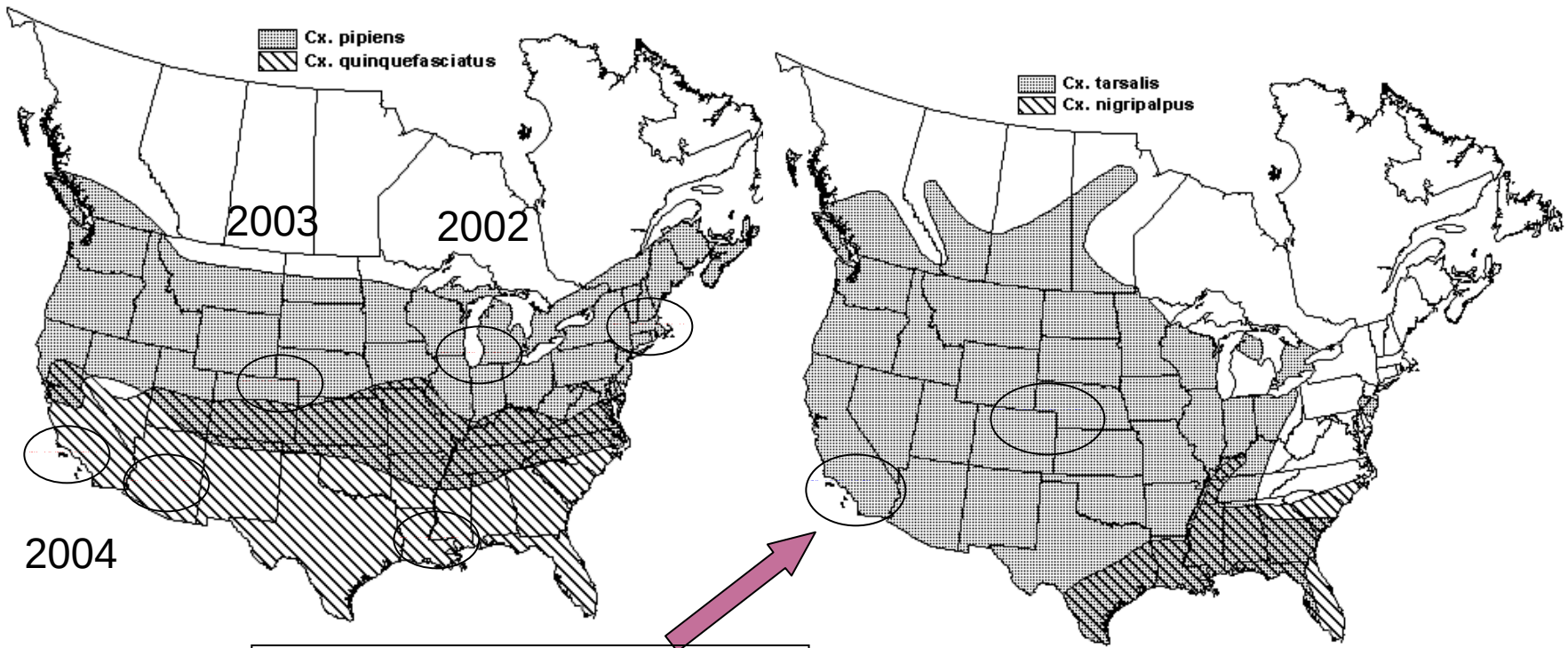
INFECTION?

BLOOD DIGESTION [>3 days]

NA mosquito species WNV positive,ArboNet, 1999-04

Species	WNV pos pools	Species	WNV pos pools	Species	WNV pos pools
Aedes aegypti	7	*Culex coronator*	2	*Ochlerotatus atlanticus*	6
Aedes albopictus	167	*Culex erraticus*	37	*Ochlerotatus c. canadensis*	25
Aedes atropalpus	1	*Culex erythrothorax*	175	*Ochlerotatus cantator*	3
Aedes cinereus	5	*Culex nigripalpus*	123	*Ochlerotatus dorsalis*	2
Aedes sp	13	*Culex pipiens*	3,797	*Ochlerotatus dupreei*	2
Aedes vexans	244	*Culex pipiens complex*	553	*Ochlerotatus fitchii*	2
Anopheles atropos	1	*Culex pipiens-restuans (Mixed)*	2,863	*Ochlerotatus fulvus pallens*	3
Anopheles barberi	5	*Culex quinquefasciatus*	4,186	*Ochlerotatus grossbecki*	1
Anopheles crucians	14	*Culex restuans*	1,484	*Ochlerotatus infirmatus*	1
Anopheles franciscanus	1	*Culex restuans/salinarius*	2	*Ochlerotatus j. japonicus*	69
Anopheles freeborni	7	*Culex salinarius*	586	*Ochlerotatus melanimon*	13
Anopheles hermsi	1	*Culex sp.*	6,728	*Ochlerotatus nigromaculis*	3
Anopheles punctipennis	52	*Culex stigmatosoma*	41	*Ochlerotatus provocans*	1
Anopheles quadrimaculatus s.l.	34	*Culex tarsalis*	2,969	*Ochlerotatus sollicitans*	12
Anopheles quadrimaculatus s.s.	15	*Culex territans*	1	*Ochlerotatus sp.*	1
Anopheles sp.	8	*Culex thriambus*	3	*Ochlerotatus squamiger*	1
Anopheles walkeri	10	*Culiseta impatiens*	1	*Ochlerotatus sticticus*	12
Coquillettidia perturbans	44	*Culiseta inornata*	8	*Ochlerotatus stimulans*	13
Coquillettidia sp.	1	*Culiseta melanura*	123	*Ochlerotatus taeniorhynchus*	20
		Culiseta morsitans	4	*Ochlerotatus triseriatus*	115
		Culiseta sp.	4	*Ochlerotatus trivittatus*	58
		Deinocerites cancer	2	*Orthopodomyia signifera*	6
		Mansonia titillans	1	*Orthopodomyia sp.*	1
				Psorophora ciliata	1
				Psorophora columbiae	35
Totals				*Psorophora ferox*	17
Mosquito species/groups	72			*Psorophora howardii*	2
Positive pools	24,901			*Psorophora sp.*	1
Culex species	93%			*Uranotaenia sapphirina*	10
Cx. pipiens complex	73%			*Other Species / Unknown*	142

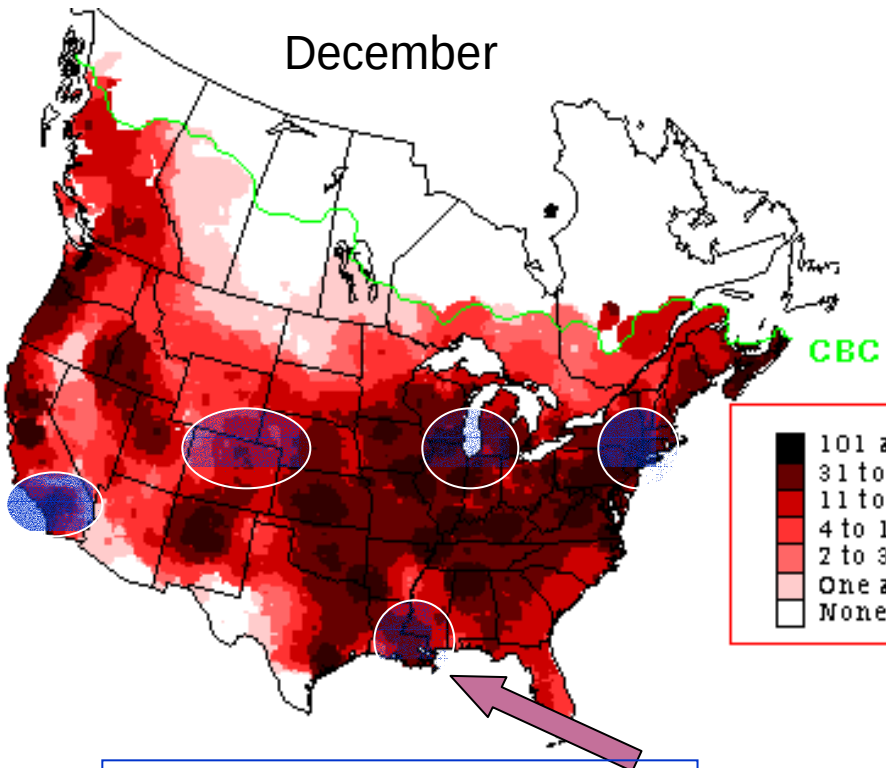
Distribution of major vectors in North America

