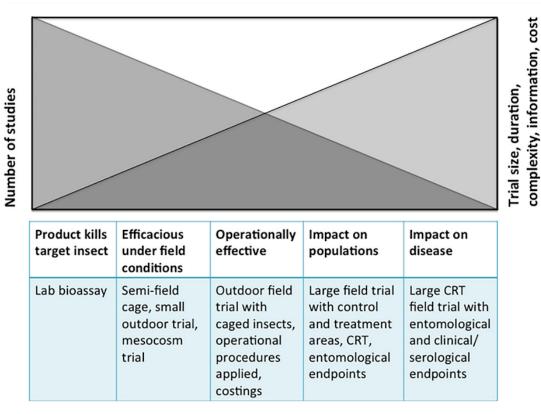
Transient tolerance to pyrethroids in gravid mosquitoes: Implications for viral transmission and ULV control

Mark Clifton PhD· North Shore Mosquito Abatement District Chris Xamplas· North Shore Mosquito Abatement District Roger Nasci PhD· Vector-Borne Disease Consulting LLC Justin Harbison PhD· Loyola University-Chicago

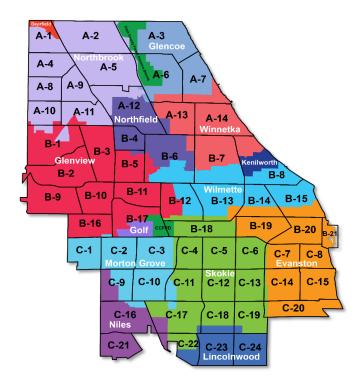
Studies examining the effect of ULV on natural populations are rare

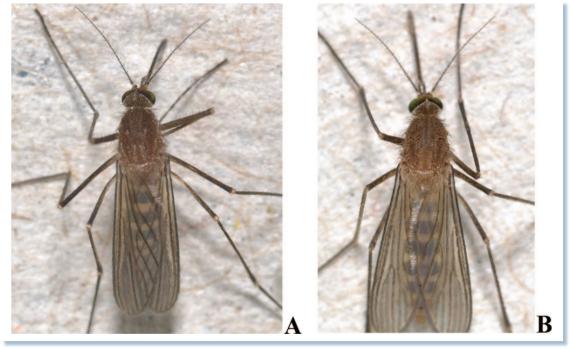


Ritchie, S. A., & Devine, G. (2016). Conventional vector control: evidence it controls arboviruses. Arboviruses: molecular biology, evolution and control, 281-290.

What makes up a population of mosquitoes?

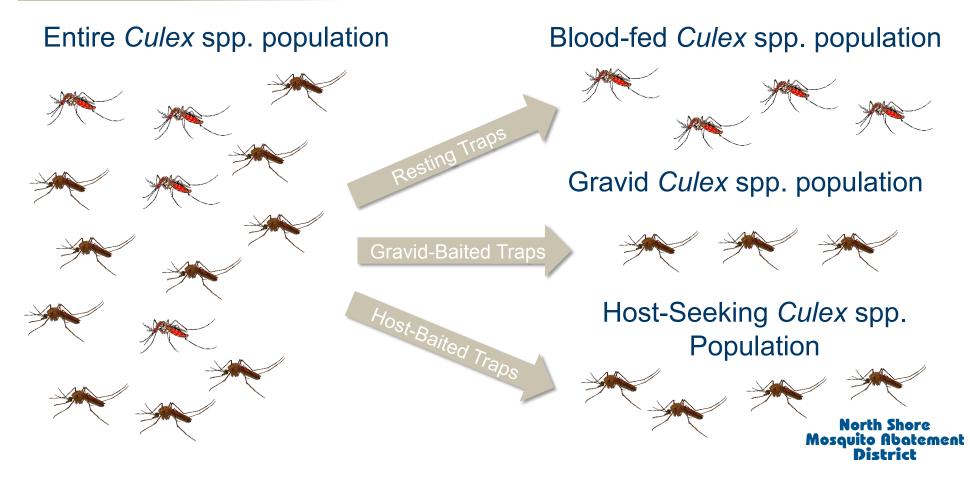
Culex restuans (Theobald) and Culex pipiens (Linnaeus)





(A) *Culex restuans* and (B) *Culex pipiens.* Harrington, L.C., & Poulson, R.L. (2008) Considerations for Accurate Identification of Adult *Culex restuans* (Diptera: Culicidae) in Field Studies, 1-8.

