University of California Research in Coachella Valley:

a quarter century of collaboration

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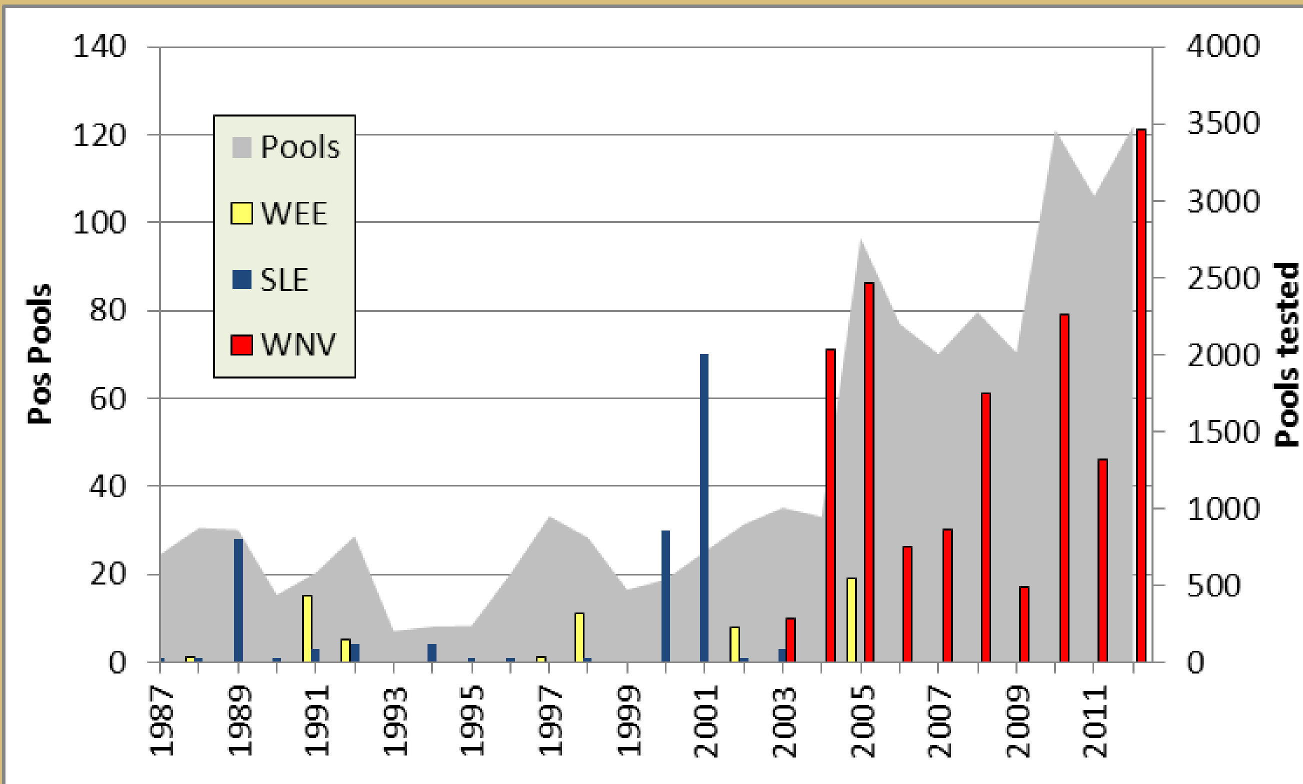
Projects: summary of research topics

- Berkeley [1987 – 1996]
  - Distribution of *Culex*, WEEV and SLEV in Southern California
  - Chicken, pigeon and rabbit sentinel systems
  - Mosquito demography: dispersal, survival, population size
  - GIS programs and sampling
  - Human seroprevalence
  - Time of host-seeking
  - Start and end of diapause
  - Impact of temperature on WEEV and SLEV vector competence

- Davis [1996 – present]
  - Role of different avian species in arbovirus introduction, maintenance and amplification
  - Host selection by *Culex:* importance of flight patterns
  - Introduction of West Nile virus
  - Control of Culex
  - Host competence studies
  - Sugar feeding: a new surveillance tool
  - WNV genetics

Mosquitoes tested in Coachella Valley for virus infection, 1987 - 2012



Summary:

1. Total of 33,069 pools tested, with 103 WEEV, 149 SLEV, and 547 WNV positive
2. Prior to our involvement surveillance consisted of 1 chicken flock and <100 pools per year
3. WEEV and SLEV were prevalent in Coachella Valley but have disappeared?
4. WNV first detected in 2003
5. WNV infection rates less than SLEV and WEEV
6. WNV seems to have displaced SLEV in Coachella Valley and many parts of the USA
7. 2012 had the most positive pools
8. Few human cases recorded for any of the arboviruses

Mosquito and Arbovirus Ecology in Southeastern California, 1986–1990

W. K. REISEN,[1] J. L. HARDY,[1] S. B. PRESSER,[1] M. M. MILBY,[1] R. P. MEYER,[1,2]
S. L. DURSO,[3,4] M. J. WARGO,[3] AND E. GORDON[5]

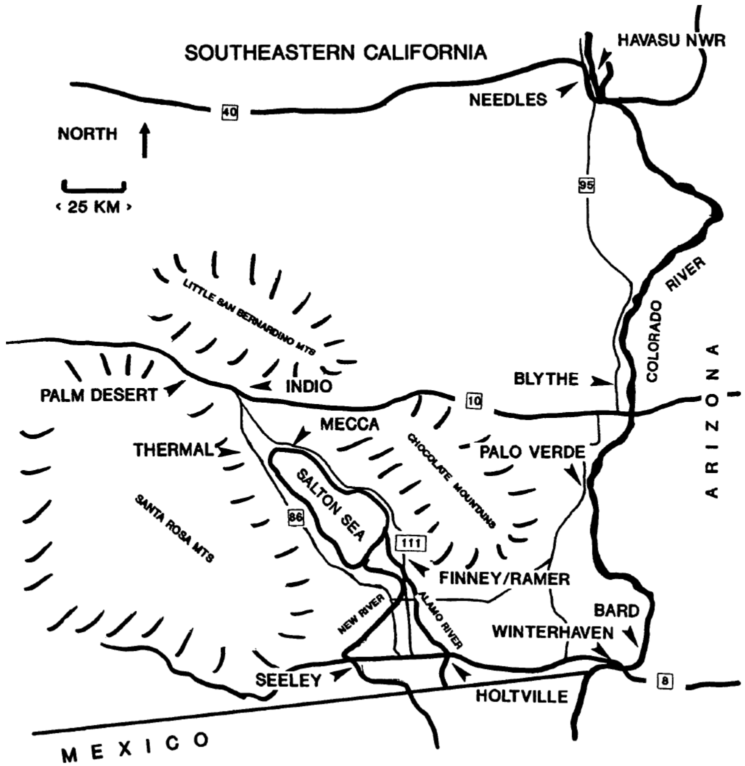


Fig. 1. Study areas in southeastern California, 1986–1990.

Summary:

1. No S-N progression in virus activity
2. *Cx. tarsalis* was the main vector
3. Virus infections/transmission greatest during hottest time of the summer

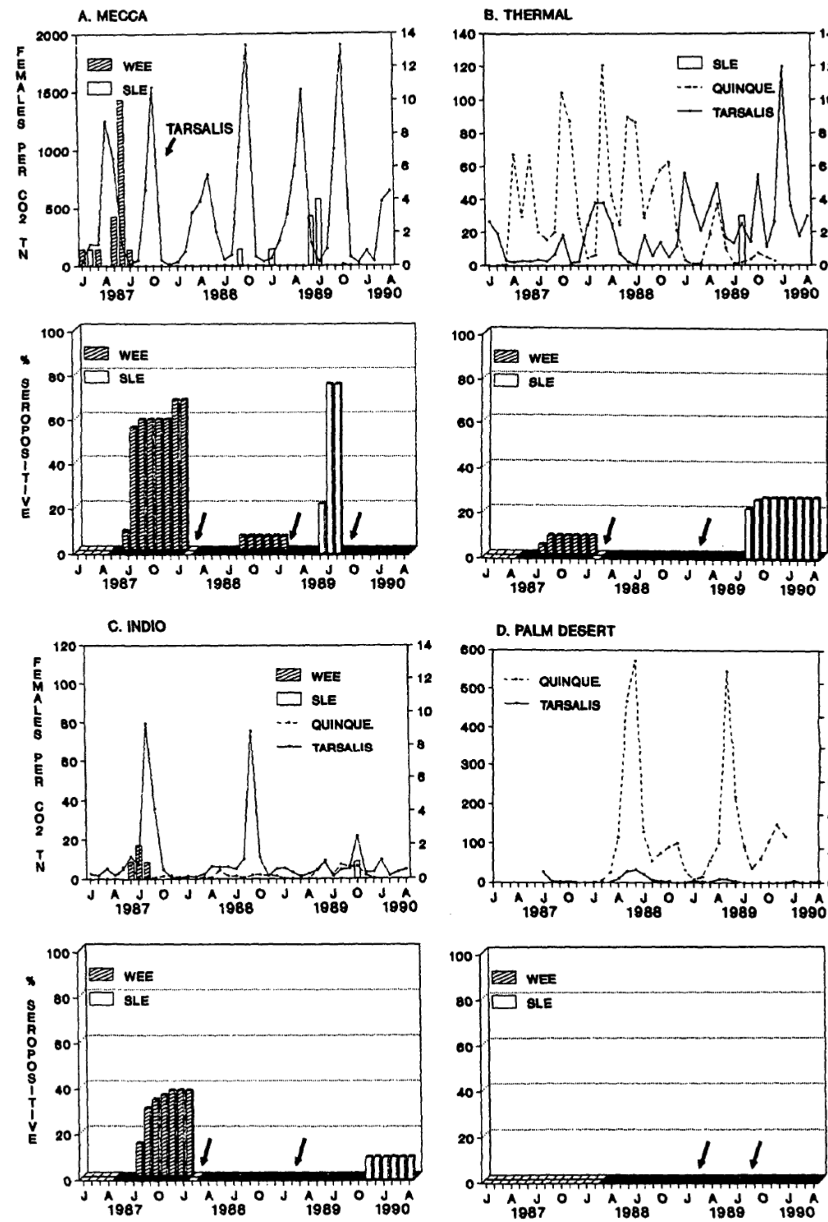
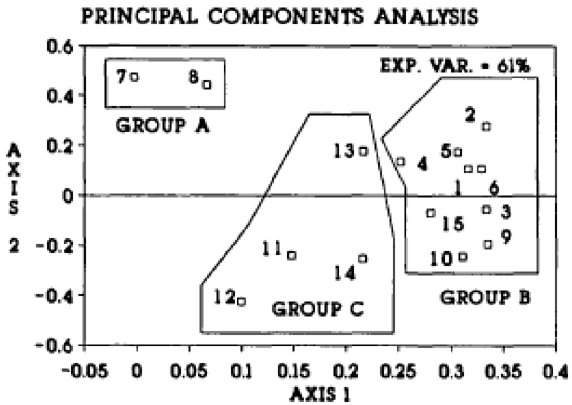


Fig. 6. Mean *Cx. tarsalis* and *Cx. quinquefasciatus* abundance (females per CO_2 trap-night per month) and total number of virus-positive pools (upper panel), and cumulative seroconversion rates in sentinel chickens (lower panel) in the Coachella Valley at (A) Mecca, (B) Thermal, (C) Indio, and (D) Palm Desert, 1987–1990. Arrows indicate months when sentinel chickens were replaced.