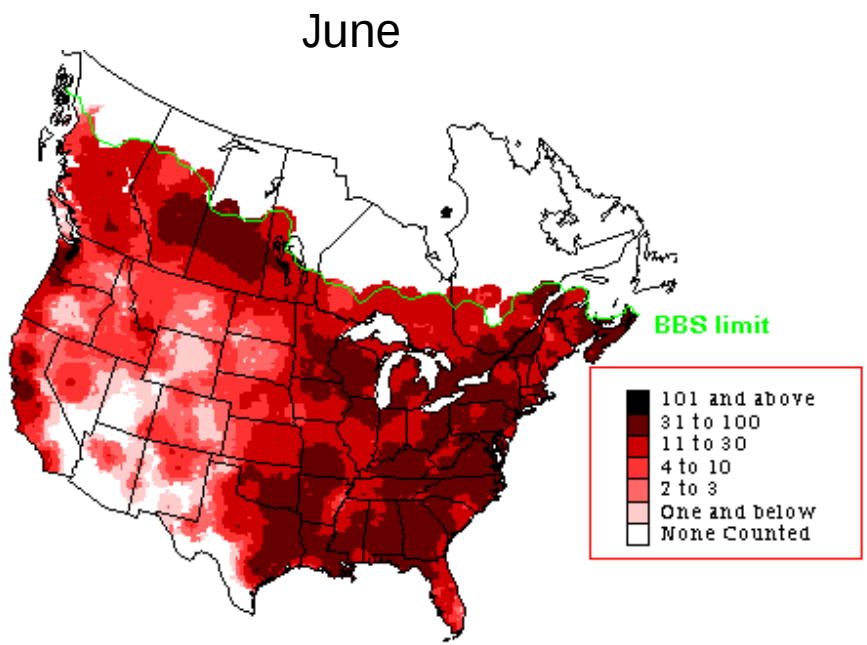


Circles show the locations of the largest epidemics

Modified from Darsie & Ward Mosquitoes of North America

USGS CBC and BBS data showing distribution of AMCOs

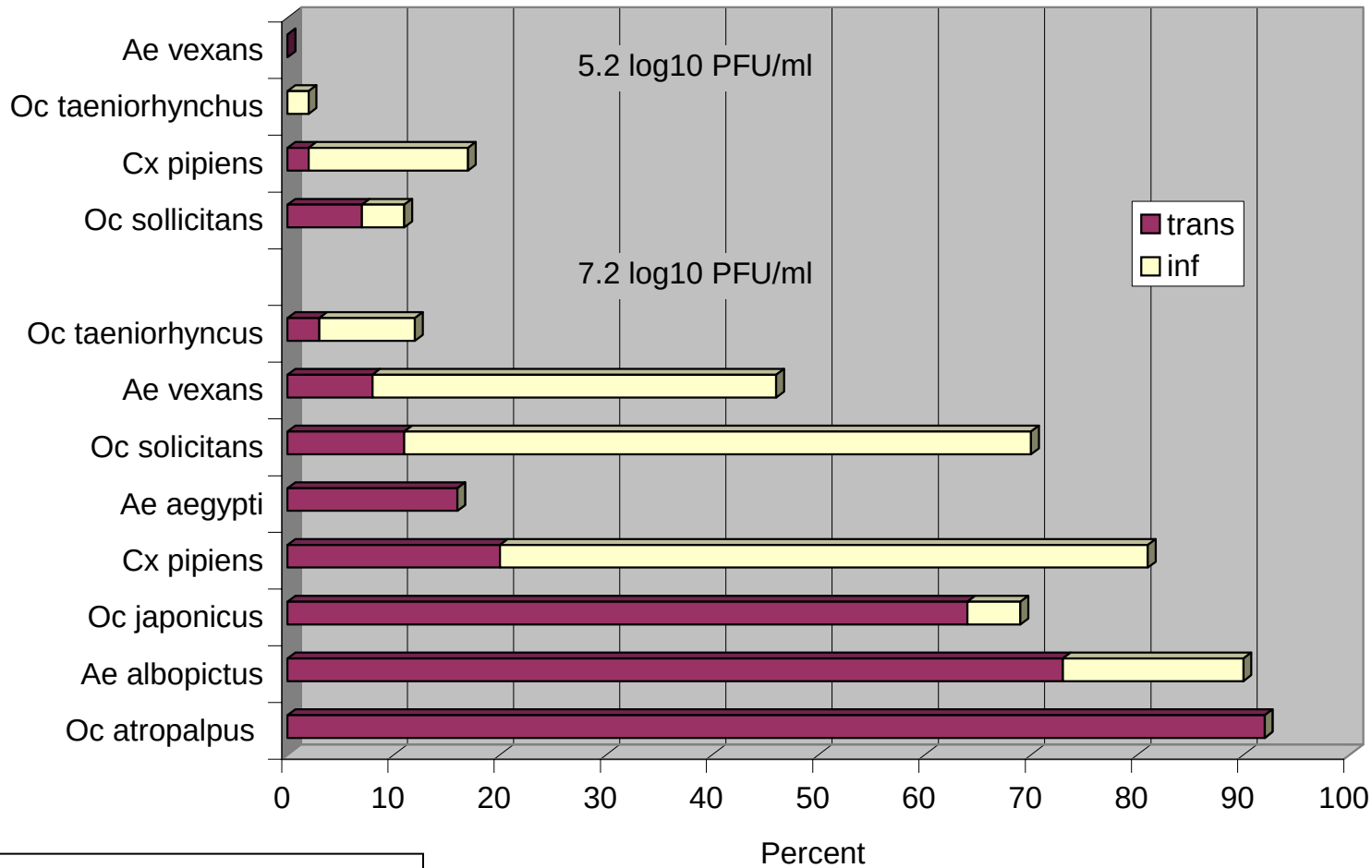




Circles show the locations of the largest epidemics

Copied from USGS website
http://www.mbr-pwrc.usgs.gov/

Vector competence of some NA mosquitoes for WVN after feeding on a viremic chicken



Turell et al. 2001. JME 38: 130

Summary of vector competence characteristics of some eastern NA mosquitoes

TABLE 1. Potential for selected North American mosquitoes to transmit West Nile (WN) virus based on distribution, bionomics, vector competence, virus isolations, and involvement with other arboviruses

Species	Field isolations of WN virus[a]	Other viruses[b]	Host preference	Vector competence for WN virus[c]	Potential to serve as a	
					Enzootic vector[d]	Bridge vector[e]
Aedes albopictus	+	EEE	Opportunistic	++++	+	++++
Ae. vexans	+++	EEE	Mammals	+	0	++
Culex nigripalpus	0	EEE/SLE	Opportunistic	++	++	++
Cx. pipiens	+++++	SLE	Birds	+++	+++++	++
Cx. quinquefasciatus	0	SLE	Birds	+++	++++	++
Cx. restuans	+++	SLE	Birds	++++	+++++	++
Cx. salinarius	+++	EEE/SLE	Opportunistic	++++	+++	++++
Ochlerotatus atropalpus	0	—	Mammals	++++	+	++
Oc. canadensis	0	EEE	Mammals	+	0	+
Oc. cantator	+	—	Mammals	+	0	+
Oc. j. japonicus	+++	—	Opportunistic	++++	+	++++
Oc. sollicitans	0	EEE	Large mammals	++	0	+
Oc. taeniorhynchus	0	EEE	Large mammals	+	0	+
Oc. triseriatus	+++	—	Mammals	+++	0	+++

[a]Relative number of WN virus-positive pools detected. 0 = none; + = one; +++++ = many.
[b]EEE = eastern equine encephalomyelitis virus; SLE = St. Louis encephalitis virus.
[c]Efficiency with which this species is able to transmit WN virus in the laboratory. 0 = incompetent; + = inefficient; ++++ = extremely efficient vector (Turell *et al.*[19,20]; Sardelis & Turell[22]; Dohm, O'Guinn, Sardelis, Turell unpublished data).
[d]Potential for this species to be an enzootic or maintenance vector based on virus isolations from the field, vector competence, feeding behavior, etc. 0 = little to no risk; +++++ = this species may play a major role.
[e]Potential for this species to be an epizootic or bridge vector based on virus isolations from the field, vector competence, feeding behavior, etc. 0 = little to no risk; +++++ = this species may play a major role.

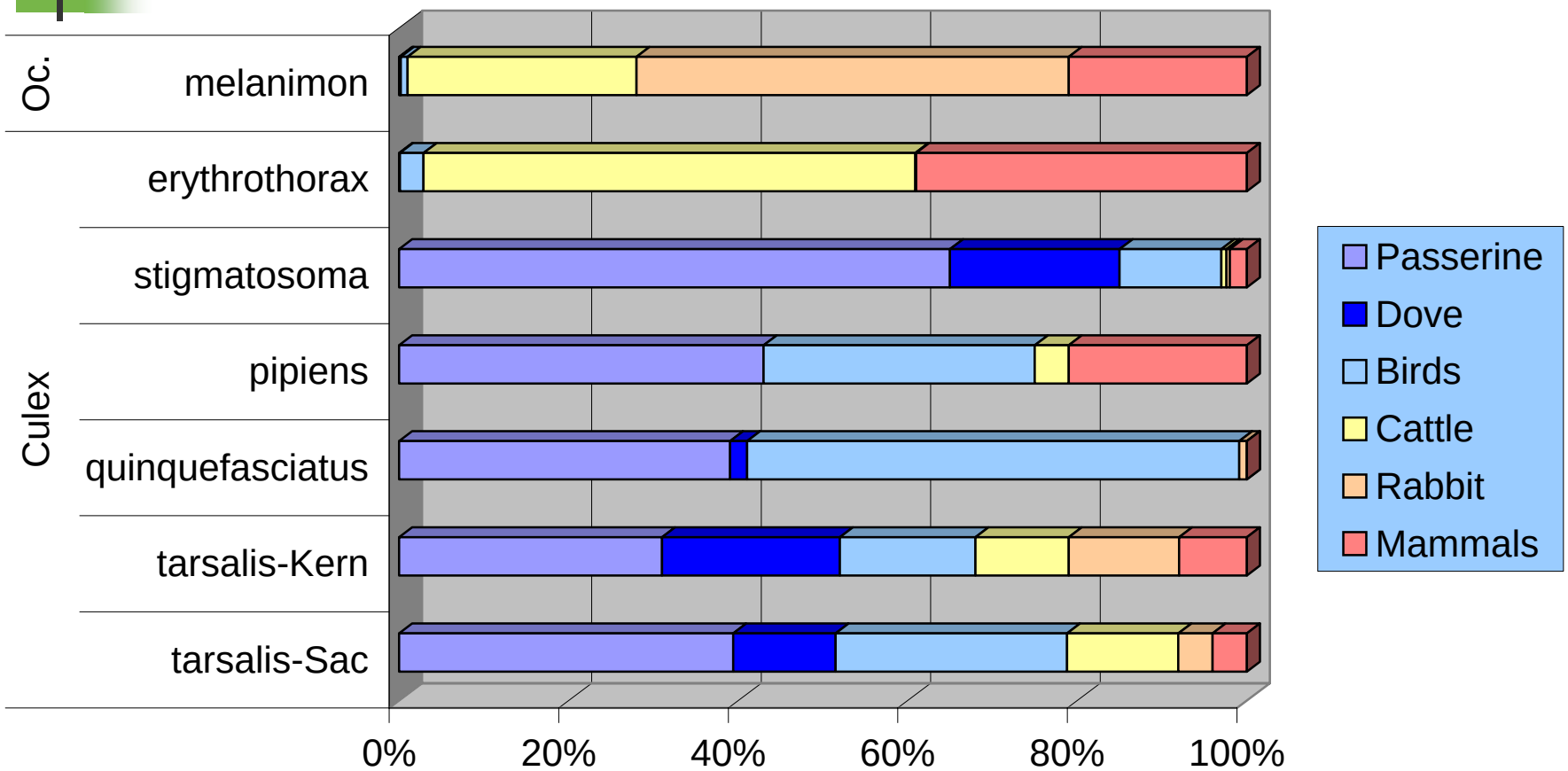
Turell et al. 2001. Ann NY Acad Sci 951: 317