A natural mosquito population consists of many different subpopulations



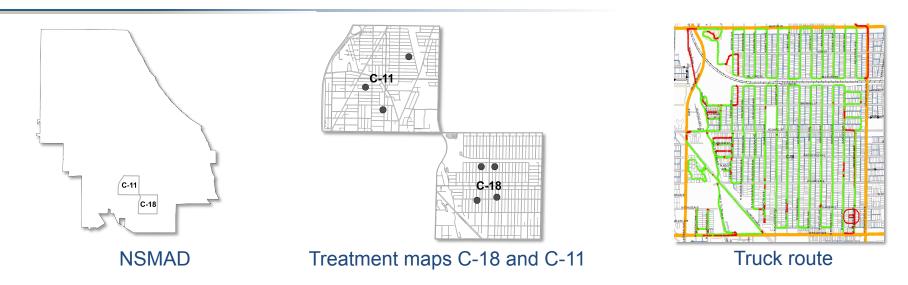
Objective: Observe a "natural population" during and after a ULV treatment

Host-Seeking BG-Counter

Gravid BG-Counter

Catch m BG-Bag Counter Fan CO₂ in CO_2 out BG-Counter Fan C Water/Alfalfa Infusion **BG-** Sentinel 2 12 VDC

Study location, trap placement, and ULV treatments



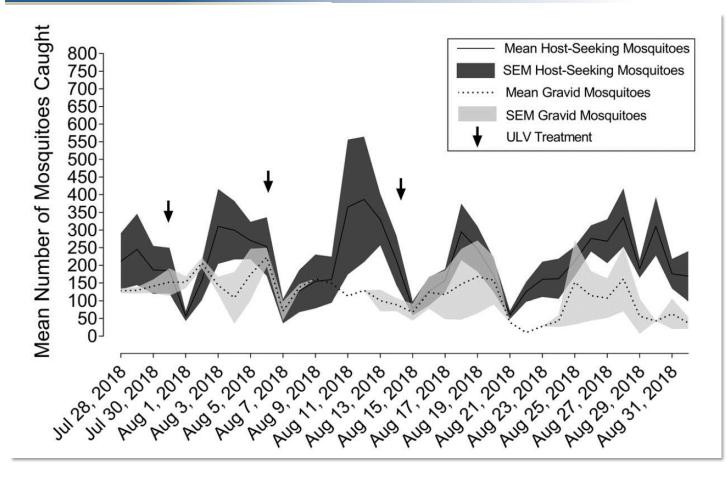
□ Treatment areas C-11 and C-18 in Skokie, Illinois.

□ 4 Treatments occurred on 7/12/2018, 7/31/2018, 8/6/2018, and 8/14/2018.

□ DuetTM was applied at 1.25 oz/acre (Near maximum label rate) by Clarke ULV Cougar.

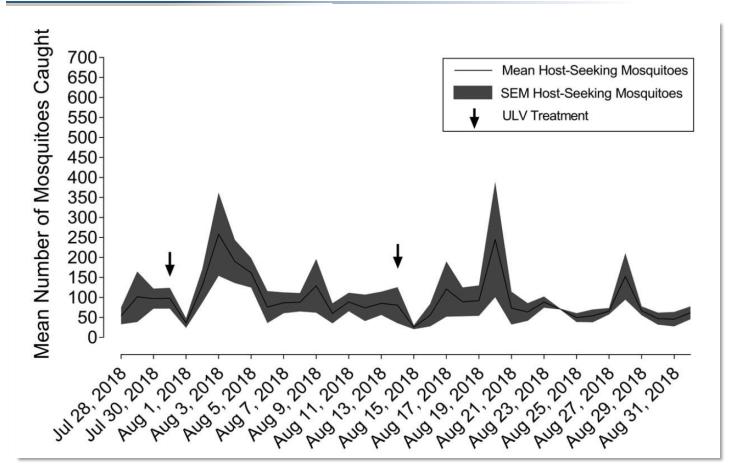
□ BG-Counters were monitored continuously from 7/11/2018 through 8/31/2018.

Host-seeking and gravid mosquito abundance in C-18



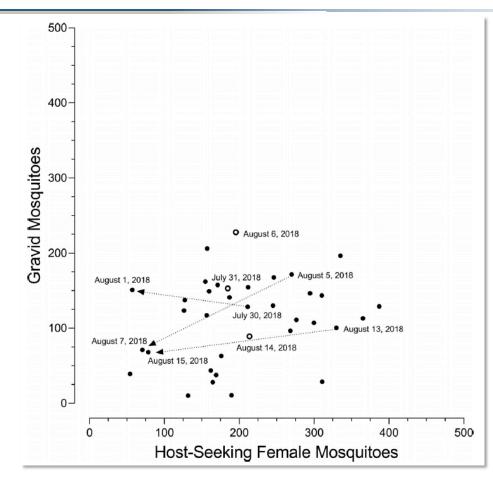
- ULV treatments produced a decline in host-seeking abundance followed by a rebound.
- The effect on gravid mosquitoes was variable.

