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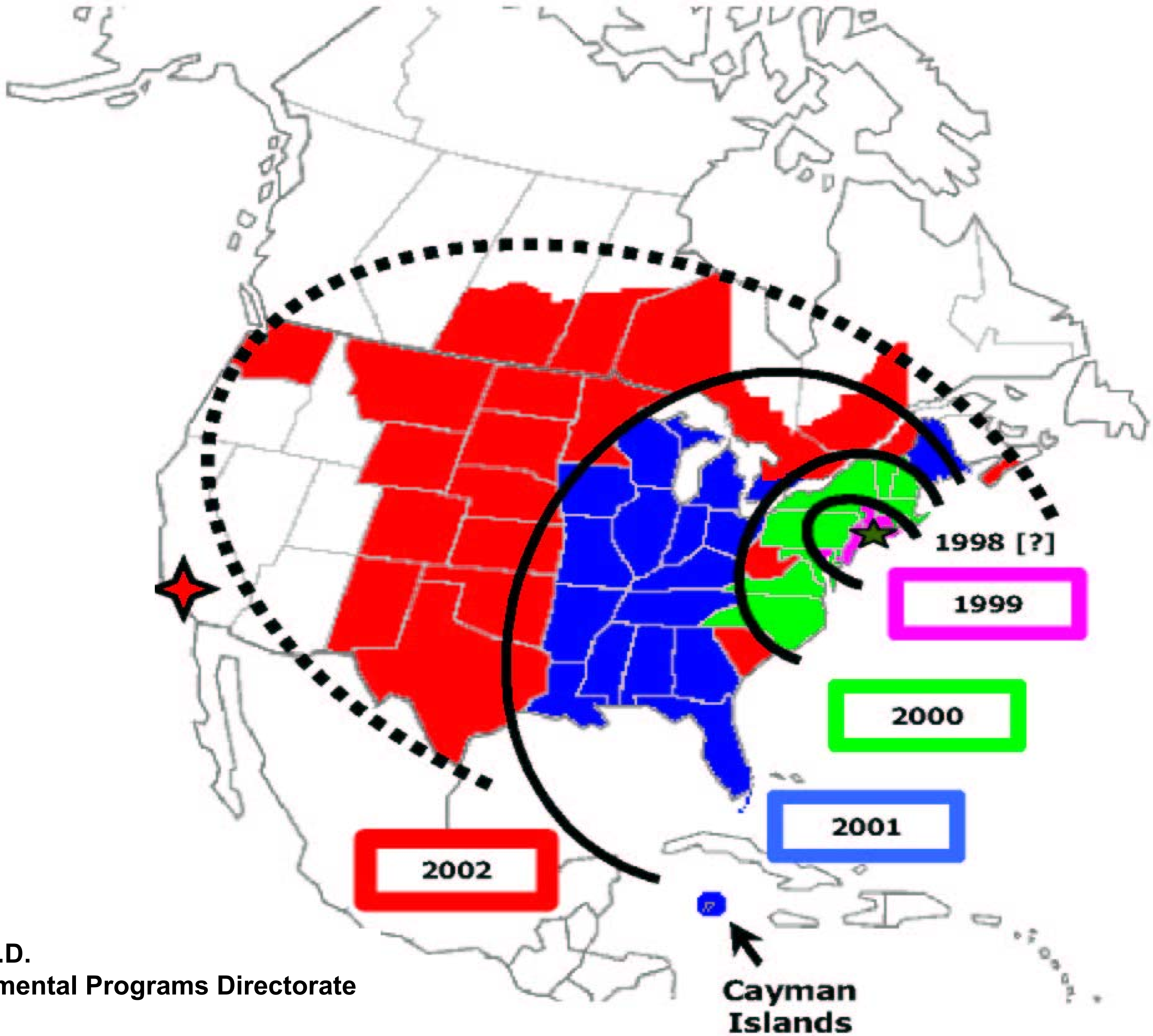
Potential for North American Mosquitoes to transmit West Nile Virus

Michael J. Turell, Michael R. Sardelis, David J. Dohm, and Monica L. O'Guinn

U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, Maryland

WEST NILE VIRUS IN NORTH AMERICA

[From CDC and Heath Canada data as of 25 Oct 2002]