California mosquitoes testing positive for West Nile Virus Jan - Nov 2004

Species	Pools	Mosquitoes	WN Positives	MIR per 1,000
Ae albopictus	7	105	0	0.00
Ae vexans	101	3,490	0	0.00
An franciscanus	6	111	0	0.00
An freeborni	155	5,161	0	0.00
An hermsi	145	4,234	1	0.24
An punctipennis	4	93	0	0.00
Cq perturbans	1	8	0	0.00
Cs incidens	366	9,180	0	0.00
Cs inornata	85	1,494	0	0.00
Cs particeps	22	520	0	0.00
Cx erraticus	4	83	0	0.00
Cx erythrothorax	1,966	88,489	19	0.21
Cx pipiens	1,330	49,021	12	0.24
Cx quinquefasciatus	4,479	154,776	738	4.77
Cx restuans	2	26	0	0.00
Cx stigmatosoma	250	5,549	41	7.39
Cx tarsalis	5,056	202,616	318	1.57
Cx thriambus	27	827	3	3.63
Oc dorsalis	35	1,537	0	0.00
Oc melanimon	433	18,586	2	0.11
Oc nigromaculis	1	13	0	0.00
Oc sierrensis	5	101	0	0.00
Oc squamiger	12	378	1	2.65
Oc taeniorhynchus	27	1,223	0	0.00
Oc tahoensis	2	52	0	0.00
Oc washinoi	78	3,334	0	0.00
Ps columbiae	3	88	0	0.00
Total	14,602	551,095	1,135	2.06

Data from Calif Encephalitis Virus Surv Prog; summary by CM Barker

Host selection patterns of some California mosquitoes



Data from: Reeves. 1990. Epidemiology and Control of Mosquito-borne Arboviruses in California, 1943-1987. Calif. Mosq. Vector Control Assoc.

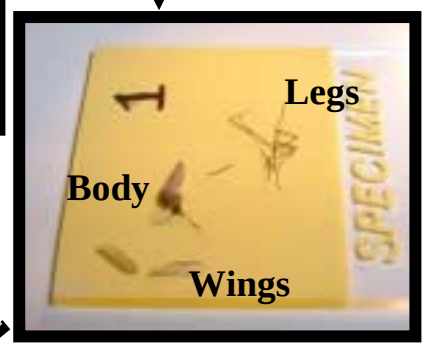
Vector Competence Methods

1 Insectary at 24±2°C
Adults aged 4-6 days

2 Fed on blood with known dose of virus

Kept at 26°C
For 2 wks

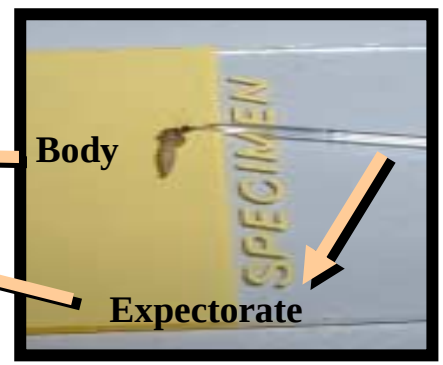
3



4

Legs

-70°C



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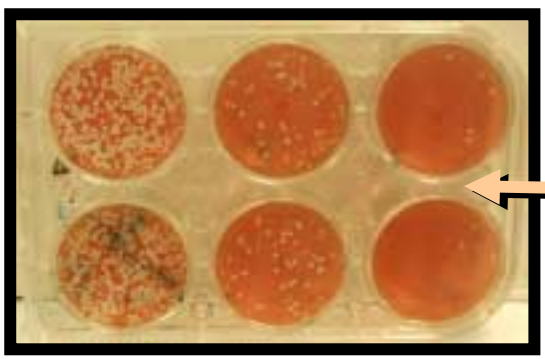
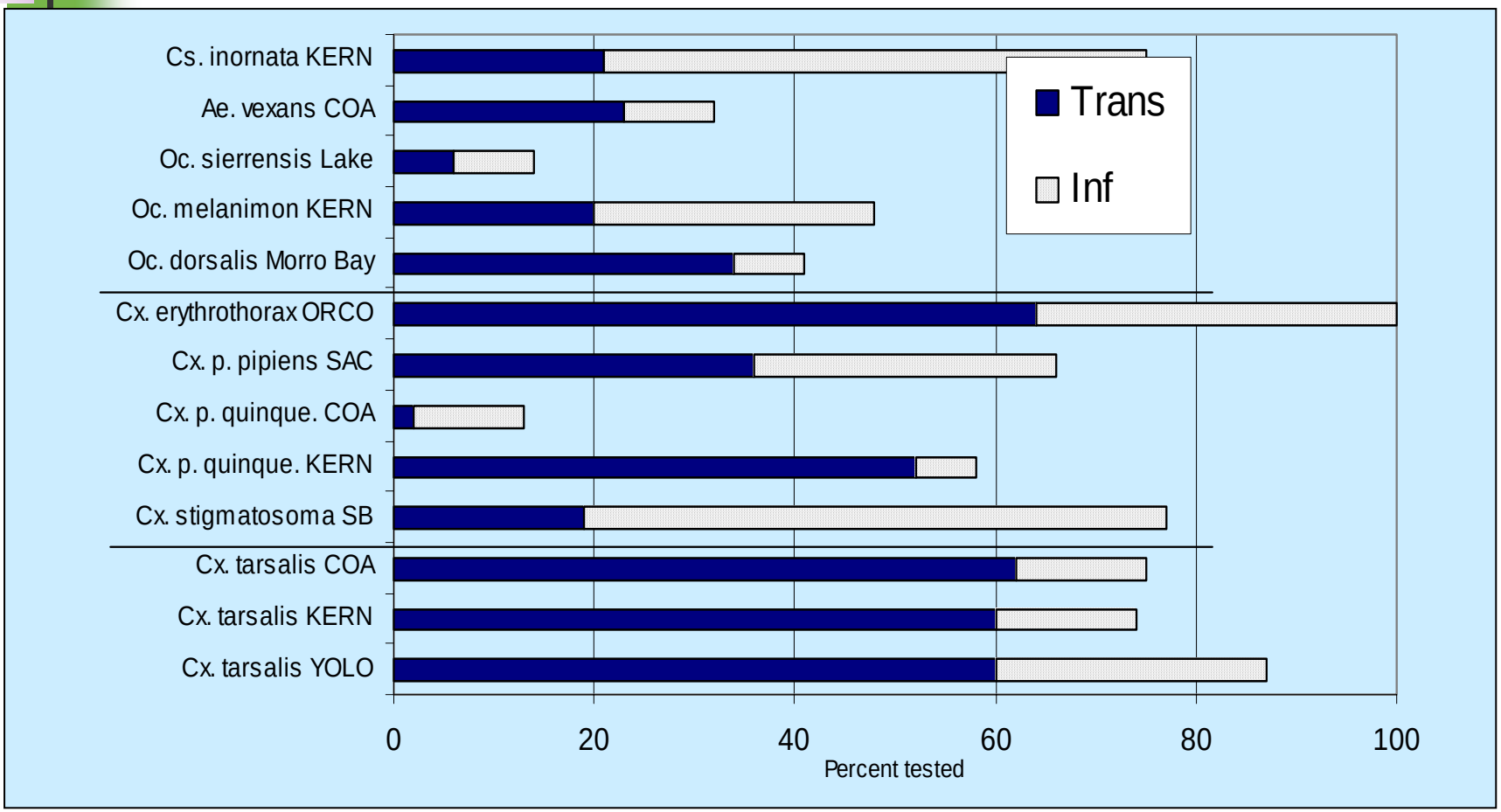