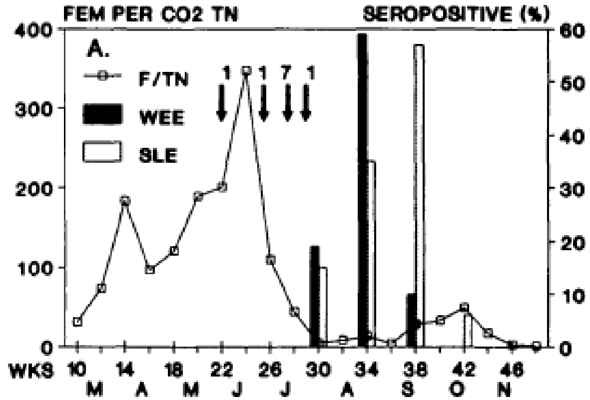
Landscape Ecology of Arboviruses in Southern California: Temporal and Spatial Patterns of Vector and Virus Activity in Coachella Valley, 1990–1992

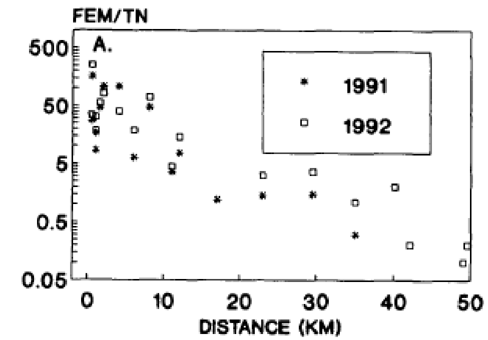
W. K. REISEN,[1] H. D. LOTHROP,[1] S. B. PRESSER,[1] M. M. MILBY,[1] J. L. HARDY,[1] M. J. WARGO,[2] AND R. W. EMMONS[3]

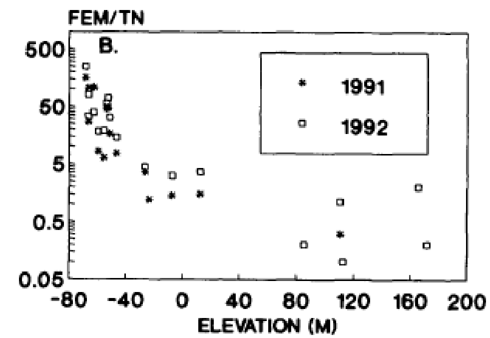
Abundance with distance from Sea or elevation.



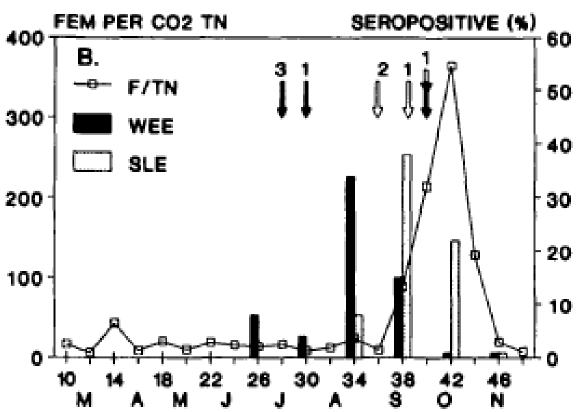
A. Salton Sea







B. Duck Clubs



C. Upper Valley

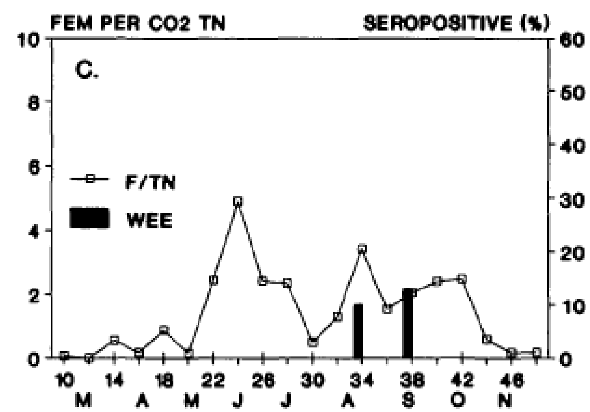
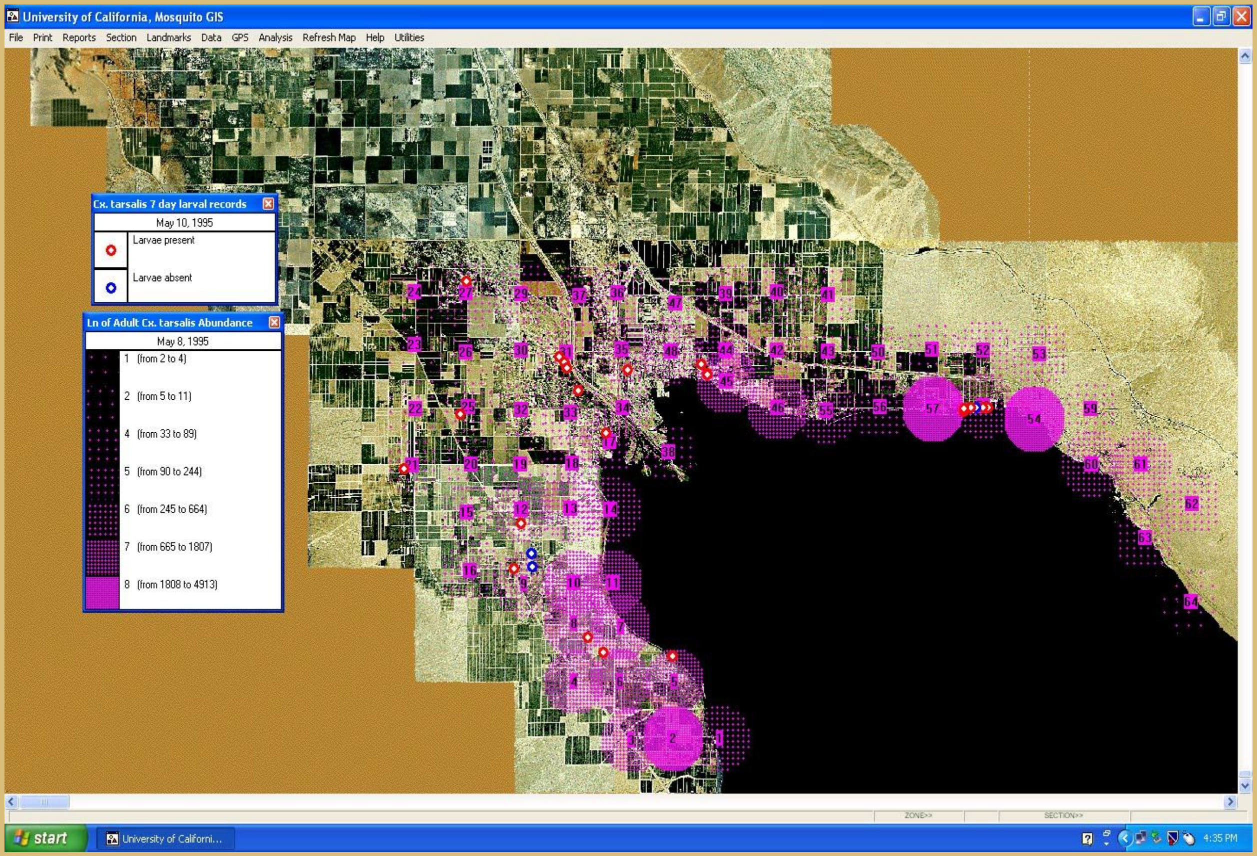


Fig. 4. Principal components analysis segregating 15 study sites in Coachella Valley into groups A–C based on similarities among the seasonal patterns of *Cx. tarsalis* female abundance during 1991 (upper left panel). Also shown are biweekly mean numbers of *Cx. tarsali* females per CO_2 trap night (F/TN) and the percentage of sentinel chickens seroconverting to WEE or SLE viruses on each bleeding date for groups A, B, and C. Arrows indicate the total number of pools of *Cx. tarsalis* females positive for WEE (black arrows) or SLE (white arrows) viruses on each sampling date.

Summary:
1. *Cx. tarsalis* abundance decreased with elevation
2. Virus activity temporally was independent of abundance and seemed to track temperature
3. Virus activity started in southern Valley and moved north
4. Water use changed abundance patterns

Geographical Information System



Summary:

1. First operational mapping program for Coachella Valley MVCD
2. Showed dispersion pattern of mosquitoes in both time and space
3. Combined with larval sources, soil and other surfaces
4. Used to record operational data

Population Ecology and Dispersal of *Culex tarsalis* (Diptera: Culicidae) in the Coachella Valley of California

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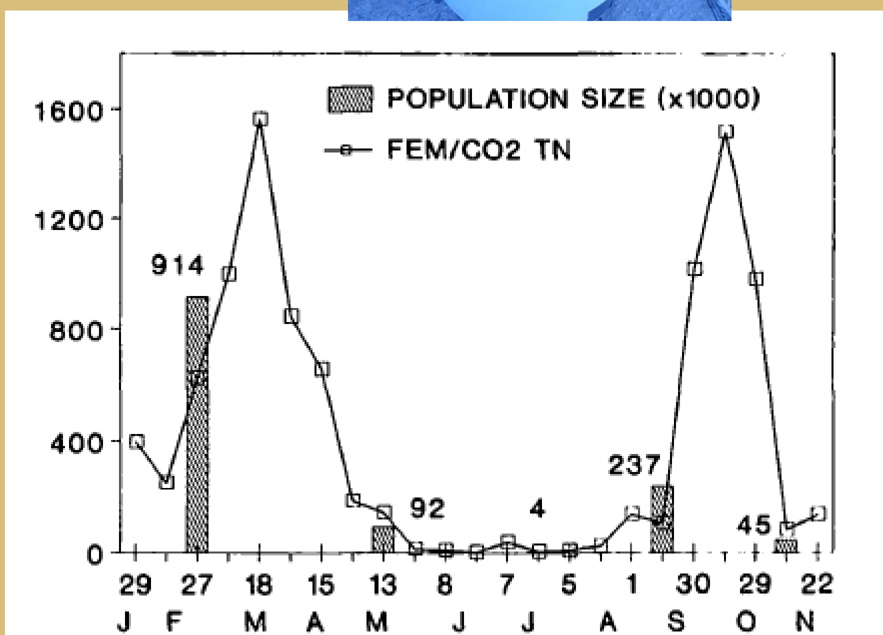


Summary:

1. Dispersed 0.2 km/d after release
2. Population size agreed with abundance
3. Size ranged from 8,744 to 1.8M F/km^2
4. Survivorship range 0.64 – 0.92
5. Most females stayed close to release point