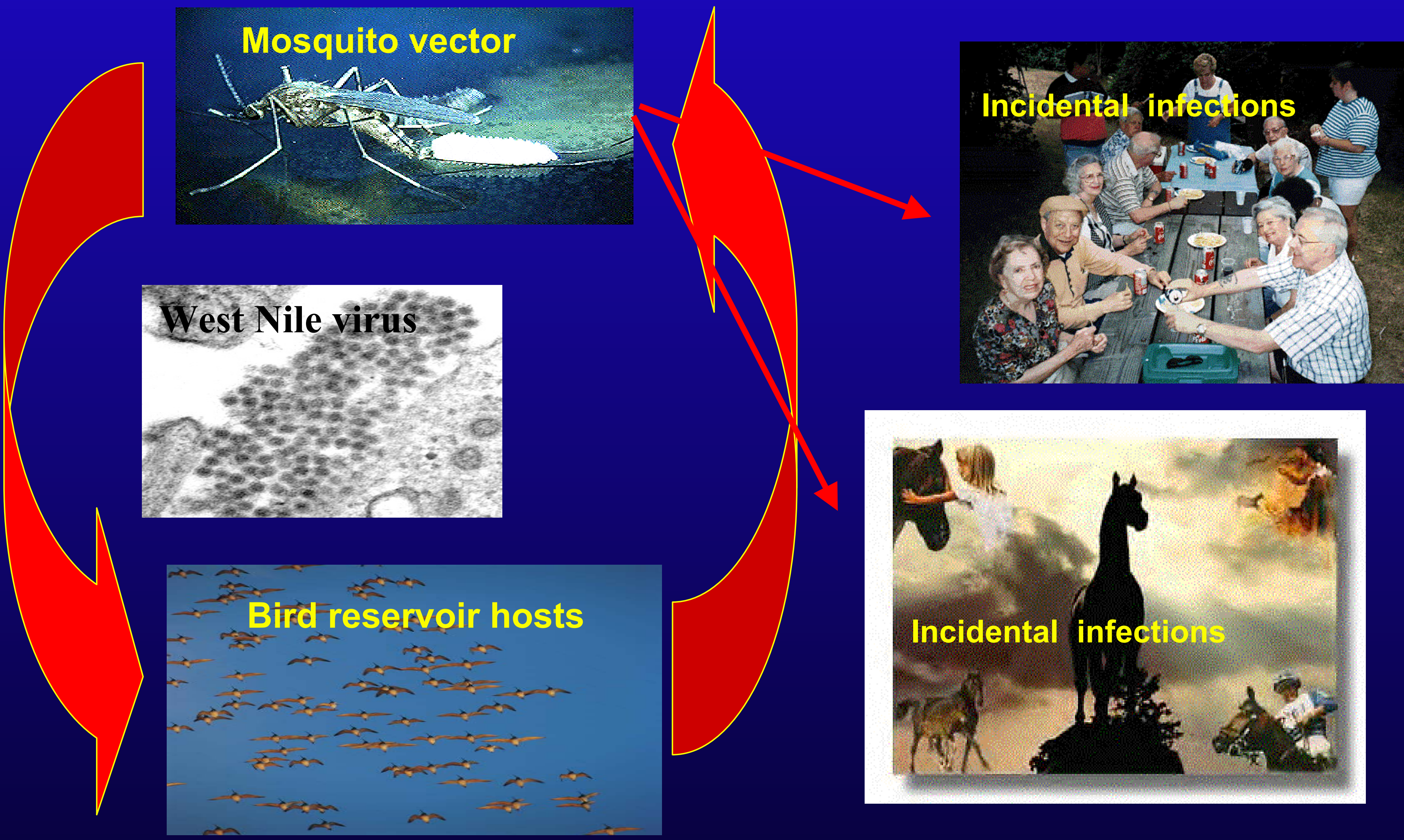
Joseph Dudley, Ph.D.
J.S. Army Environmental Programs Directorate
Versar, Inc.

West Nile Viral Activity in the Continental US

Year	Human	Horses	States
1999	62	25	4
2000	31	63	12
2001	66	733	27
2002	2,741	14,901	44

Overview of West Nile virus

• Transmission Cycle



WHY SHOULD WE STUDY THE DISEASE TRANSMISSION CYCLE?

A BETTER UNDERSTAND OF THE NATURAL TRANSMISSION CYCLE ALLOWS US TO:

- learn which vectors and vertebrates are involved in the transmission cycle
- predict when disease outbreaks may occur
- prevent these outbreaks by:
  - controlling the vector
  - controlling the reservoir host
  - vaccinating the susceptible population

WHAT DO WE KNOW ABOUT POTENTIAL VECTORS IN NORTH AMERICA

DETECTION OF WEST NILE VIRUS IN FIELD-COLLECTED MOSQUITOES

Field isolates of WNV from NA mosquitoes

Culex pipiens
Culex restuans
Culex nigripalpus
Culex quinquefasciatus
Culex salinarius
Culex tarsalis
Culex territans

Field isolates of WNV from NA mosquitoes

Oc. canadensis
Oc. cantator
Oc. japonicus
Oc. sollicitans
Oc. triseriatus
Oc. trivittatus