6

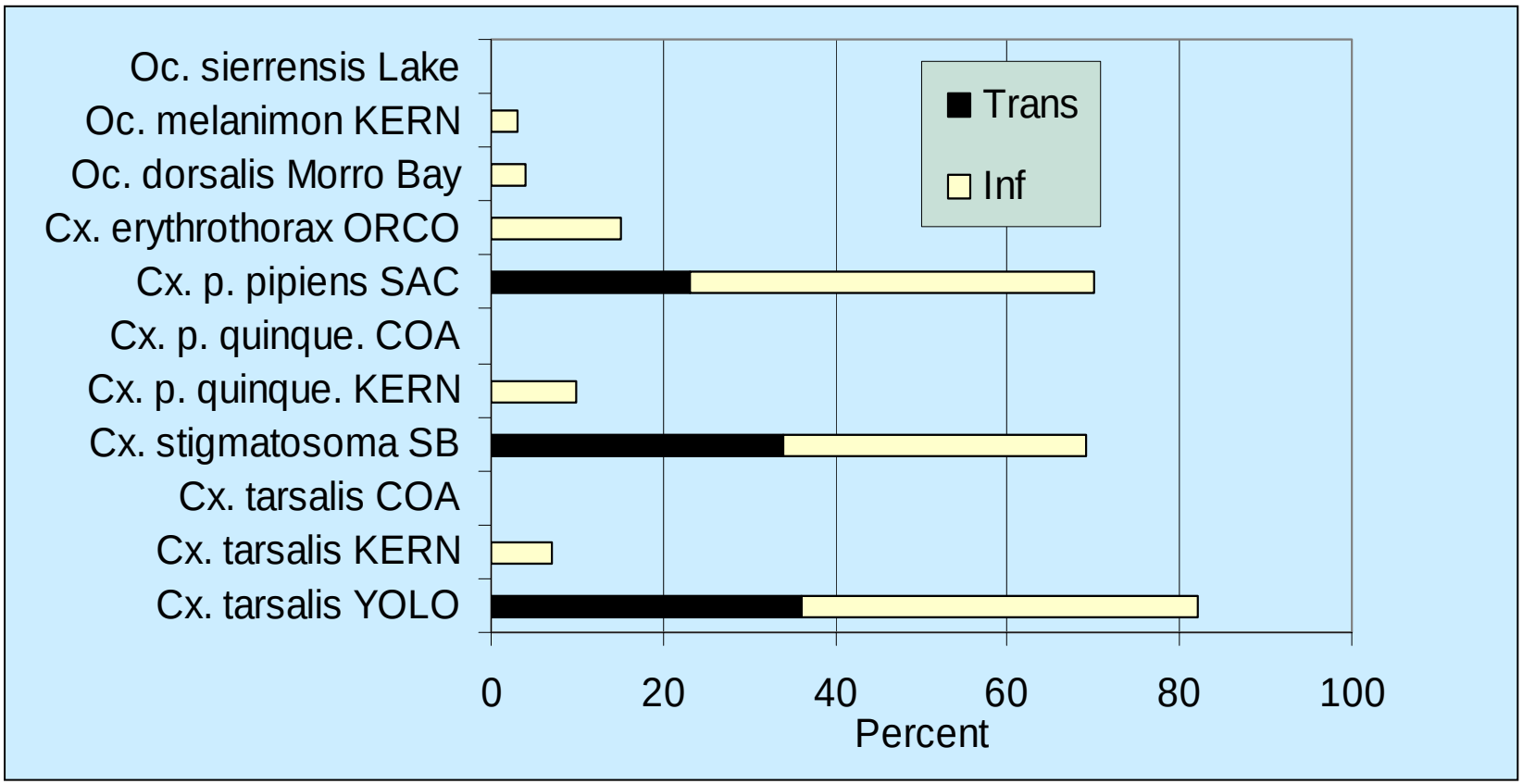
Plaque Assay at 0, -2 and –4 Dilutions

Vector competence of California mosquitoes for WNV [7 $\log_{10}$ PFU/ml]



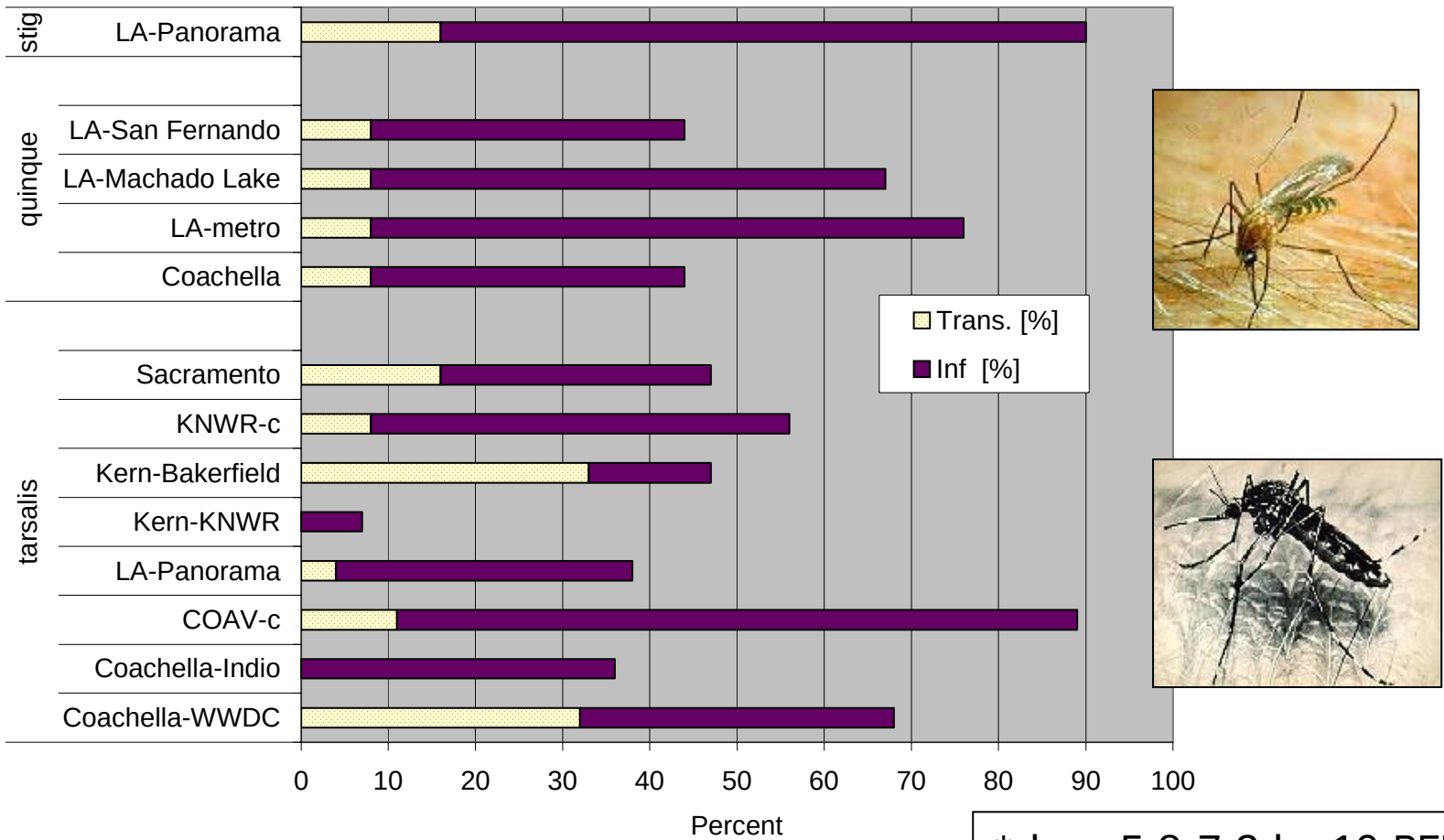
Goddard et al. 2002 EID 8: 1385

Vector competence of California mosquitoes for WNV [dose = 4.9 $\log_{10}$ pfu/ml]



Goddard et al. EID 8 [12]

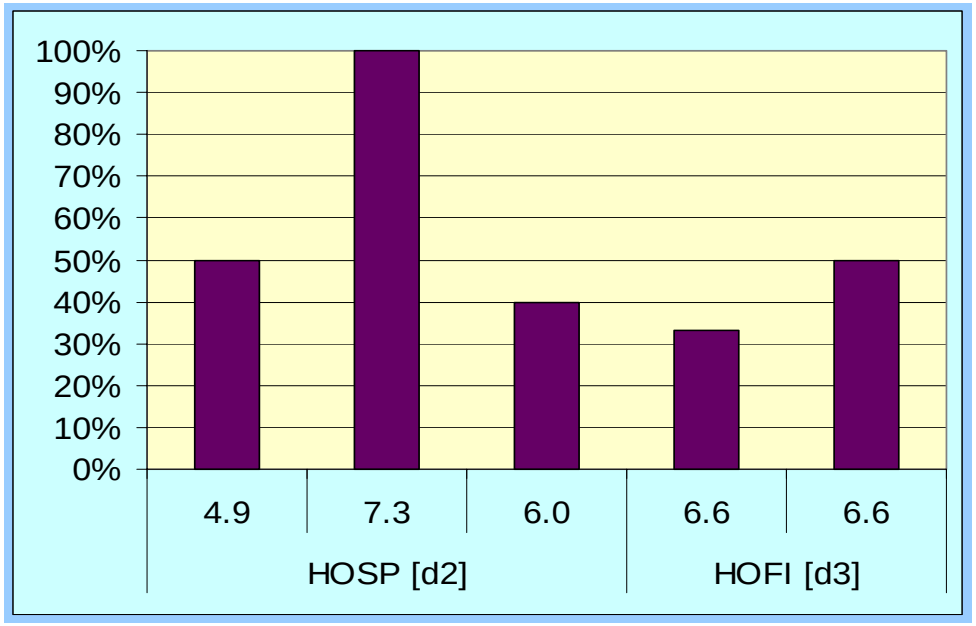
Infection and transmission of WNV by *Culex,* virus presented on pledgets*, Southern California, 2003



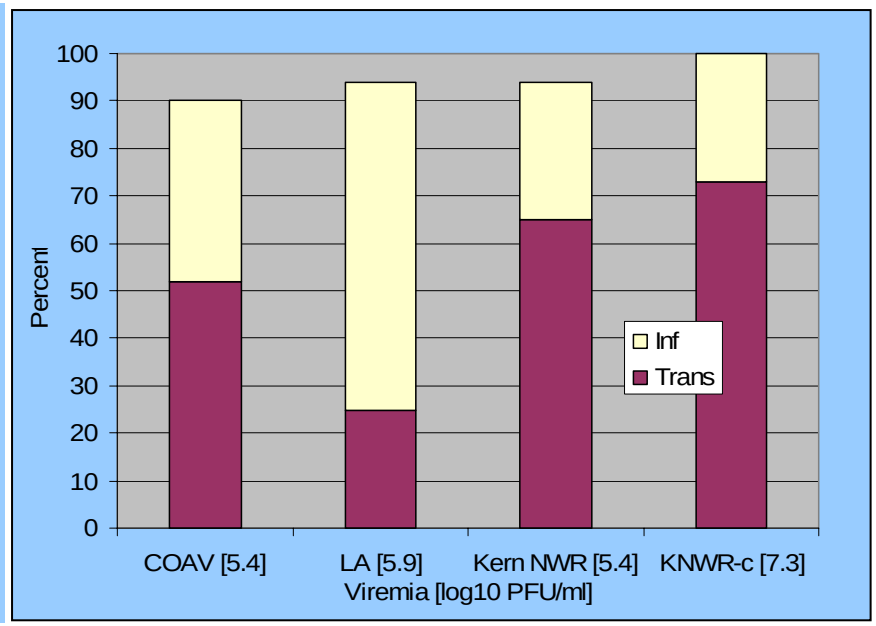
*dose 5.8-7.3 log10 PFU/ml

Reisen et al. 2005 JME [in press]