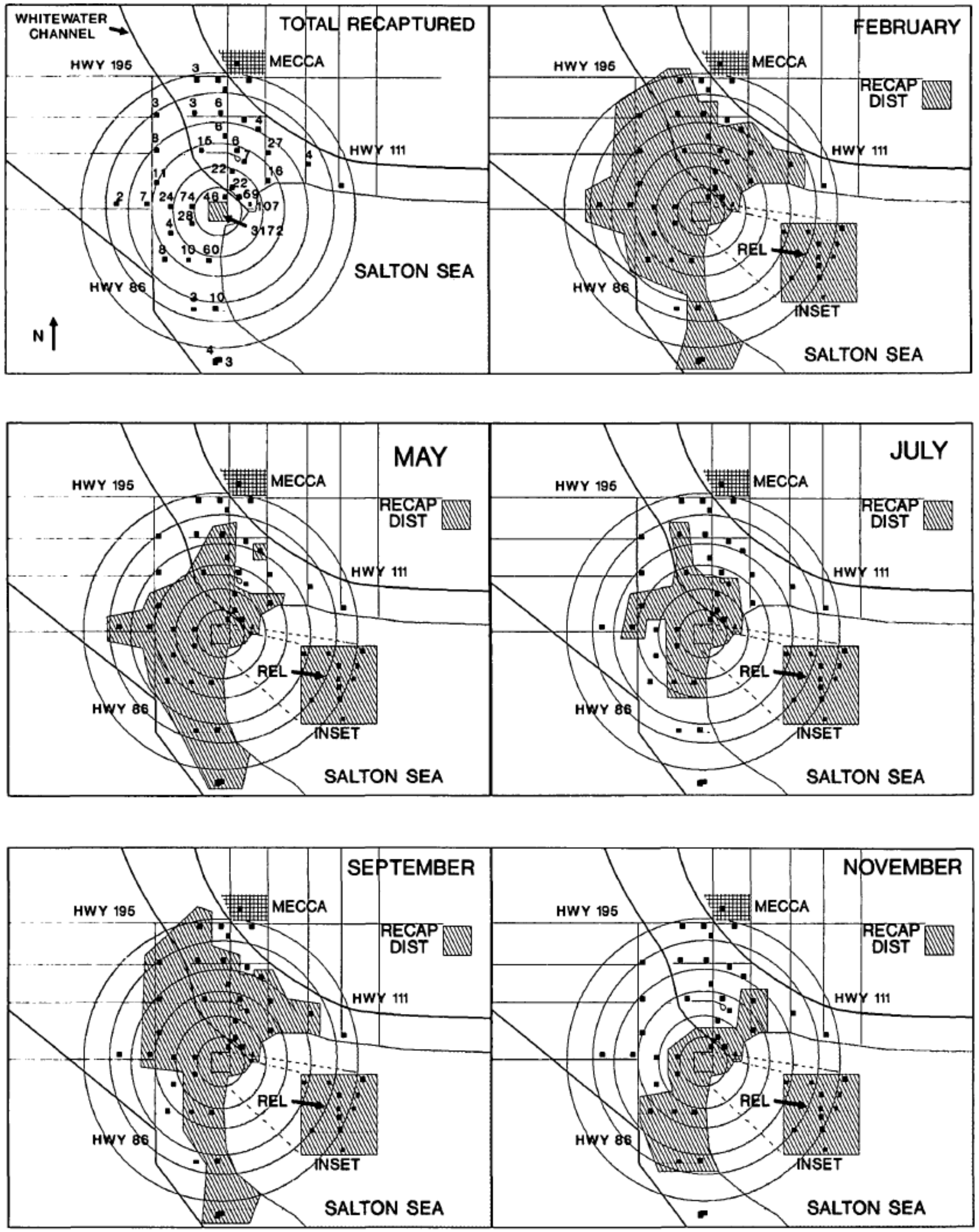


Fig. 6. Total females recaptured at all traps during all experiments and the distribution of recaptured females, RECAP DIST, during each experiment in the Coachella Valley during 1993. Traps were included within the shaded recapture area if ≥1 marked female from any released cohort was collected during any recapture attempt. Circles at 1-km intervals.

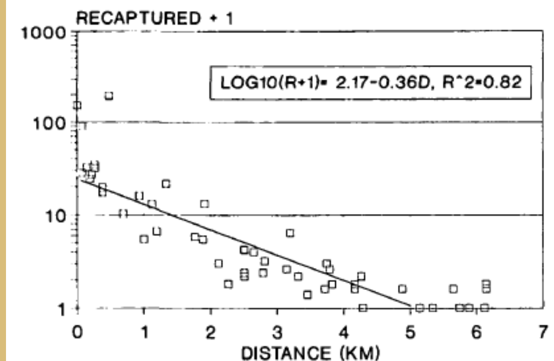


Fig. 7. Total *Cx. tarsalis* females recaptured per trap plotted as a function of trap distance from the release site.

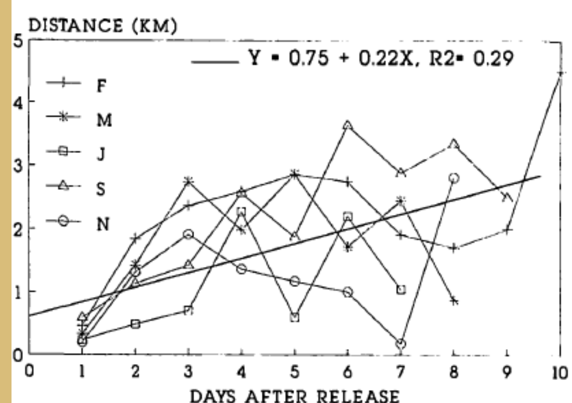
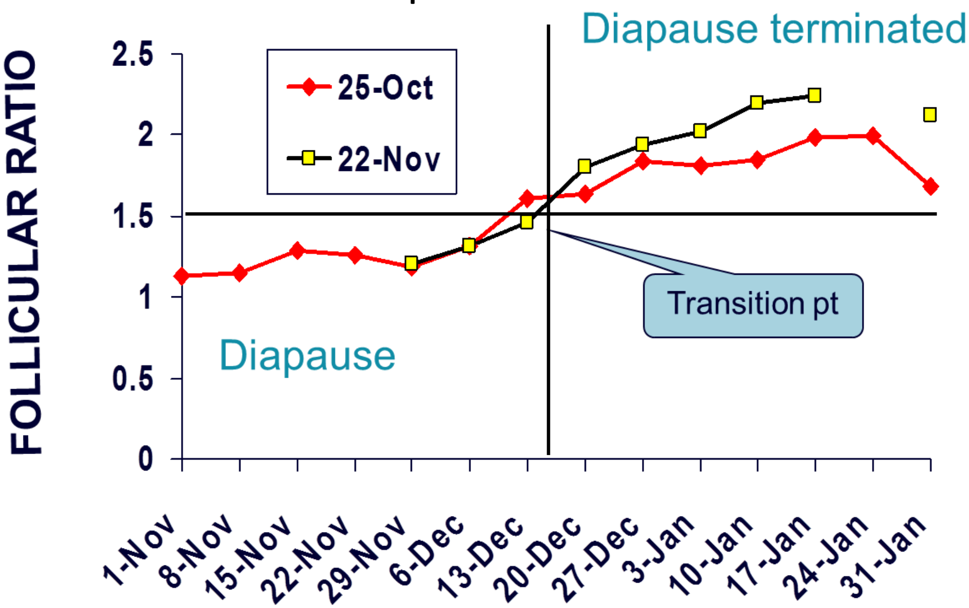
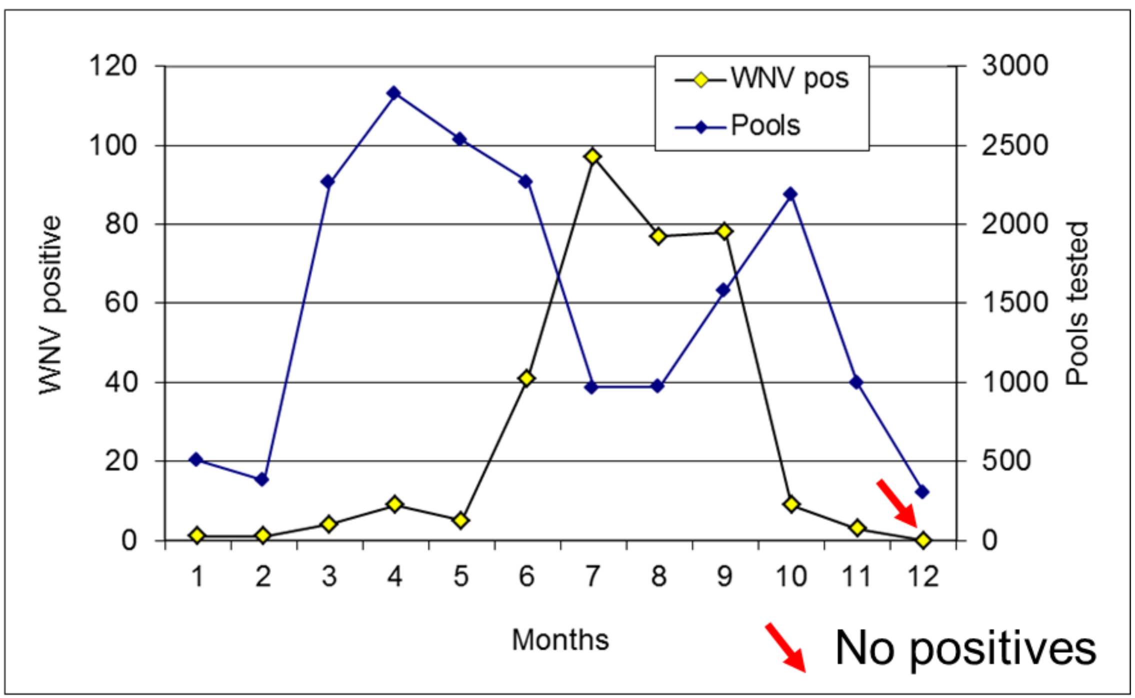


Fig. 8. Mean distance dispersed per day by marked *Cx. tarsalis* during each experiment plotted as a function of time in days after release. Shown is the overall regression function.