Ae. aegypti
Ae. albopictus
Ae. cinereus
Ae. vexans

Field isolates of WNV from NA mosquitoes

An. punctipennis
An. quadrimaculatus

Ps. columbiae
Ps. ciliata
Ps. ferox

Or. signifera

Cq. perturbans

Cx. (Dei.) cancer

Cs. inornata
Cs. melanura

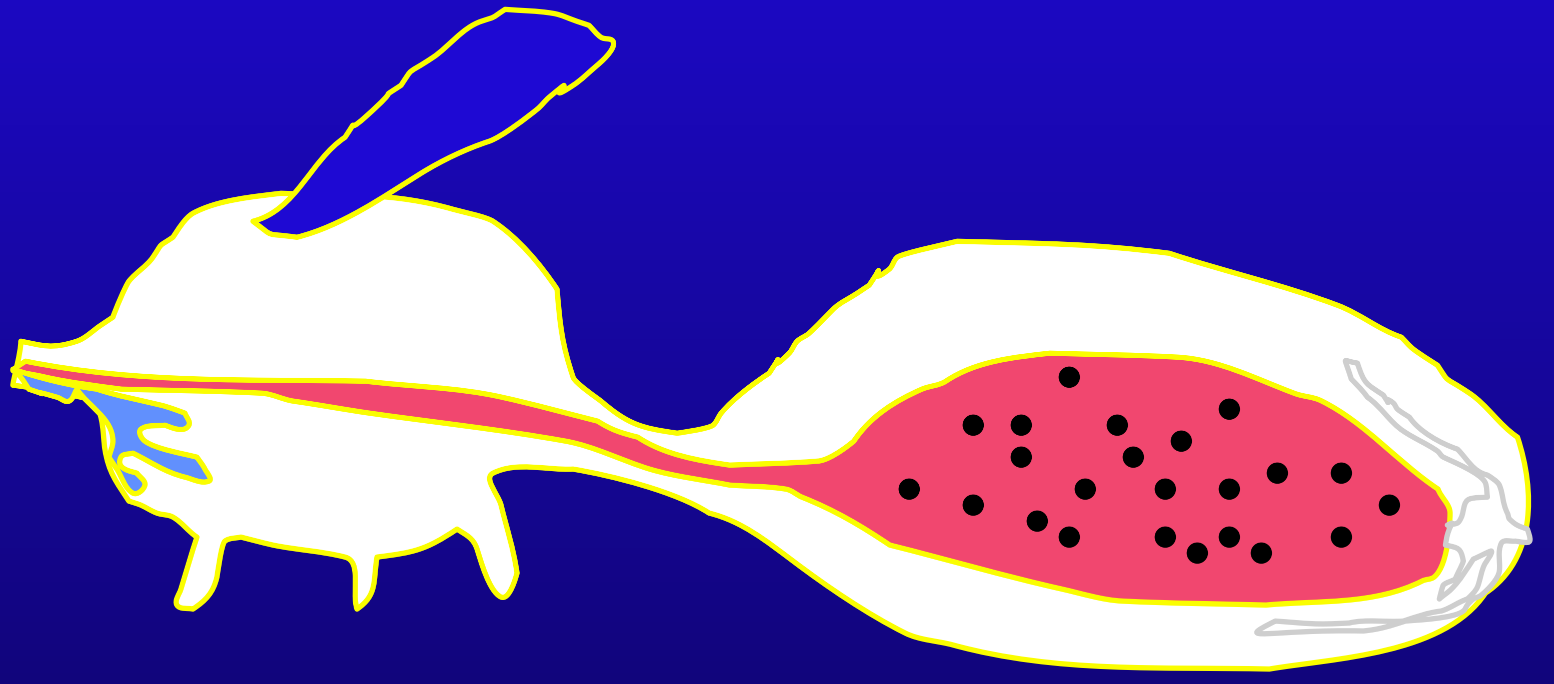
Ur. sapphirina

Vector Incrimination

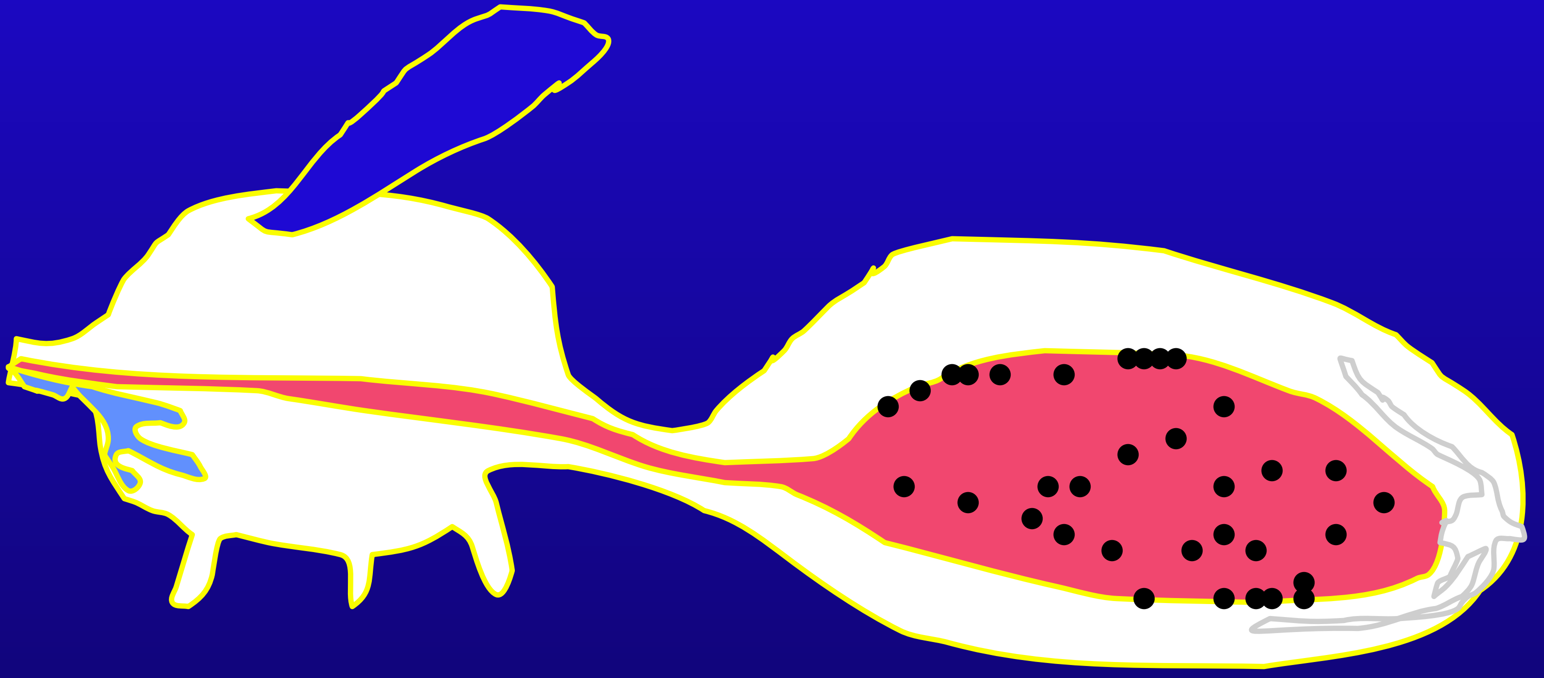
Criteria for Vector Incrimination

- Repeated isolations of virus from field-collected individuals of that species
- Susceptibility of the arthropod to infection in the laboratory
- Ability of the arthropod to transmit the virus in the laboratory
- Association in nature between the arthropod and naturally infected vertebrate hosts
- A temporal association between the arthropod’s activity and virus transmission