Percent of *Cx. tarsalis* infected and transmitting after feeding on adult House sparrows or House finches infected with West Nile virus

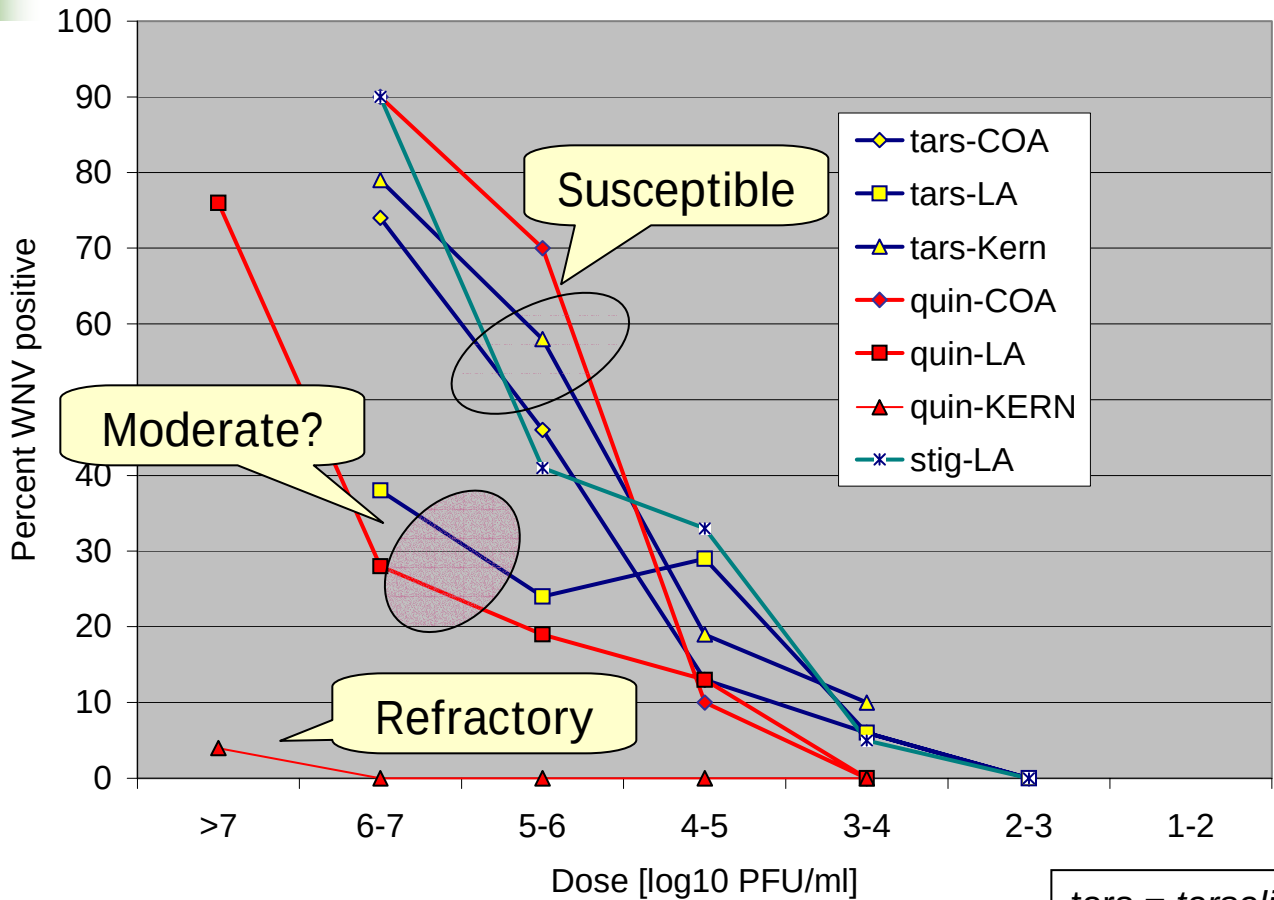


KNWR colony: % infected



Field populations: % infected and transmitting after feeding on House finches with different viremias

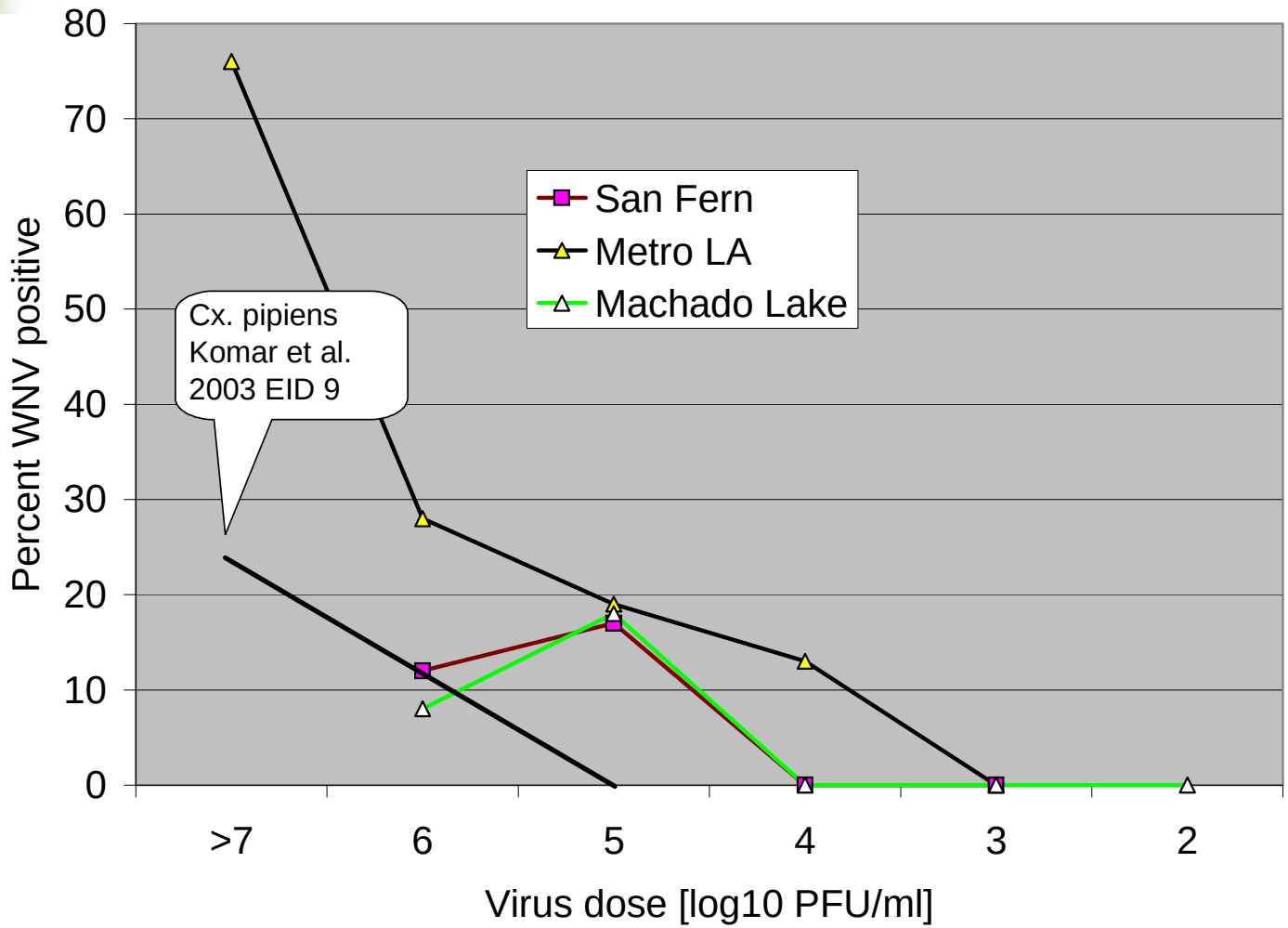
Culex WNV vector competence: Dose response of infection



tars = *tarsalis*
quin = *pipiens quinquefasciatus*
stig = *stigmatosoma*

Reisen et al. 2005 JME [in press]