Cx. tarsalis diapause





Overwintering summary:

1. Primary virus vector *Cx. tarsalis* undergoes short term diapause that is terminated in mid-December
2. Females start host-seeking in late December leading to rapid population increases
3. Cool weather plus diapause slow/stop WNV transmission during December
4. Break in transmission leads to slow spring amplification

Am. J. Trop. Med. Hyg., 55(6), 1996, pp. 667–671

PREVALENCE OF ANTIBODIES TO MOSQUITO-BORNE ENCEPHALITIS VIRUSES IN RESIDENTS OF THE COACHELLA VALLEY, CALIFORNIA

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Division of Epidemiology and Public Health Biology, School of Public Health, University of California, Berkeley, California

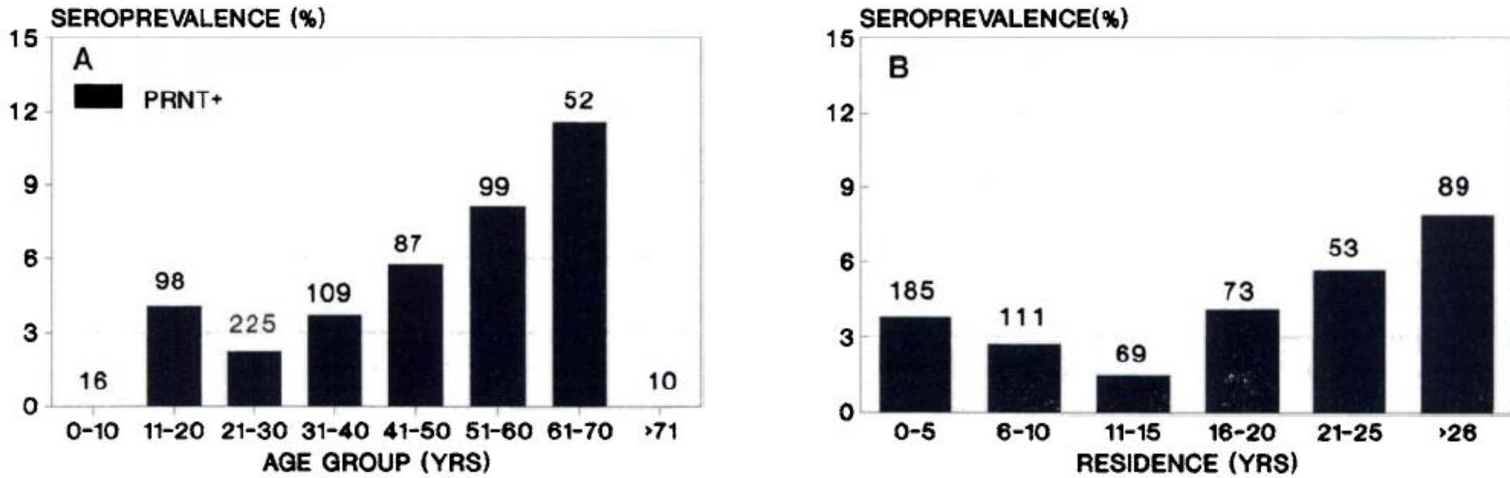
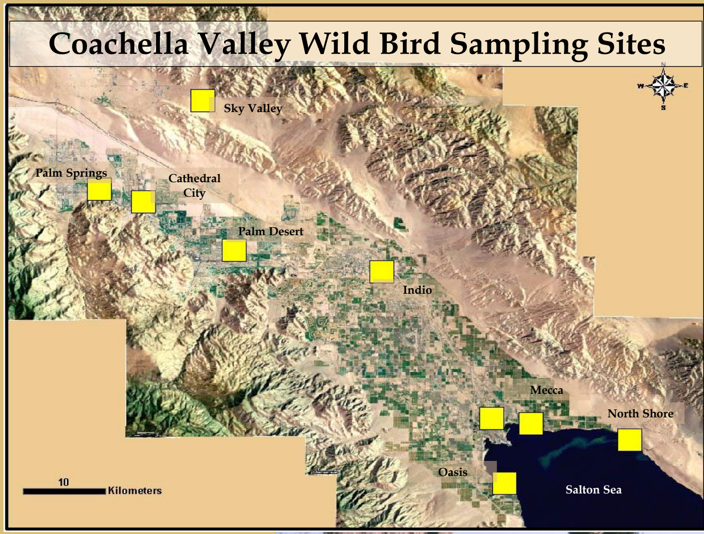


FIGURE 2. Plaque-reduction neutralization test (PRNT) St. Louis encephalitis seroprevalence plotted as a function of **A,** age grouped by decade and **B,** duration of residency in Coachella Valley, California. The numbers above the bars are sample sizes.

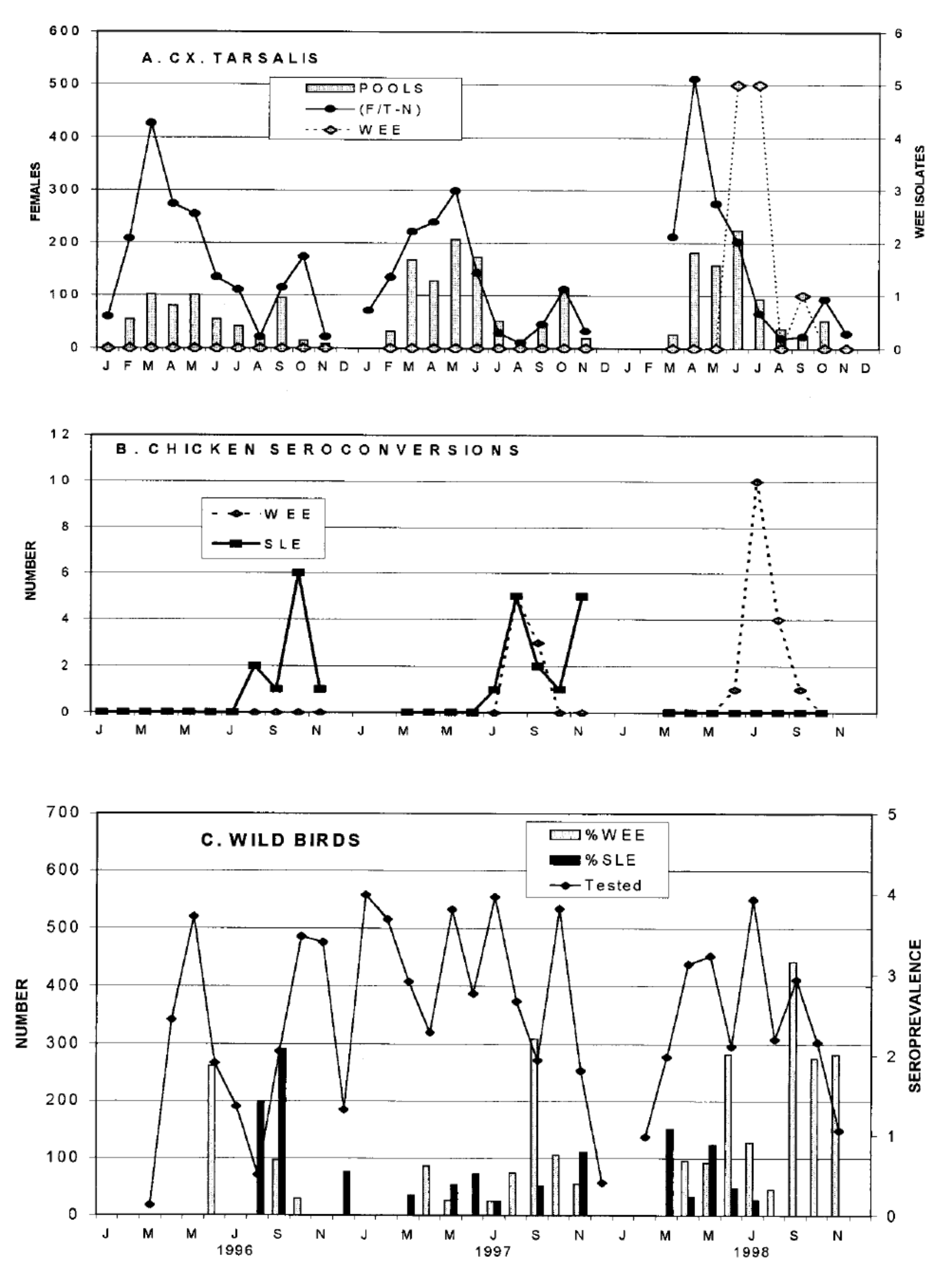
Summary:

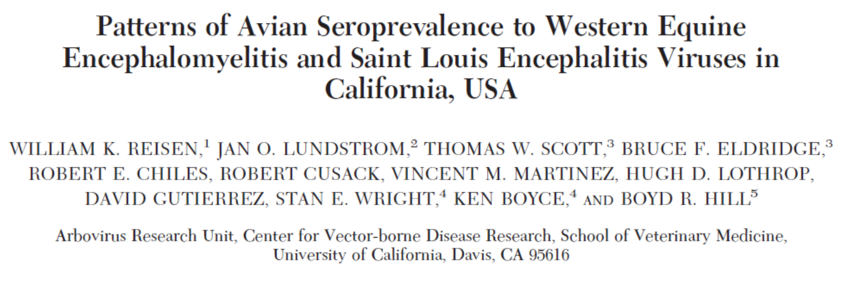
1. 1% and 5% PRNT of 719 outpatients had IgG against WEEV and SLEV [2.6% and 16.4% pos by EIA]
2. Similar to Imperial Valley: 1.5% and 12.1% of 577 pos for WEEV and SLEV
3. Seroprevalence increased as a function of age
4. Humans were infected with arboviruses but few disease cases reported



Wild bird studies 1996 - 2012

Coachella Valley




Patterns of Avian Seroprevalence to Western Equine Encephalomyelitis and Saint Louis Encephalitis Viruses in California, USA

WILLIAM K. REISEN,[1] JAN O. LUNDSTROM,[2] THOMAS W. SCOTT,[3] BRUCE F. ELDRIDGE,[3] ROBERT E. CHILES, ROBERT CUSACK, VINCENT M. MARTINEZ, HUGH D. LOTHROP, DAVID GUTIERREZ, STAN E. WRIGHT,[4] KEN BOYCE,[4] AND BOYD R. HILL[5]

Arbovirus Research Unit, Center for Vector-borne Disease Research, School of Veterinary Medicine, University of California, Davis, CA 95616

Summary:

Bird sera 1996-1998

10,945 sera from 123 species; few were positive:

64 WEEV from 13 species

27 SLEV from 7 species

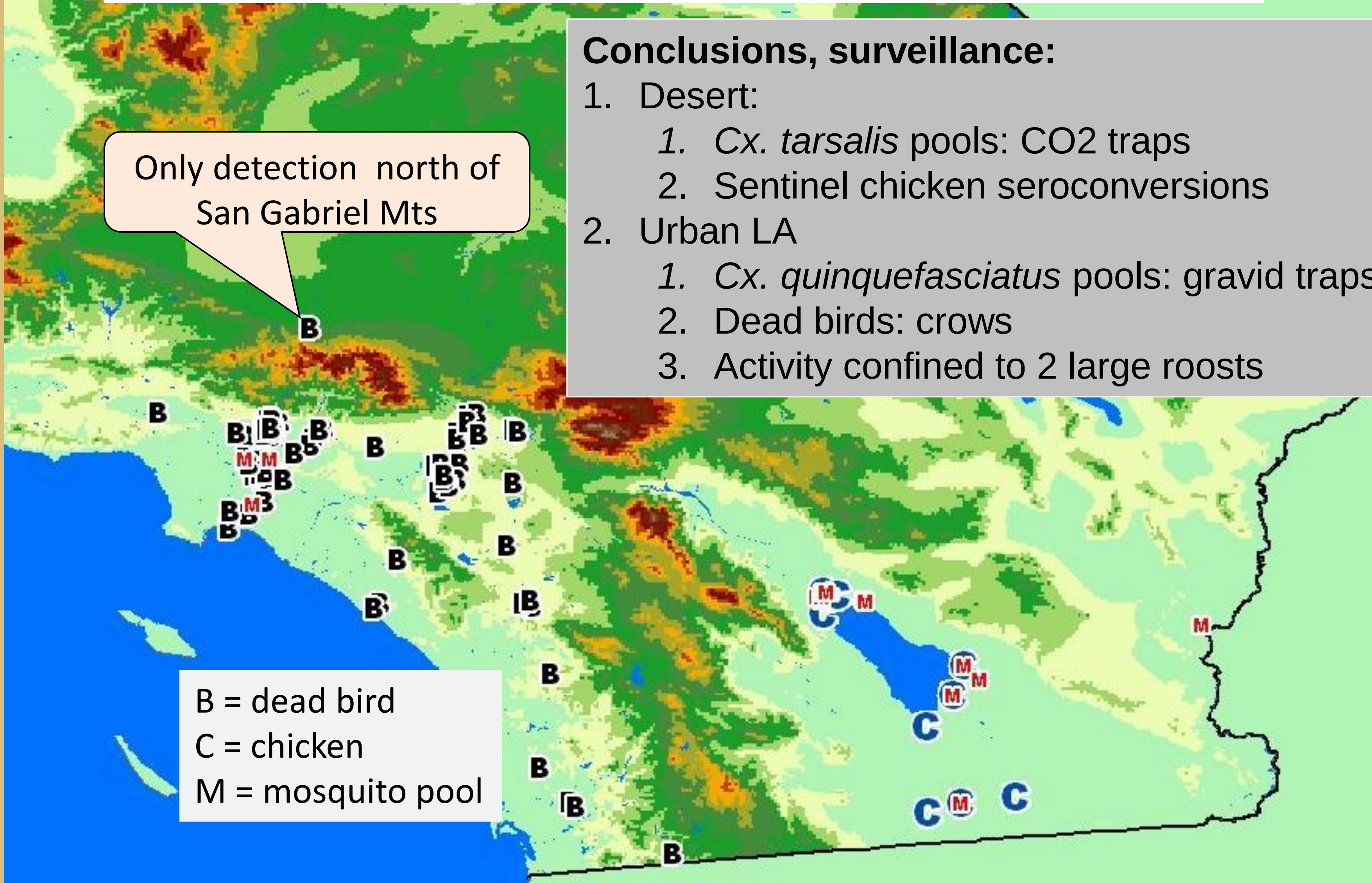
Quail, Common ground dove and House sparrow most frequently infected

West Nile Virus in California

William Reisen,* Hugh Lothrop,* Robert Chiles,* Minoo Madon,† Cynthia Cossen,‡ Leslie Woods,* Stan Husted,‡ Vicki Kramer,‡ and John Edman*

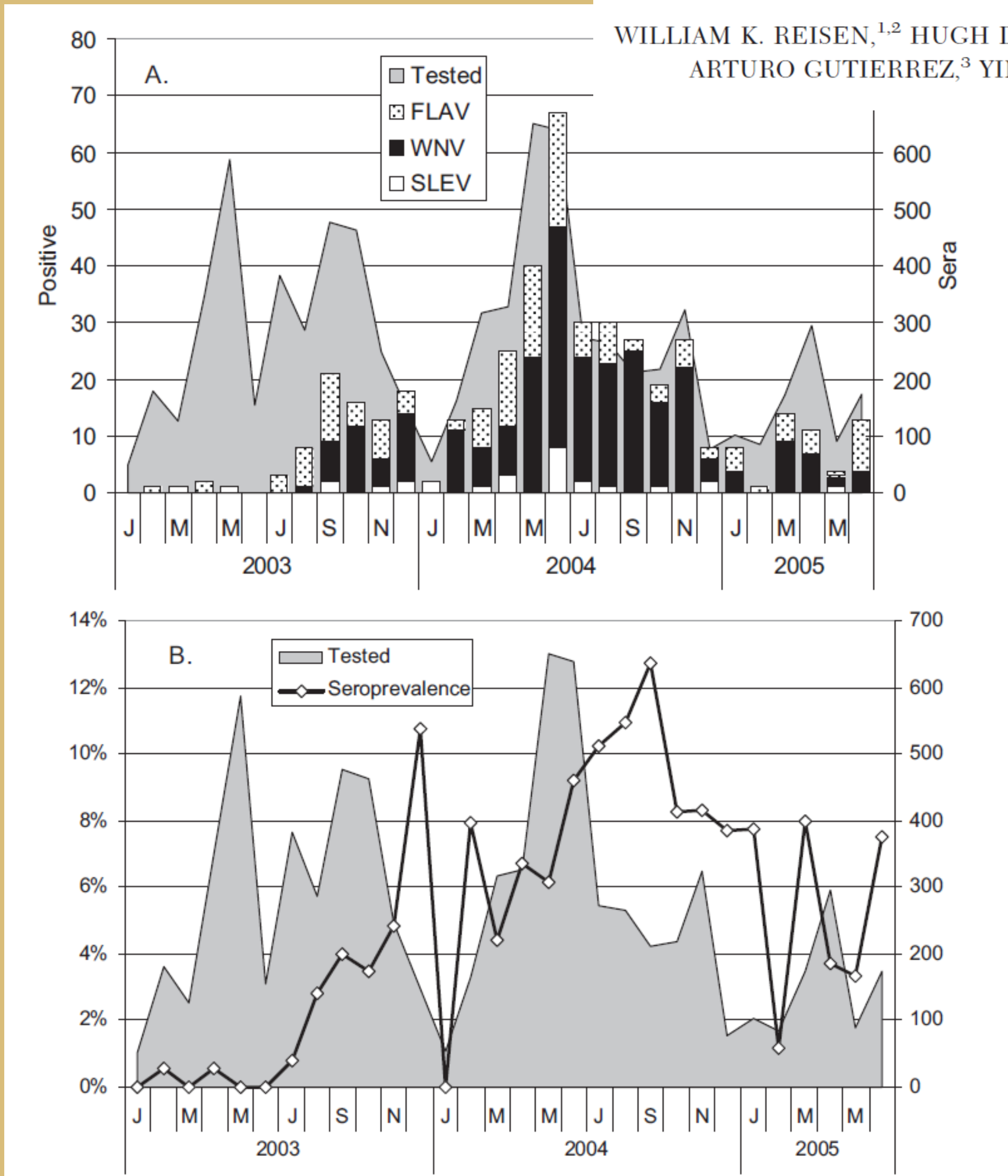
Conclusions, surveillance:

1. Desert:
   1. *Cx. tarsalis* pools: CO_2 traps
   2. Sentinel chicken seroconversions
2. Urban LA
   1. *Cx. quinquefasciatus* pools: gravid traps
   2. Dead birds: crows
   3. Activity confined to 2 large roosts



Persistent West Nile Virus Transmission and the Apparent Displacement St. Louis Encephalitis Virus in Southeastern California, 2003–2006

WILLIAM K. REISEN,[1,2] HUGH D. LOTHROP,[1] SARAH S. WHEELER,[1] MARC KENNSINGTON,[1] ARTURO GUTIERREZ,[3] YING FANG,[1] SANDRA GARCIA,[1] AND BRANKA LOTHROP[3]



Summary:

7,900 sera tested; 21 of 91 species positive: 9 WEEV, 29 SLEV, 273 WNV

1. Percent positive for WNV greater than WEEV or SLEV now or in past
2. Quail, Pigeon, Common ground dove, White-winged dove, Mourning dove, Least bittern most frequently infected – mostly low competent hosts.

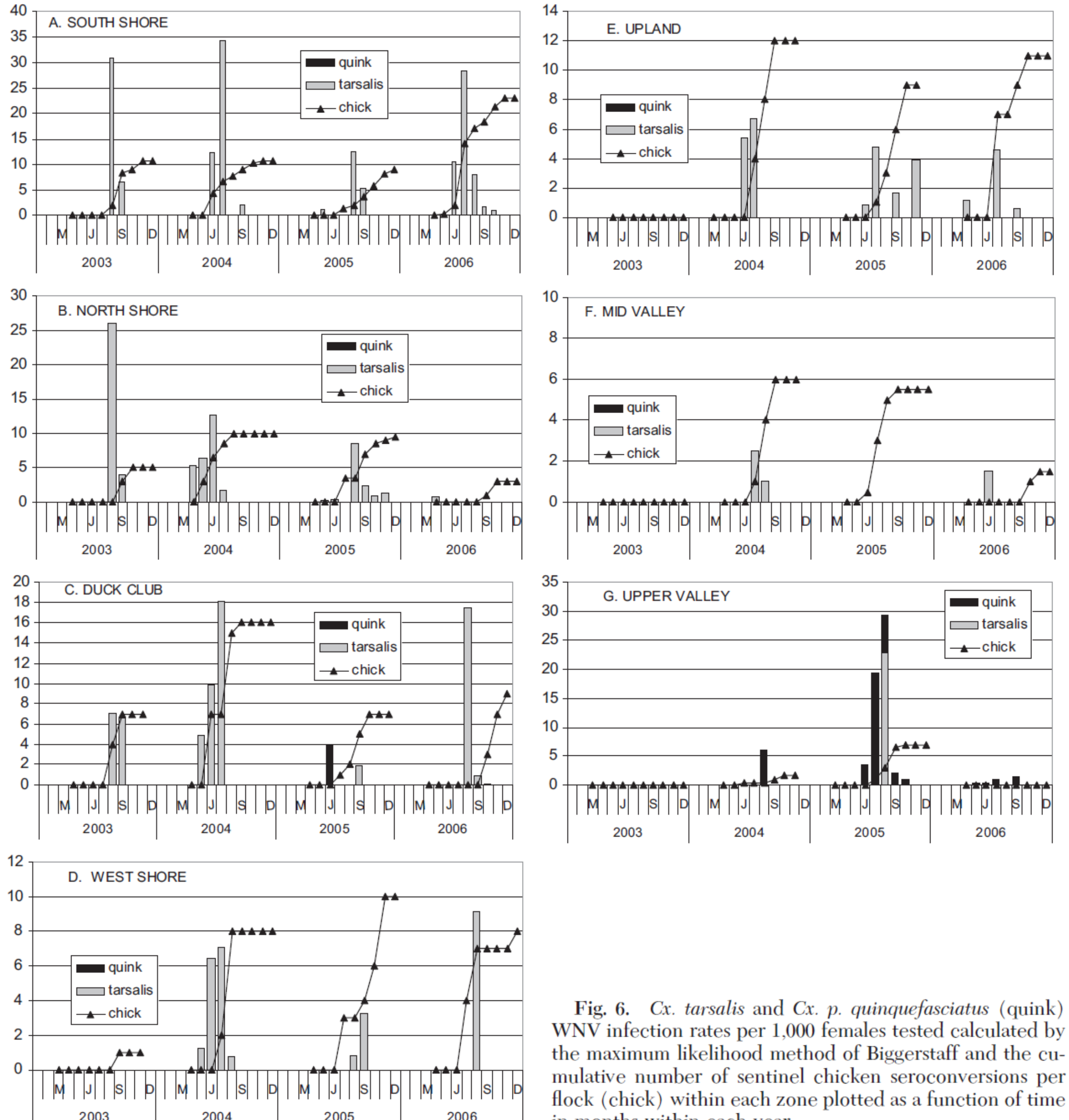


Fig. 6. *Cx. tarsalis* and *Cx. p. quinquefasciatus* (quink) WNV infection rates per 1,000 females tested calculated by the maximum likelihood method of Biggerstaff and the cumulative number of sentinel chicken seroconversions per flock (chick) within each zone plotted as a function of time in months within each year.