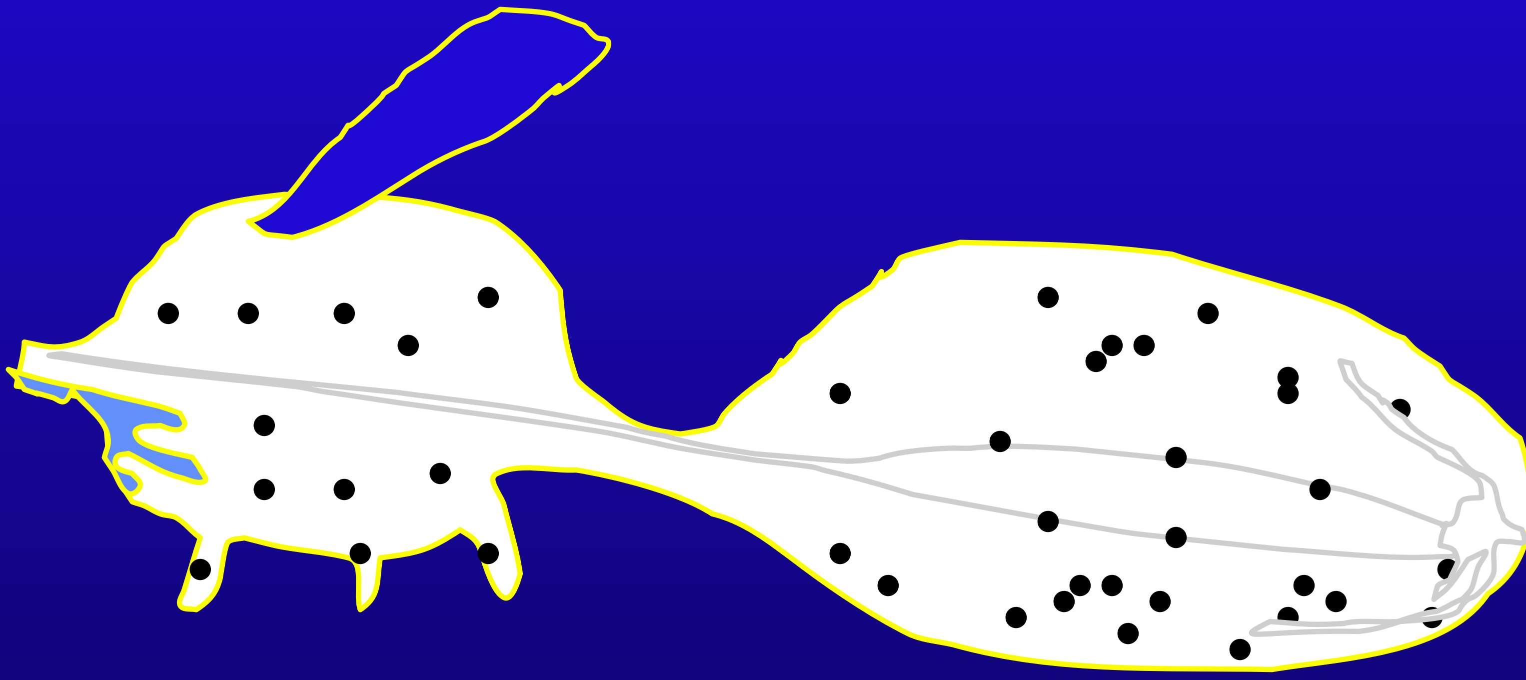
Vector Competence



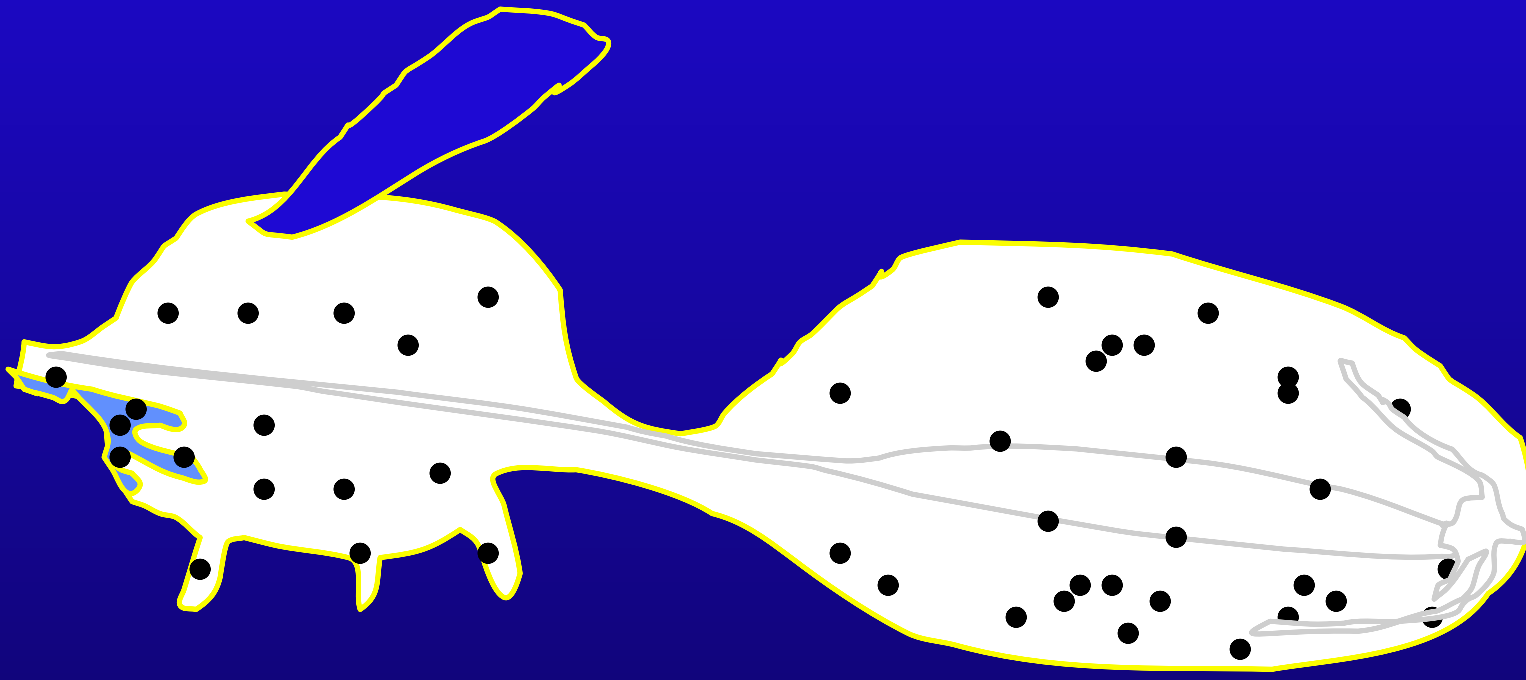
Virus in the blood meal, but mosquito not infected