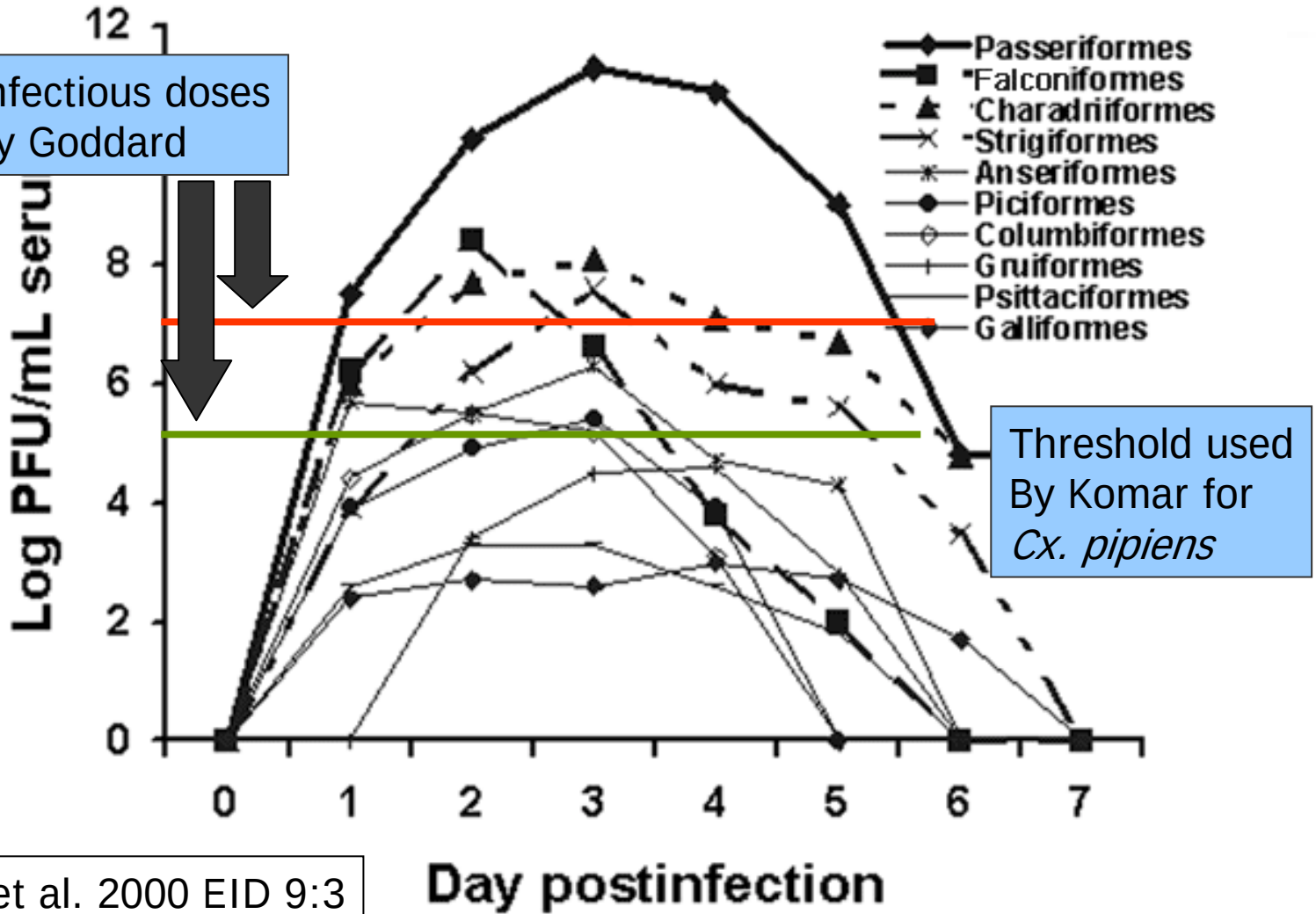
LA *Cx. p quinquefasciatus* WNV vector competence: Dose response