WNV activity throughout Coachella Valley, 2003 – 2006

1. Consistent activity around the Salton Sea
2. Inconsistent WNV activity in upper Valley
3. SLEV displaced
4. *Cx. tarsalis* main vector of WNV

Journal of the American Mosquito Control Association, 23(2):190–207, 2007

EVALUATION OF PYRETHRIN AND PERMETHRIN GROUND ULTRA-LOW VOLUME APPLICATIONS FOR ADULT *CULEX* CONTROL IN RURAL AND URBAN ENVIRONMENTS OF THE COACHELLA VALLEY OF CALIFORNIA

HUGH LOTHROP,[1] BRANKA LOTHROP,[2] MARK PALMER,[1] SARAH WHEELER,[1] ARTURO GUTIERREZ,[2] DONALD GOMSI[2] AND WILLIAM K. REISEN[1,3]

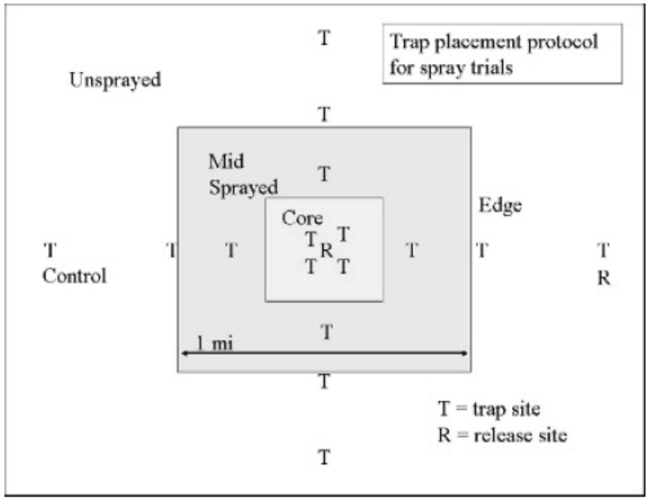


Fig. 1. Trap deployment scheme along north–south and east–west transects to assess fogging over a 1-mi² area (1 section or 640 acres = 2.8 km²).

<u>Results for ground applications</u>:

1. *Cx. tarsalis* abundance suppression dependent upon landscape
2. *Cx. quink* control in urban areas difficult because of houses
3. Landscape features dramatically altered droplet dispersal and penetration

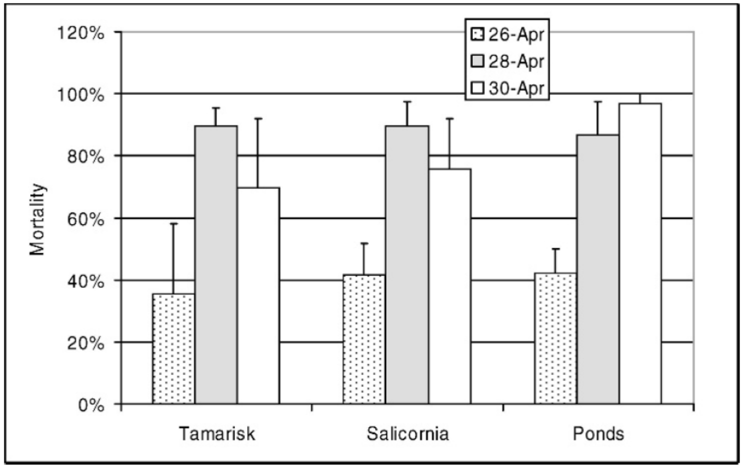


Fig. 9. Mean + SE percentage of mortality of caged sentinel mosquitoes along transects through 3 different vegetative types downwind and perpendicular to 3 truck applications of Aqua-Reslin® during Experiment 3 in April 2004.

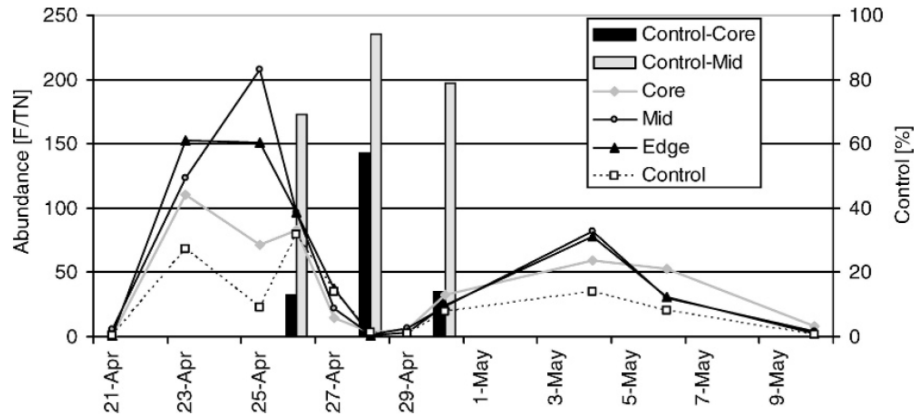
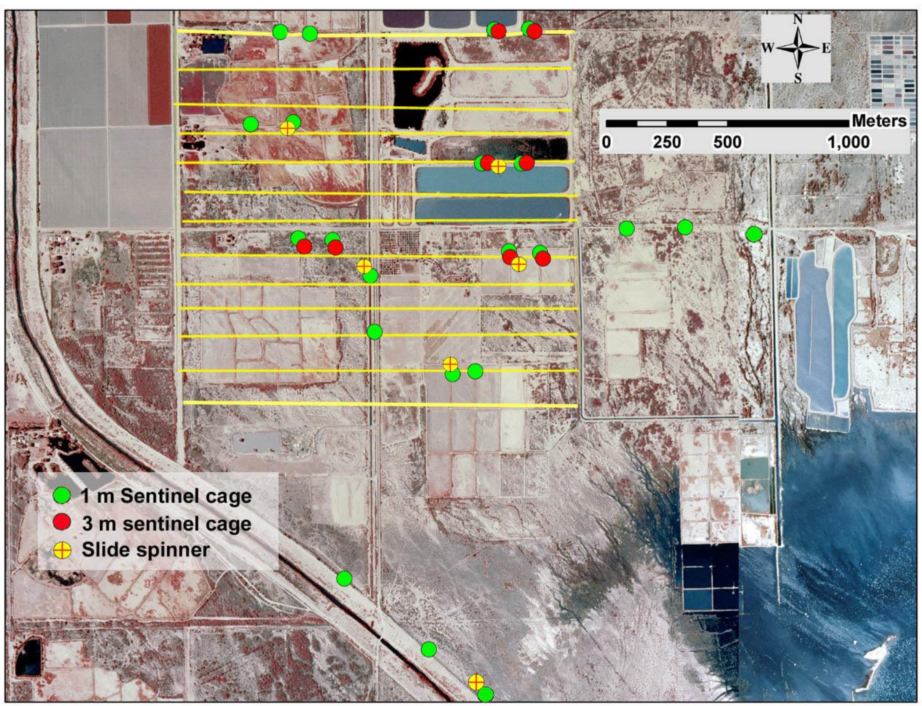


Fig. 10. Relative abundance (geometric mean number of female [F] *Culex tarsalis* per CO_2 trap-night [TN]) at replicate traps within core, mid, edge, and control zones during Experiment 3 in April 2004. Columns show percentage of control calculated using Mulla's formula for the nights of ultra-low volume Aqua-Reslin® application.

Journal of the American Mosquito Control Association, 23(4):405–419, 2007

EVALUATION OF PYRETHRIN AERIAL ULTRA-LOW VOLUME APPLICATIONS FOR ADULT *CULEX TARSALIS* CONTROL IN THE DESERT ENVIRONMENTS OF THE COACHELLA VALLEY, RIVERSIDE COUNTY, CALIFORNIA

HUGH LOTHROP,[1] BRANKA LOTHROP,[2] MARK PALMER,[1] SARAH WHEELER,[1] ARTURO GUTIERREZ,[2] PATRICK MILLER,[1] DONALD GOMSI,[2] AND WILLIAM K. REISEN[1,3]



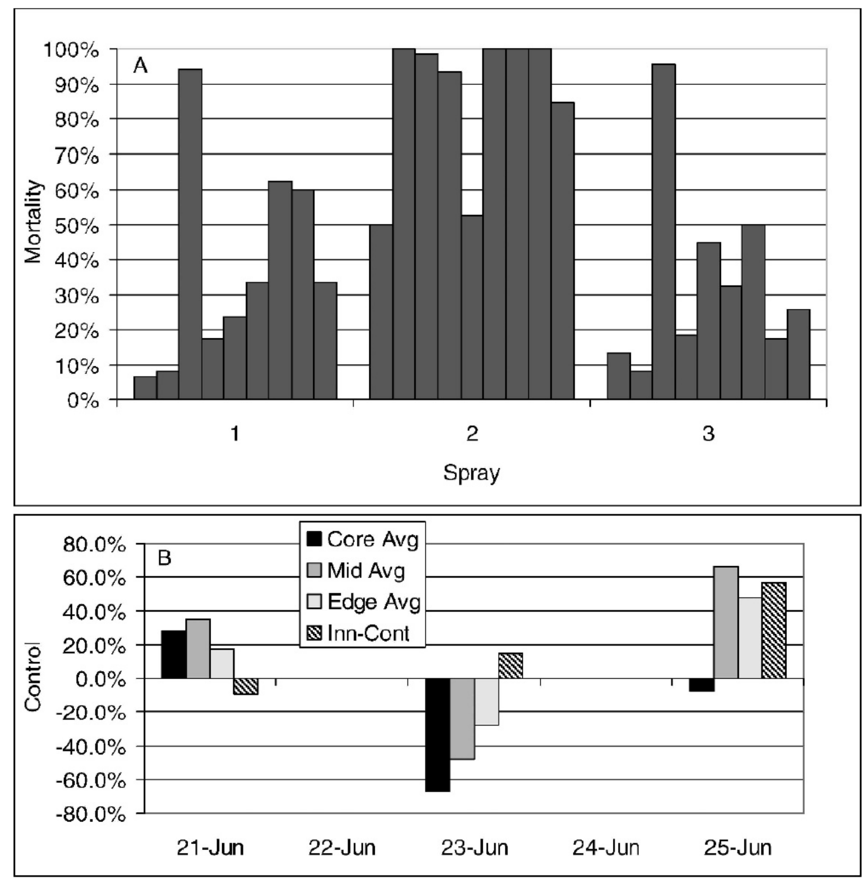


Fig. 8. (A) Percentage kill of sentinel mosquitoes (15–30 per cage) 12 h after exposure at 9 locations at 3 ft height and (B) percentage control estimated using Mulla's formula for core, mid, and edge strata during each of 3

Aerial spray evaluations

1. 1:2 Pyrenone 24-5: BVA oil mix best in hot weather
2. Kill sporadic – hard to control droplets
3. General area wide suppression in March & June, but not September