Host-seeking mosquito abundance in C-11



ULV treatments again produced a decline in host-seeking abundance followed by a rebound

Host-seeking vs. gravid mosquitoes after treatment



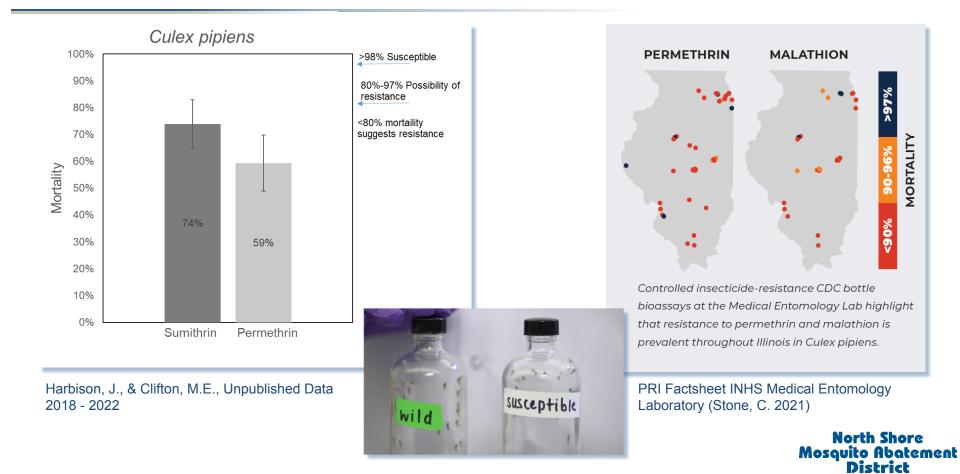
- □ Bivariate plot of host-seeking female mosquitoes and gravid mosquitoes from study site C-18.
- Open circles represent host-seeking and gravid population on day of treatment.
- Arrows connect population of mosquitoes 24h prior to treatment with mosquito population 24h posttreatment to show differential effect of ULV treatments on gravid and host-seeking mosquitoes.

Summary of results

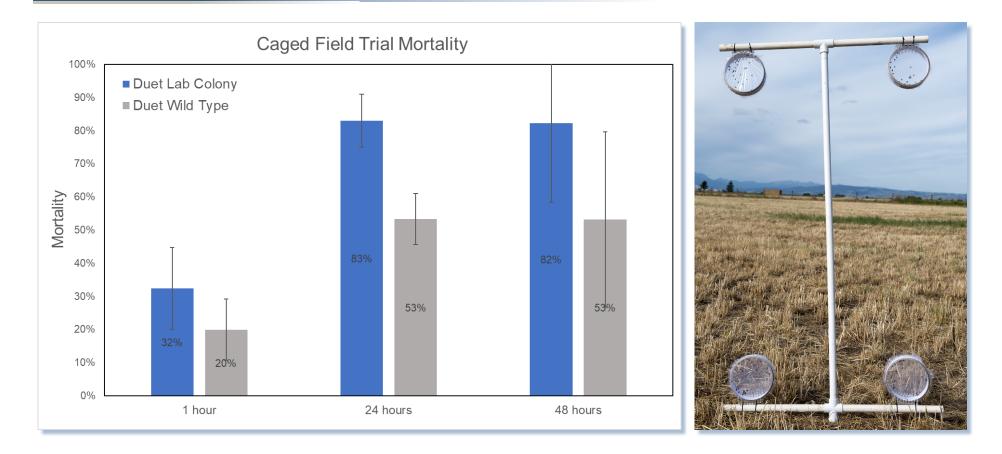
		24 h pretrea	tment	24 h	posttr	eatment	72 h	posttr	eatment
Study site	Treatment date	Total mosquitoes	No. of traps	Total mosquitoes	No. of traps	% change from 24 h pretreatment	Total mosquitoes	No. of traps	% change from 24 h posttreatment
Host-seeking mose	uitoes								
C-11	Jul. 31, 2018	294	3	108	3	-63.3	774	3	616.7
C-18	Jul. 31, 2018	739	4	228	4	-69.1	931	4	308.3
C-18	Aug. 6, 2018	759	3	282	4	-62.8	619	4	119.5
C-11	Aug. 14, 2018	242	3	77	3	-68.2	363	3	371.4
C-18	Aug. 14, 2018	855	4	314	4	-63.3	626	4	99.4
Mean % change ± SEM Gravid mosquitoes						-65.3 ± 1.4		-	303.1 ± 94.4
C-18	Jul. 12, 2018	578	4	584	4	1.0	465	4	-20.4
C-11	Jul. 31, 2018	160	1	97	1	-39.4	57	1	-41.2
C-18	Jul. 31, 2018	305	2	304	2	-0.3	287	2	-5.6
C-18	Aug. 6, 2018	446	$\frac{2}{2}$	142	$\frac{2}{2}$	-68.2	162	1	14.1
C-11	Aug. 14, 2018	96	ĩ	53	ĩ	-44.8	61	1	15.1
C-18	Aug. 14, 2018	178	2	136	2	23.6	234	2	72.1