Mosquito infected, but limited to midgut



Virus disseminated to hemocoel, but salivary glands not infected



Salivary glands infected, ready to transmit by bite

Vector competence NA mosquitoes for WNV

STUDY PROCEDURE

ALLOW MOSQUITOES TO FEED
ON INFECTED CHICKEN

ENGORGED
(Hold 12-14 d)

REFEED

TRITURATE
(Legs + Bodies)

ASSAY FOR VIRUS

UNENGORGED
(Inoculate for
transmission study)

Potential vectors of West Nile virus

based on laboratory vector competence studies

Efficient	Moderate	Inefficient
Ae. albopictus	*Ae. aegypti*	*Ps. ferox*
	Ae. vexans	
Cx. salinarius		*Cq. perturbans*
Cx. tarsalis	*Cx. nigripalpus*	
	Cx. pipiens	*Oc. canadensis*
Oc. atropalpus	*Cx. quinquefasciatus*	*Oc. cantator*
Oc. j. japonicus	*Cx. restuans*	*Oc. sollicitans*
		Oc. taeniorhynchus
	Oc. triseriatus	

Infection and dissemination rates for mosquitoes that ingested $10^{7.0 \pm 0.5}$ PFU/ml of West Nile virus

Species	Number tested	Infection rate (%)	Dissem. rate (%)
Ae. vexans	75	44	17
Cx. nigripalpus	127	84	12
Cx. pipiens	95	81	23
Cx. tarsalis	71	96	86
Oc. triseriatus	28	32	25
Ps. ferox	24	33	0

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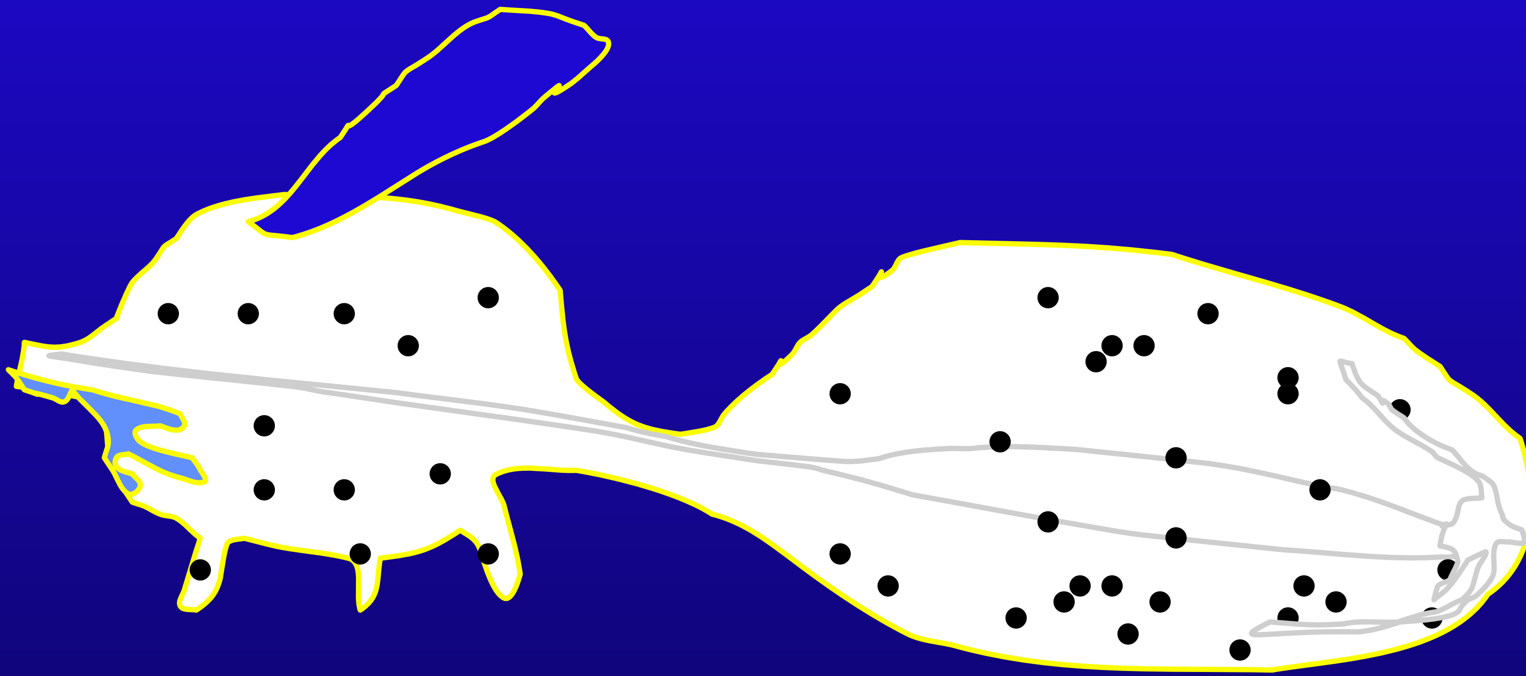

Virus disseminated to hemocoel, but salivary glands not infected

Transmission rates for mosquitoes with a disseminated infection with West Nile virus

Species	Number fed	Number trans.	Trans. rate
Ae. vexans	16	15	94
Cx. nigripalpus	15	13	87
Cx. tarsalis	6	6	100
Cq. perturbans	17	4	24
Oc. triseriatus	3	2	67
Ps. ferox	4	0	0

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Transmission rates for mosquitoes with a disseminated infection with of West Nile virus

Species	Number fed	Number trans.	Trans. rate
Ae./Oc. spp.	88	80	91
Cx. (Cul.) spp.	75	63	84
Cq. perturbans	17	4	24
Ps. ferox	4	0	0