VECTOR-BORNE AND ZOONOTIC DISEASES
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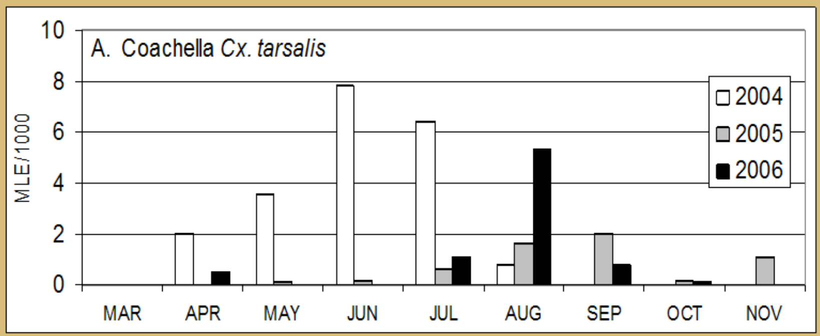
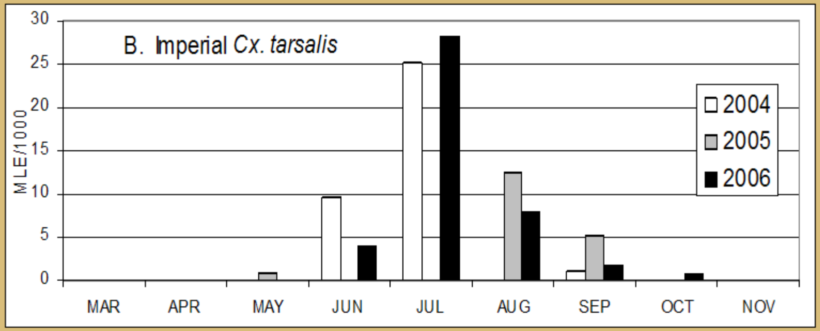
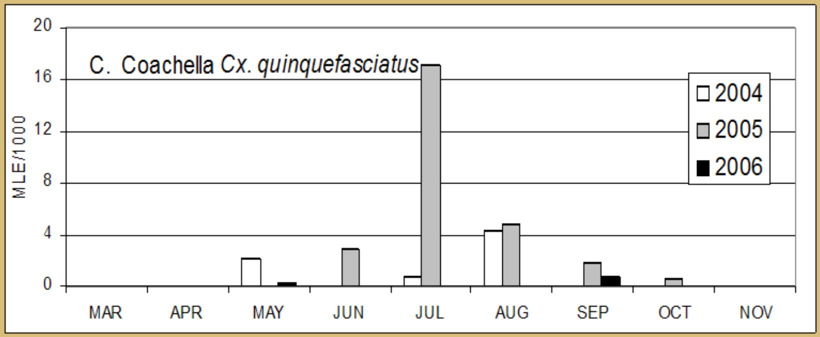
Intensive Early Season Adulticide Applications Decrease Arbovirus Transmission Throughout the Coachella Valley, Riverside County, California

HUGH D. LOTHROP,[1] BRANKA B. LOTHROP,[2] DONALD E. GOMSI,[2] and WILLIAM K. REISEN[1]

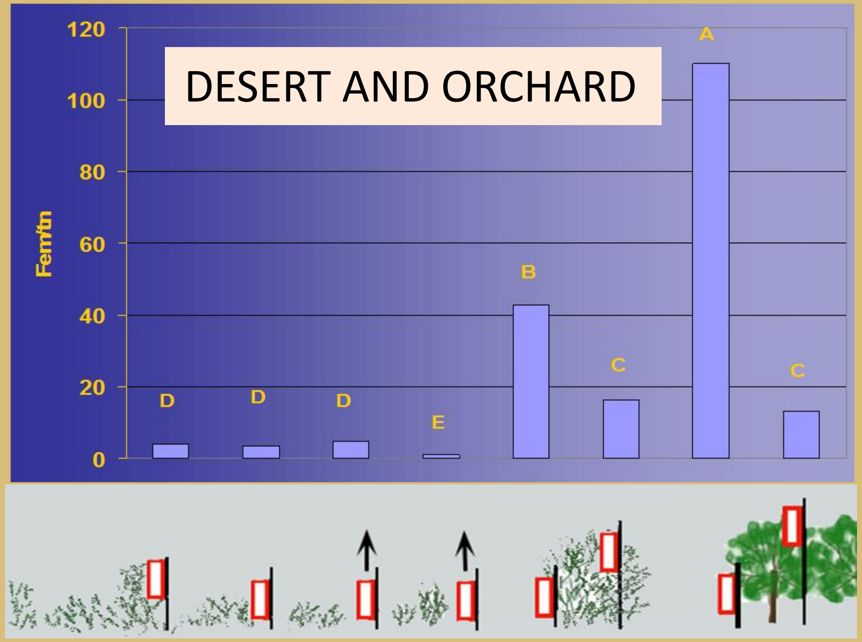






Summary:

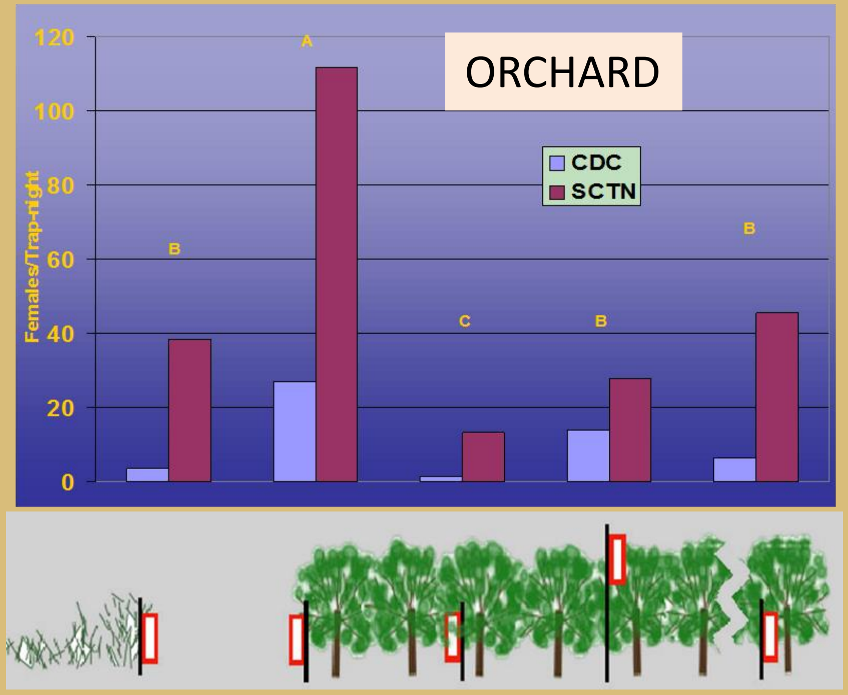
1. Recognition of site of early amplification was necessary to focus control in time and space
2. When applied repeatedly immediately after virus detection got good control and contained dispersal

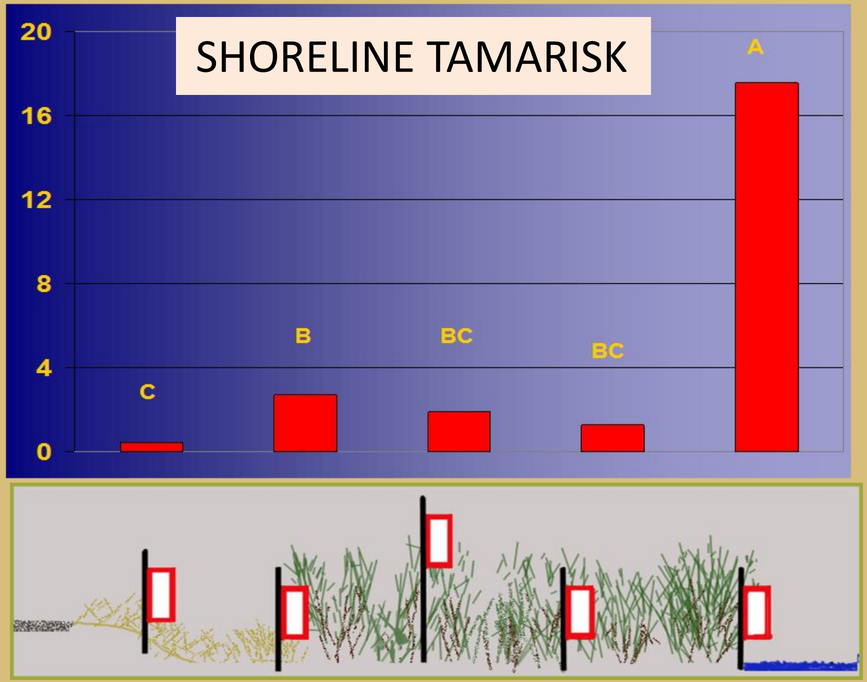


Vegetation use by host-seeking *Culex tarsalis*

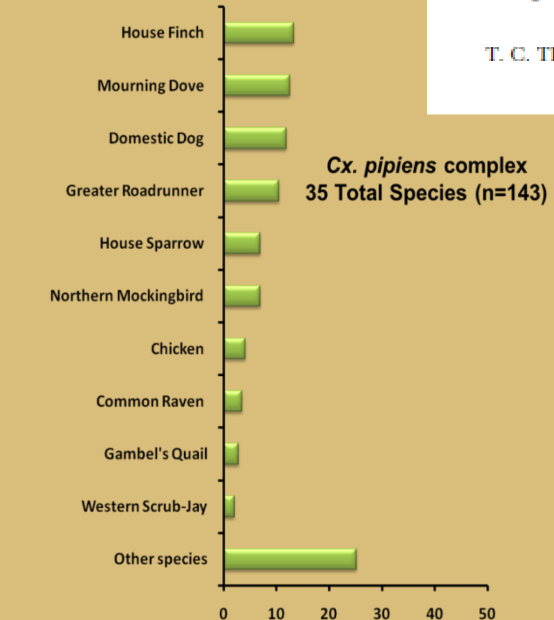
Summary:

1. Used non-attractive traps in transects
2. Females most abundant at ecotones
3. Host-seeking females collected in some locations