Avian host competence

Avian Viremia Response

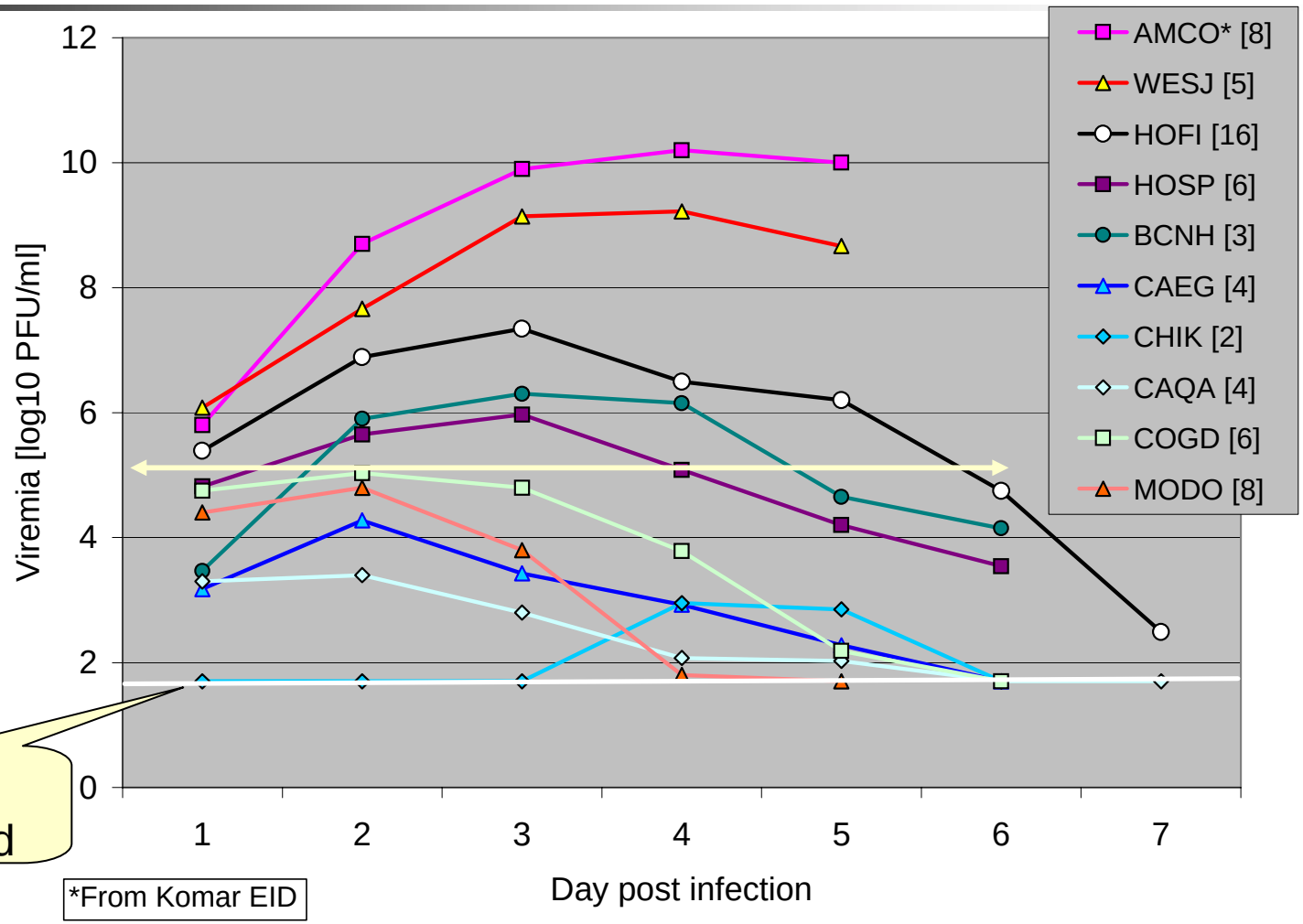
WNV infectious doses used by Goddard



Threshold used By Komar for *Cx. pipiens*

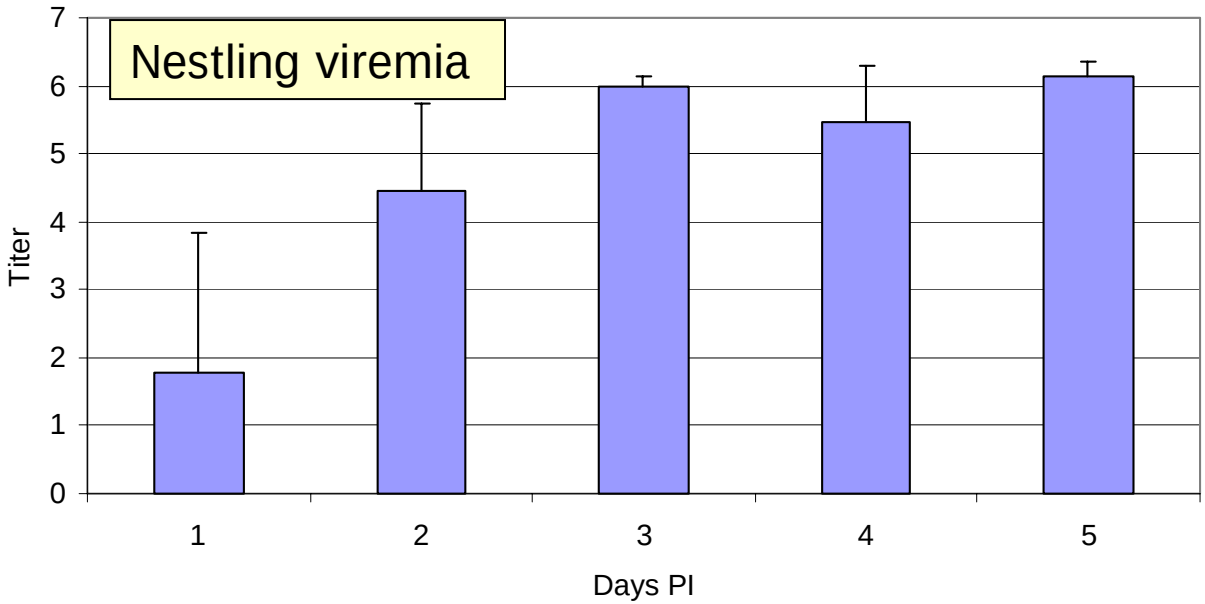
Komar et al. 2000 EID 9:3

Host competence of some California birds for WNV

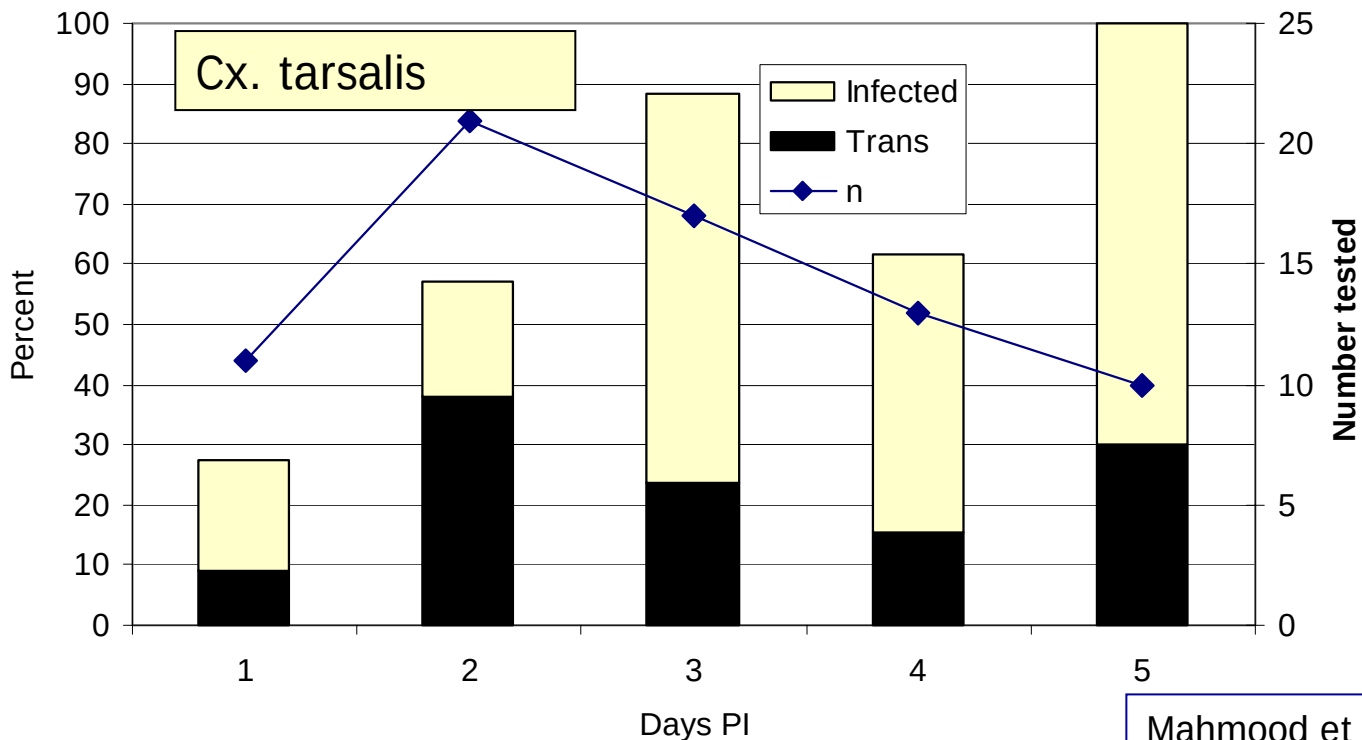


Assay threshold

*From Komar EID

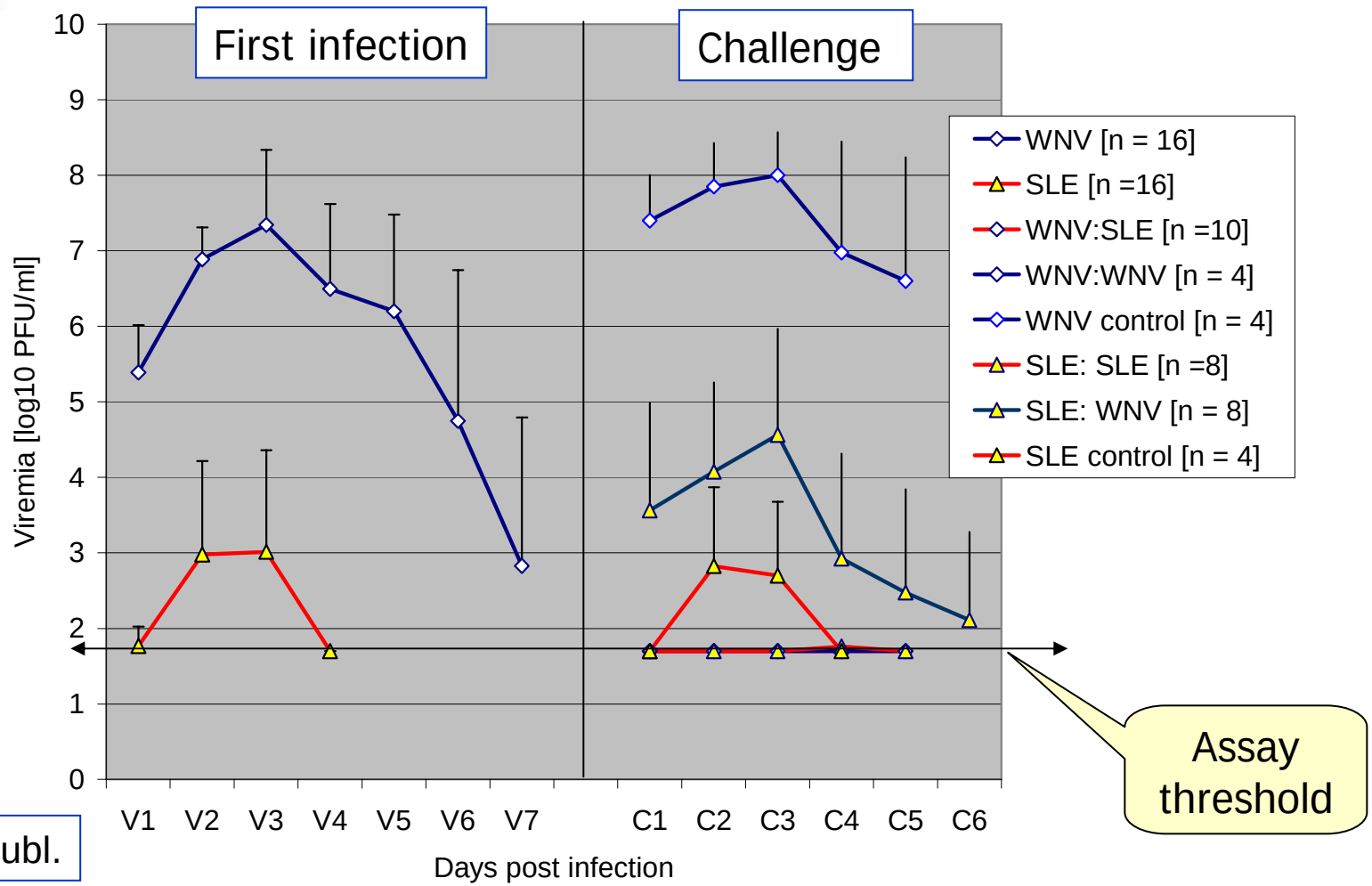


Nestling MODO: SLEV viremia response and competence of *Cx. tarsalis*



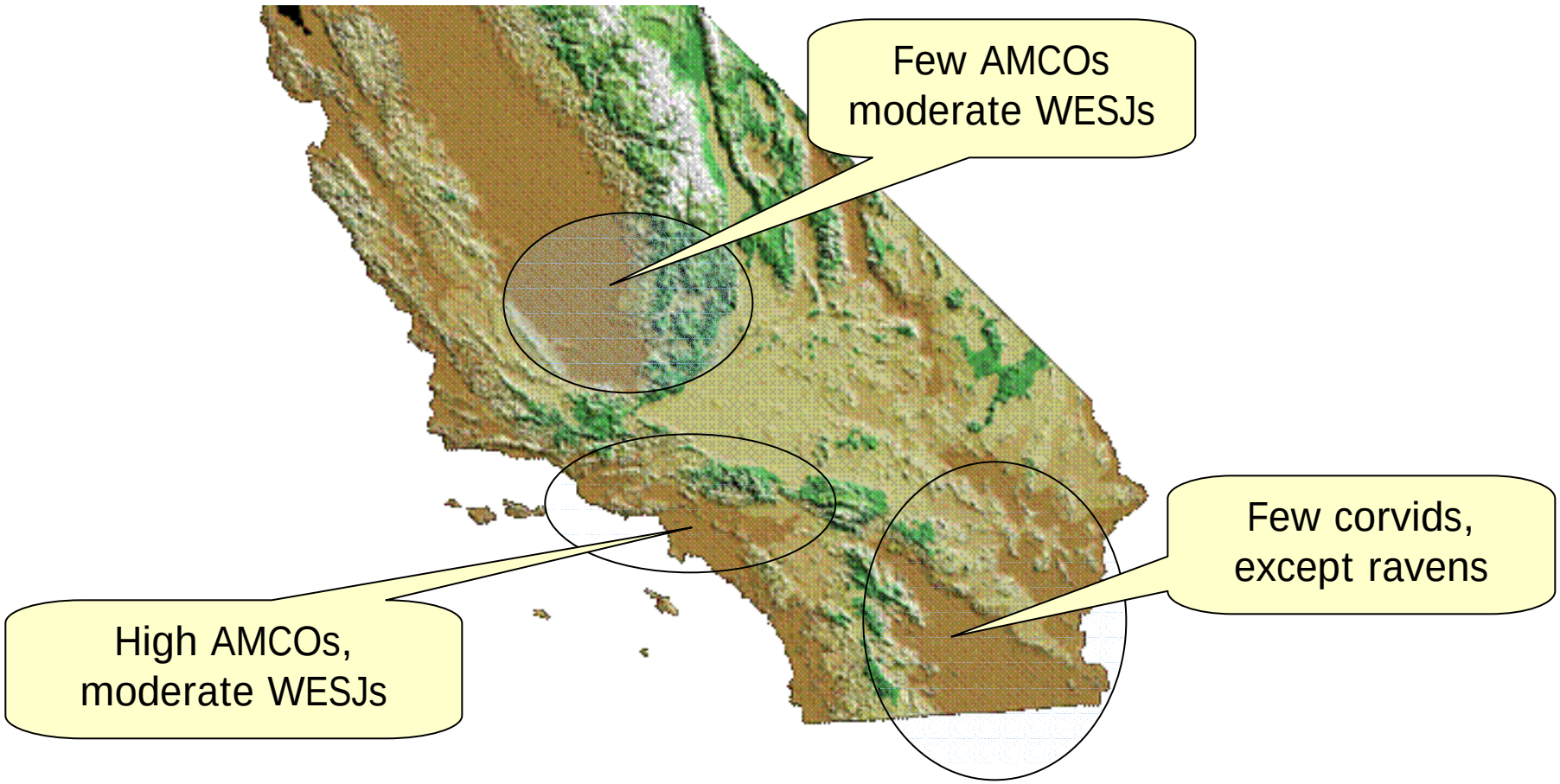
Mahmood et al. 2004. JME 41: 965

Acquired cross-immunity protects House finches and lowers viremia titers

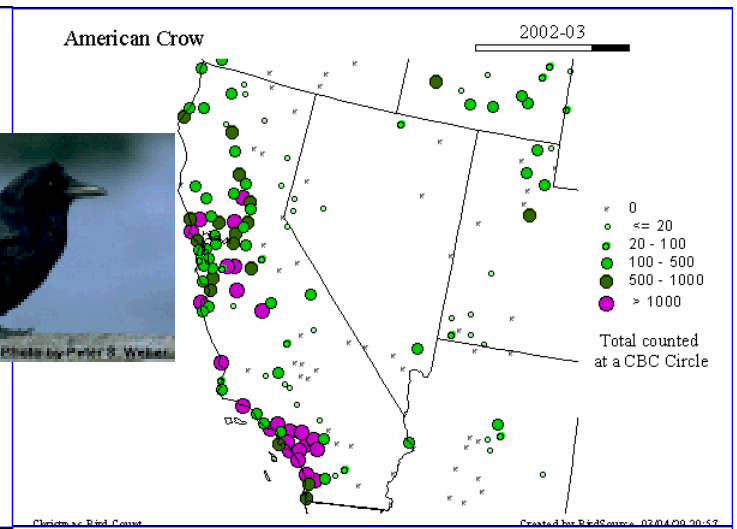


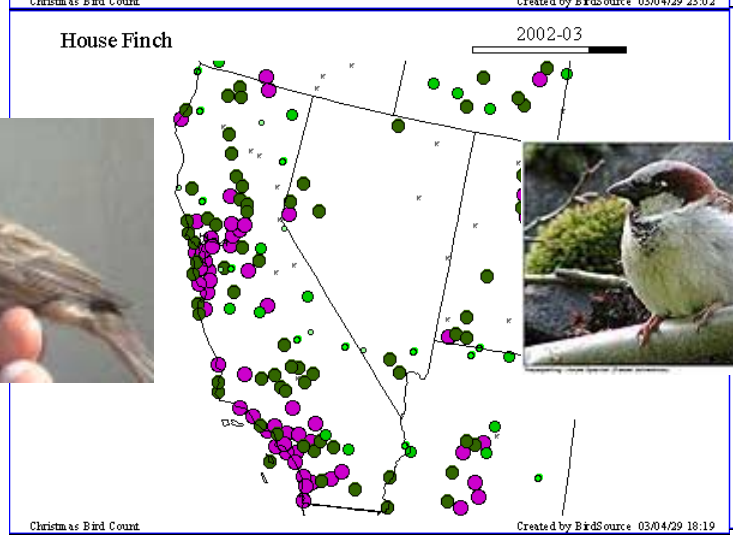
Reisen unpubl.

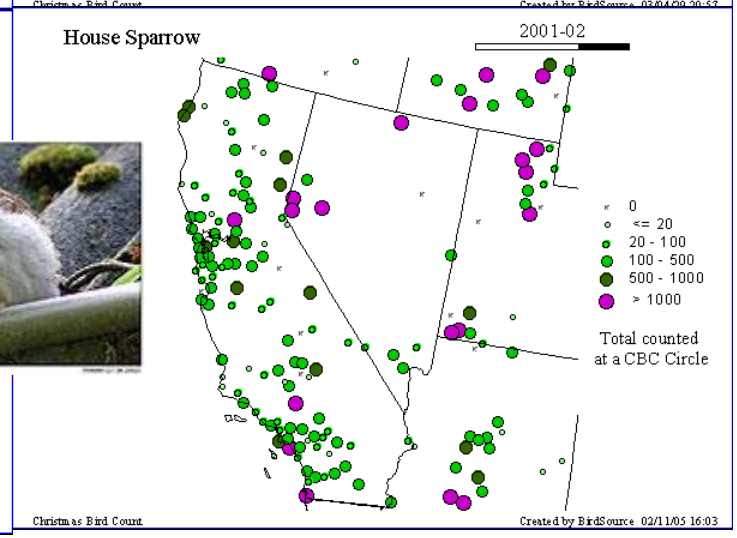
Natural experiment:
3 areas in southern California with different densities of corvids



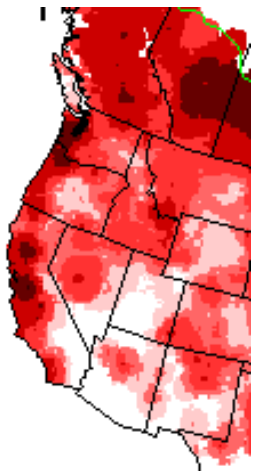
Distribution of most effective hosts in California based on CBC data



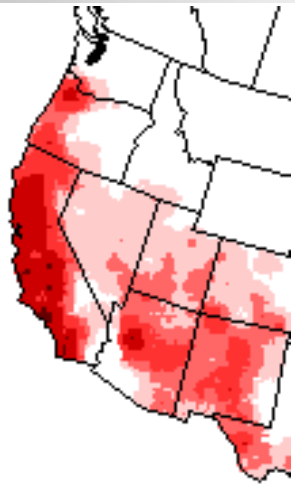




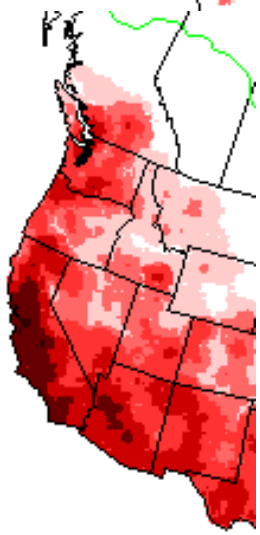
Distribution of most effective hosts in California based on BBC data [http://www.mbr-pwrc.usgs.gov/]



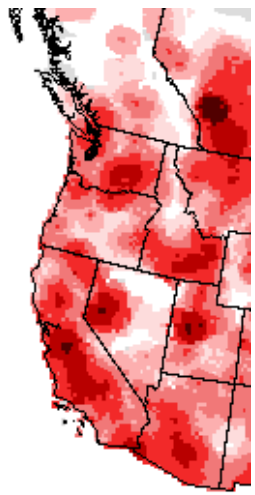
American crow



Western scrub jay



House finch