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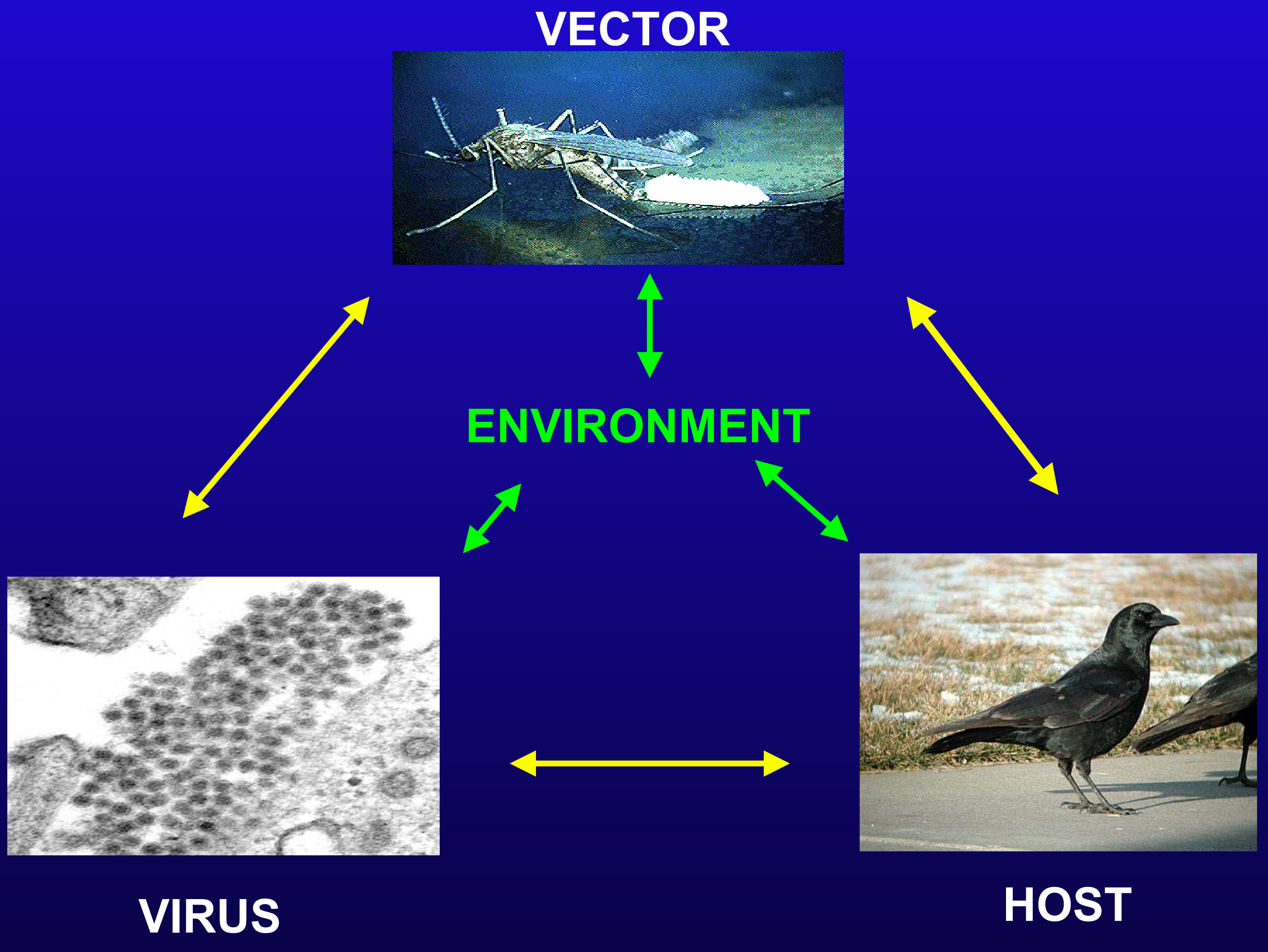

VECTOR
ENVIRONMENT
VIRUS
HOST

Effect of

Environmental temperature

Effect of over-wintering temperature

ALLOW MOSQUITOES TO FEED
ON INFECTED CHICKEN

ENGORGED

UNENGORGED (discarded)

17 C for 7 days
then transfer to 10 C for 1 month

26 C for 14 days

10 C

26 C

TRITURATE

ASSAY FOR VIRUS

Effect of over-wintering temperatures

Days at 10°C	Days at 26°C	No. Tested	% Infec.
>1 mo	0	50	0
1 mo	7	37	81
0	14	23	96
1 mo	14	12	100

Effect of over-wintering temperatures

Days at 10°C	Days at 26°C	No. Tested	% Infected
> 1 mo	0	50	0
41	1	16	31
39	3	13	69
37	5	13	69
35	7	13	54