2007-2009

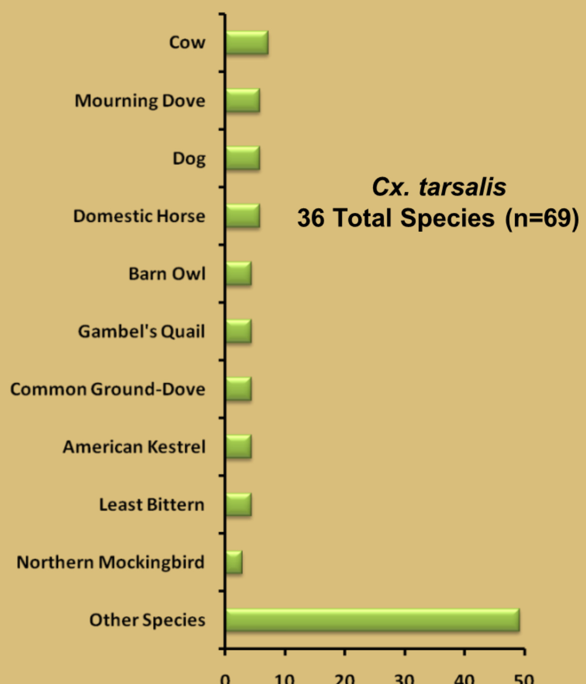


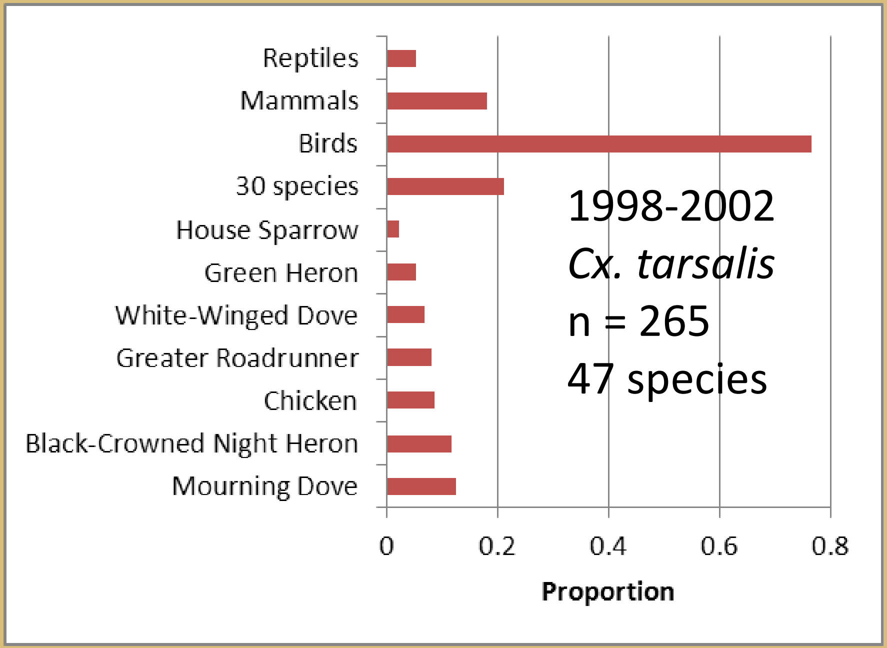

Spatial Variation in Host Feeding Patterns of *Culex tarsalis* and the *Culex pipiens* complex (Diptera: Culicidae) in California

T. C. THIEMANN,[1] D. A. LEMENAGER,[2] S. KLUH,[3] B. D. CARROLL,[1] H. D. LOTHROP,[1] AND W. K. REISEN[1,4]

Summary:

1. No apparent host-preference [all <15%]
2. Host selection based on contact in environment
3. Influenced by flight paths
4. High host diversity causes dilution effect of blood meals among less competent hosts and reduces transmission efficiency
5. May explain low level of spill over transmission to humans





Use of Scented Sugar Bait Stations to Track Mosquito-Borne Arbovirus Transmission in California

HUGH D. LOTHROP, SARAH S. WHEELER, YING FANG, AND WILLIAM K. REISEN[1]

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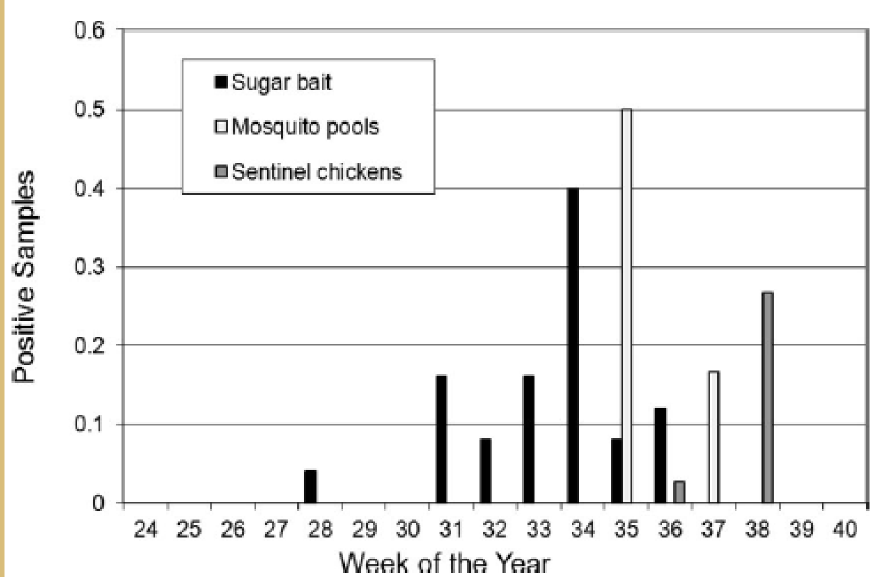
J. Med. Entomol. 49(6): 1466–1472 (2012); DOI: http://dx.doi.org/10.1603/ME12117

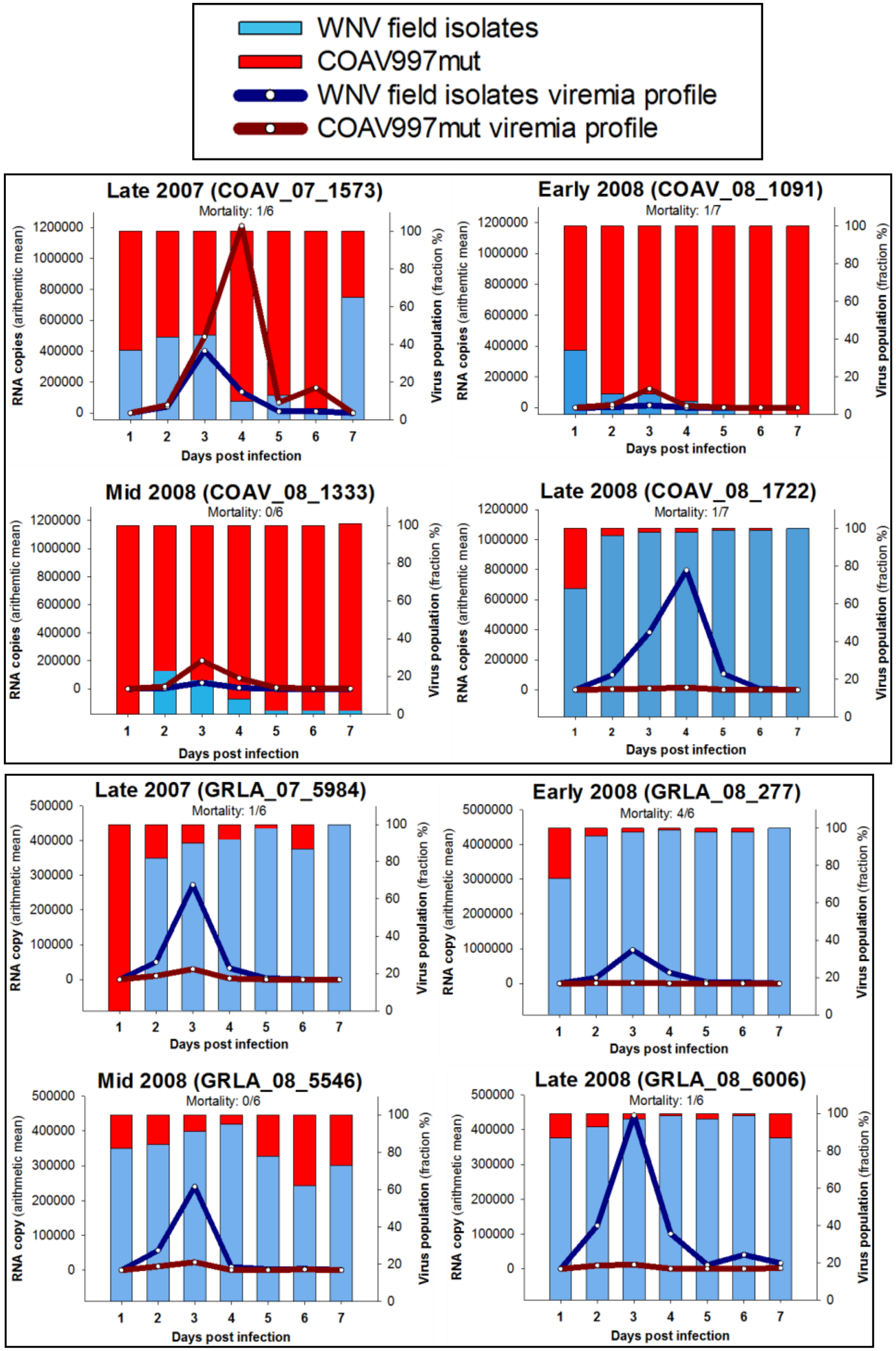


Summary:

1. Infected mosquitoes expectorate and defecate virus while sugar feeding
2. RNA but not live virus can be recovered from sugar wicks
3. Tests of wicks baited with sugar and phenyl acetaldehyde detected WNV in the laboratory and field

Table 3. Number of weekly sugar bait samples testing positive by qRT-PCR compared with infection detected by testing mosquito pools by qRT-PCR and transmission determined by seroconversions in sentinel chickens deployed in the vicinity of bait stations in Coachella Valley, CA, during the virus activity period from Sept. to Oct. 2012

Site name	Sugar bait			Mosquito pools			Sentinel chickens		
	Samples tested	WNV pos	%	Pools tested	WNV pos	%	Chickens tested	WNV aby pos	%
Adhor duck club	45	8	18%	19	1	5%	10	10	100%
North Shore State Park	55	7	13%	2	0	0%	10	0	0%
Gordons Ranch	65	6	9%	14	2	14%	10	6	60%
Jessup Ranch	55	4	7%	12	0	0%	10	0	0%
Cook St. sewer plant	55	1	2%	23	0	0%	10	0	0%
Total	275	26	9%	70	3	4%	50	16	32%

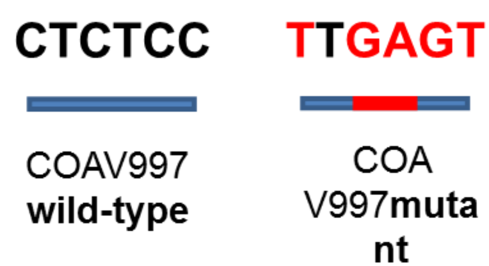


Comparative fitness of recent West Nile virus isolates from California after competitive replication in avian and vector hosts.

Worwa et al. unpublished

Summary:

1. Used site directed mutagenesis to label the invading strain of WNV from Imperial
2. Developed assay to quantify amount of each virus present
3. Competed WT vs labeled by inoculating 1:1 into House finches and *Cx. tarsalis*
4. Coachella Valley strains have become less competitive than founding strain whereas rest of California strains look like GRLA data.
5. Less difference in mosquitoes.
6. Role of temperature sensitive mutation in founding strain



Some translational products

- Tracking arboviruses in nature
  - Mosquito and chicken sampling
  - Importance of early warning
  - Measuring dispersion: when and where to control
  - Fructose feeding [future research with Sandia]
- Arbovirus ecology
  - Vector competence
  - Host competence and infection in nature
  - Migratory bird studies
  - Overwintering studies: where but not how?
  - Host selection and transmission efficiency
  - Viral evolution: phenotype and genetic sequences
- Control
  - Adulticiding
    - Impact of hot dry conditions on adulticiding
    - Importance of landscape feature in swath and penetration
  - Barrier spray – limited success
  - Sucrose baits for adults [stay tuned]

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