House sparrow

Infection rates for *Culex* species tested from southern California, May – Sep 2004

Culex species	Pools tested	Total mosquitoes tested	WNV positives	Infection Rate per 1,000	Lower Limit	Upper Limit
		Coachella Valley				
quinquefasciatus	132	3,132	4	1.29	0.42	3.08
tarsalis	424	15,137	63	4.56	3.54	5.79
erythrothorax	15	715	0			
		Kern County				
quinquefasciatus	406	15,325	86	6.42	5.17	7.89
tarsalis	410	16,893	85	5.72	4.60	7.04
		Los Angeles				
erythrothorax	263	12575	3	0.24	0.06	0.65
quinquefasciatus	1029	38,420	270	8.09	7.18	9.09
tarsalis	135	4,411	18	4.34	2.68	6.70
stigmatosoma	37	613	6	10.22	4.32	20.89

MLE Calculated from Biggerstaff: http://www.cdc.gov/ncidod/dvbid/westnile/software.htm

Incidence of WNV cases [CNS + fever] among human populations, California 2004

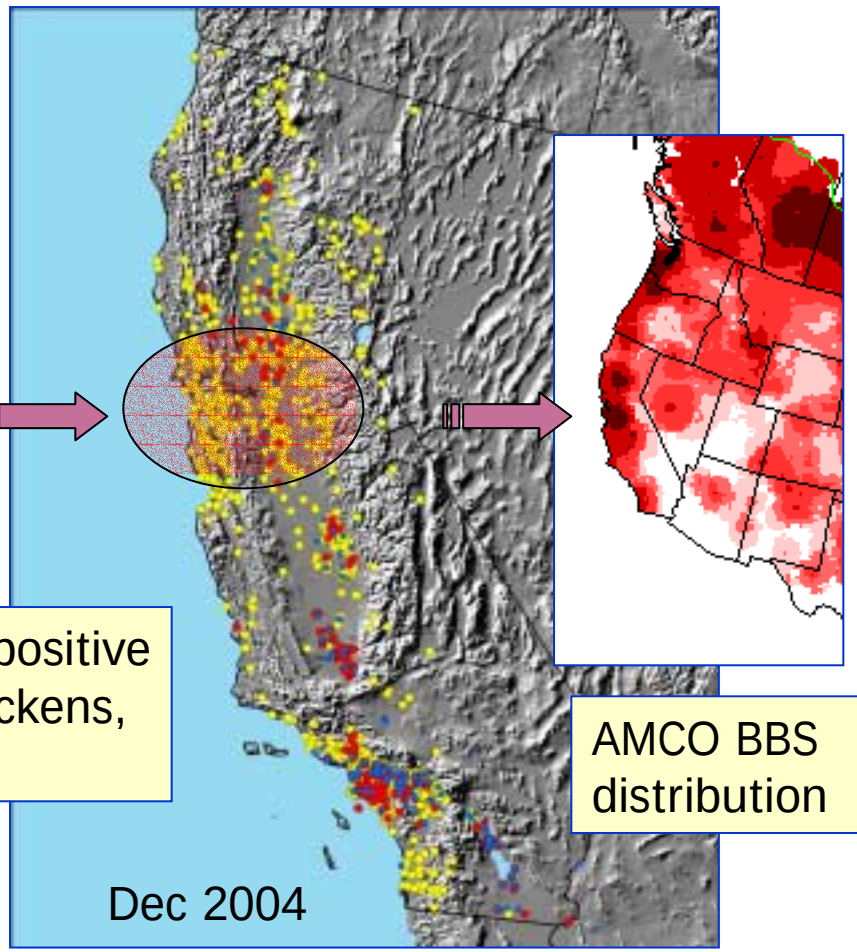
Area	Population size per 100,000[a]	WNV cases	Incidence per 100,000
California	33,871	808	2.39
Coachella Valley	336	7	2.08
Los Angeles County	9,519	322	3.38
Kern County	662	59	8.91

a Based on 2,000 census figures

Data from: http://westnile.ca.gov/2004_maps.htm

What will happen in 2005?

Possible epicenter in Central California



WNV epicenter?

Distribution of positive
Dead birds, chickens,
Mosquito pools

AMCO BBS
distribution