Effect of

Environmental temperature

on Vector Competence

Effect of environmental temperature

ALLOW MOSQUITOES TO FEED
ON AN INFECTED CHICKEN

ENGORGED

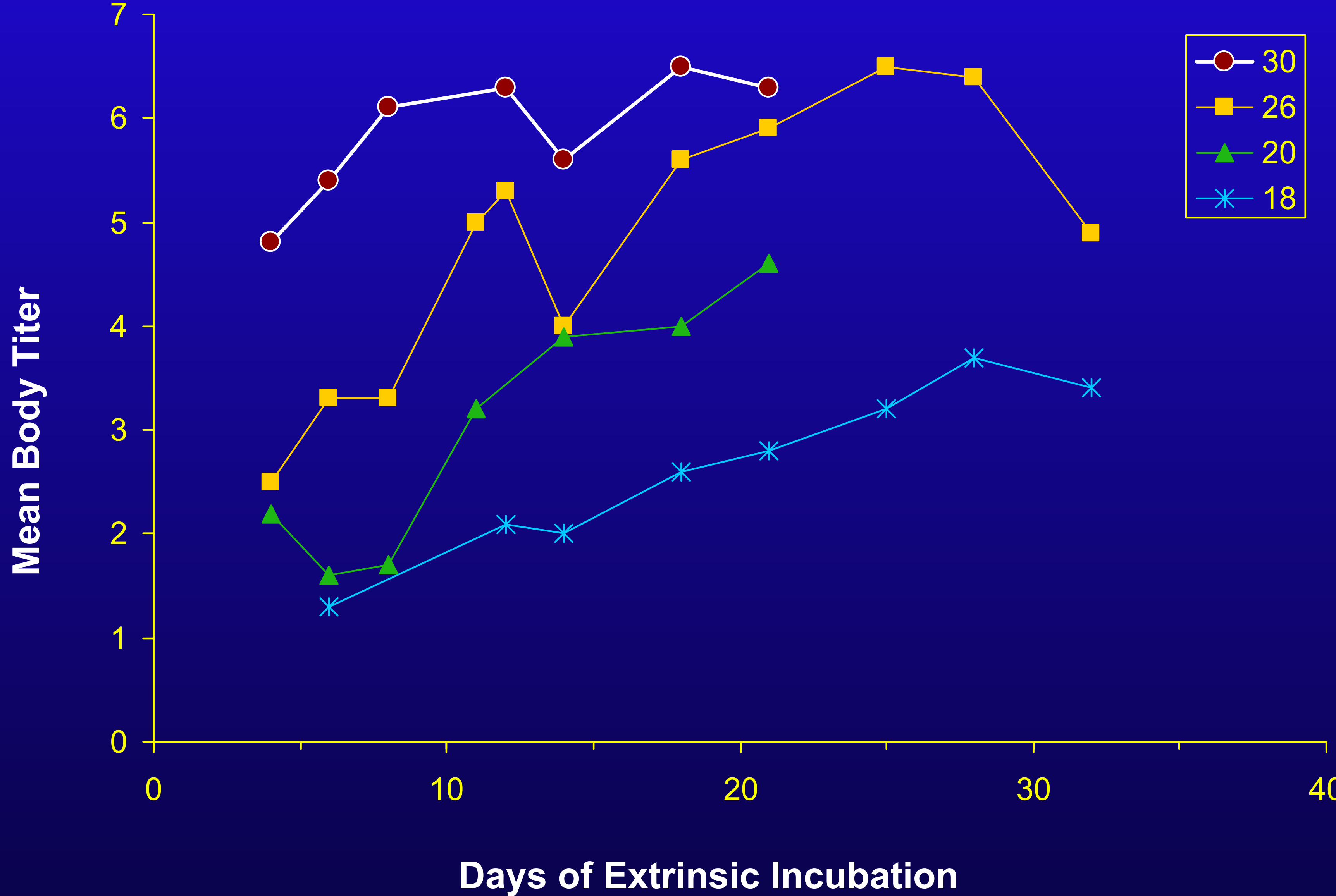
UNENGORGED
(discarded)

Place in cardboard cages maintained at

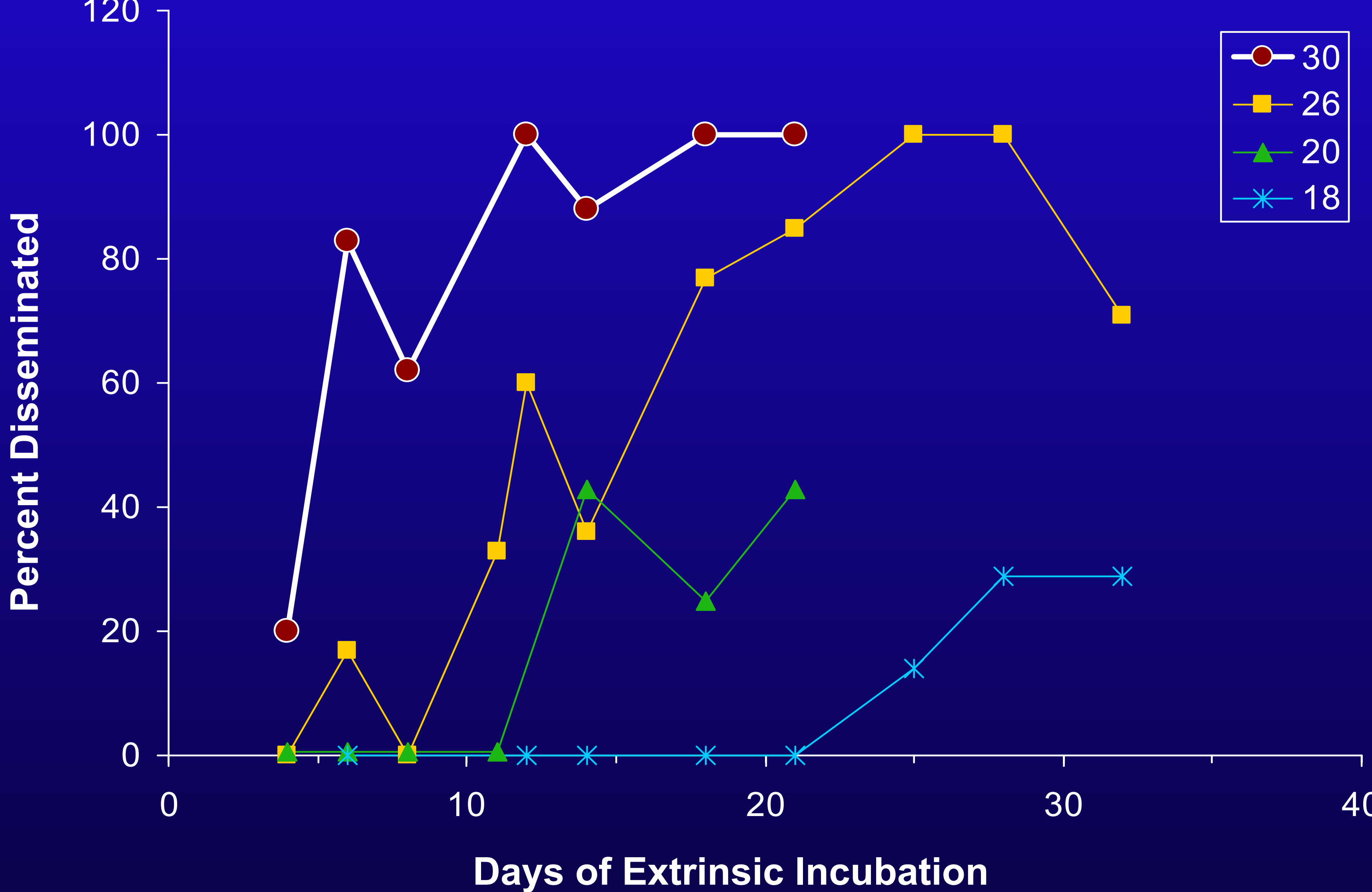
18 C   20 C   26 C   30 C

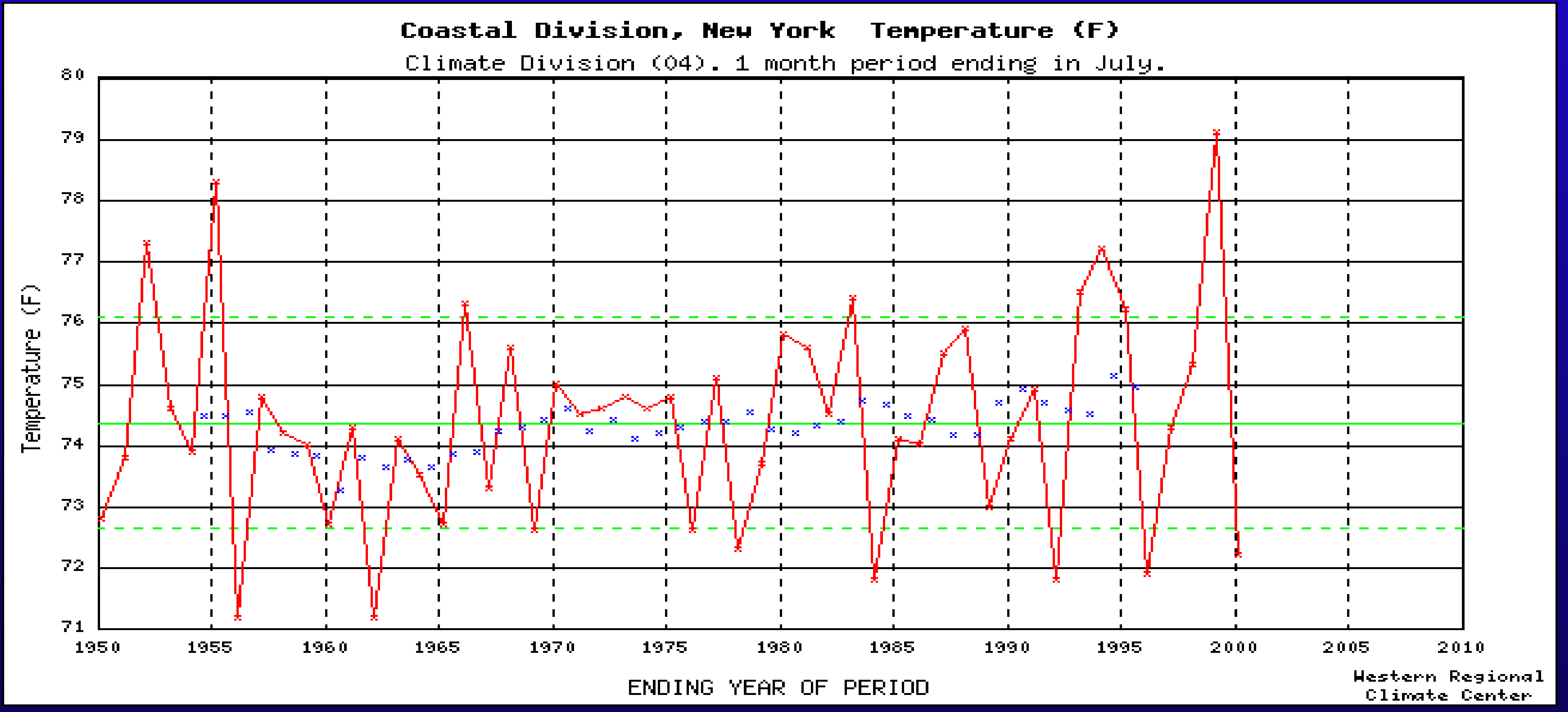
ASSAY FOR VIRUS AT SELECTED INTERVALS

EFFECT OF TEMPERATURE ON VIRAL REPLICATION



EFFECT OF TEMPERATURE ON VIRAL DISSEMINATION




Coastal Division, New York Temperature (F)
Climate Division (04). 1 month period ending in July.
Temperature (F)
80
79
78
77
76
75
74
73
72
71
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
ENDING YEAR OF PERIOD
Western Regional
Climate Center

Vertical transmission

Species	Male	Female	Totals	MFIR
Cx. pipiens	1,633 (5)	1,657 (1)	3,290 (6)	1.8
Ae. albopictus	6,704 (0)	6,739 (0)	13,443 (0)	<0.1

Bionomics of potential vectors

- Host preference
- Population density
- Biting behavior
- Longevity
- Feeding time
- Seasonallity

Potential vectors

- Enzootic/maintenance:
- Epizootic/epidemic
- Minor/incidental

Enzootic/maintenance

- Principally avian feeders
- Competent vectors
- Do not need to be involved in transmission to humans or horses

Epizootic/epidemic (Bridge vectors)

- General feeders
- Competent vectors
- May not be able to maintain infection in nature without enzootic vectors

SUMMARY

Field isolates (PCR-positive pools)

- Isolates from more than 30 distinct mosquito species
- Vast majority from *Culex* (*Culex*) *spp*.

SUMMARY

Vector competence

Most *Culex* (*Culex*) spp. were competent, though only moderately efficient, laboratory vectors of WNV.

Ae. *albopictus*, *Oc. japonicus*, and *Cx. tarsalis* were the most efficient laboratory vectors tested.

With very few exceptions, the transmission rate for individuals with a disseminated infection was high (>75%).

SUMMARY

Bionomics

- Characteristics of *Culex* spp. support the role of these mosquitoes in maintaining WNV in nature
- Selected *Aedes* and *Ochlerotatus* species probably serve as bridge vectors transmitting WNV from the *Culex*/avian cycle to humans and equines