- Host-seeking Culex spp. were only marginally controlled at full label rate (~65% reduction).
- Gravid *Culex* spp. were poorly controlled at max label rate (~29% reduction).
- Host-seeking mosquitoes rebounded by ~300% post treatment.
- Gravid mosquitoes showed a modest and variable rebound (~6%).

Back to the basics: CDC bottle bioassay



Back to the basics II: Caged field trials



Bottle bioassay vs. caged field trial vs. natural population

	CDC Bottle Bioassay	Caged Field Trial	Natural Population
North Shore Resistant Host- Seeking Mosquito Mortality	74%	53%	65%
1			







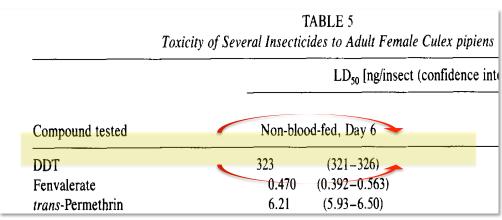
Summary of results

$\begin{array}{cccccccccccccccccccccccccccccccccccc$			24 h pretrea	tment	24 h	posttr	eatment	72 h	posttr	eatment
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Study site			of		of	from 24 h		of	from 24 h
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Host-seeking mos	quitoes								
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	C-11	Jul. 31, 2018	294	3	108	3	-63.3	774	3	616.7
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	C-18	Jul. 31, 2018	739	4	228	4	-69.1	931	4	308.3
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	C-18	Aug. 6, 2018	759		282		-62.8	619	4	119.5
Mean % change \pm SEM -65.3 ± 1.4 303.1 ± 94.4 Gravid mosquitoesC-18Jul. 12, 2018578458441.04654 -20.4 C-11Jul. 31, 20181601971 -39.4 571 -41.2 C-18Jul. 31, 201830523042 -0.3 2872 -5.6 C-18Aug. 6, 201844621422 -68.2 162114.1C-11Aug. 14, 2018961531 -44.8 61115.1	C-11	Aug. 14, 2018	242	3	77	3	-68.2	363	3	371.4
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	C-18	Aug. 14, 2018	855	4	314	4	-63.3	626	4	99.4
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	\pm SEM						-65.3 ± 1.4			303.1 ± 94.4
			578	4	584	4	1.0	465	4	-20.4
C-18Jul. 31, 201830523042-0.32872-5.6C-18Aug. 6, 201844621422-68.2162114.1C-11Aug. 14, 2018961531-44.861115.1				1		i			i	
C-18Aug. 6, 201844621422-68.2162114.1C-11Aug. 14, 2018961531-44.861115.1				2		2			2	
C-11 Aug. 14, 2018 96 1 53 1 -44.8 61 1 15.1									1	
									1	
	C-18	Aug. 14, 2018	178	2	136	2		234	2	72.1

Why are gravid mosquitoes so poorly controlled?

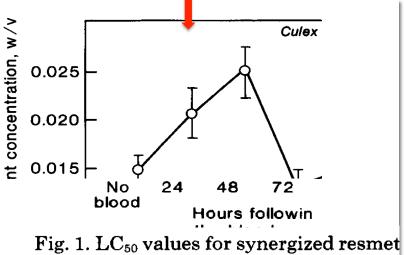
Mosquitoes develop a transient resistance post-bloodmeal

Why Does DDT Toxicity Change After a Blood Meal in Adult Female *Culex pipiens*?



Halliday and Feyereisen, Pesticide Biochemistry and Physiology. 28, 172-181. 1987.

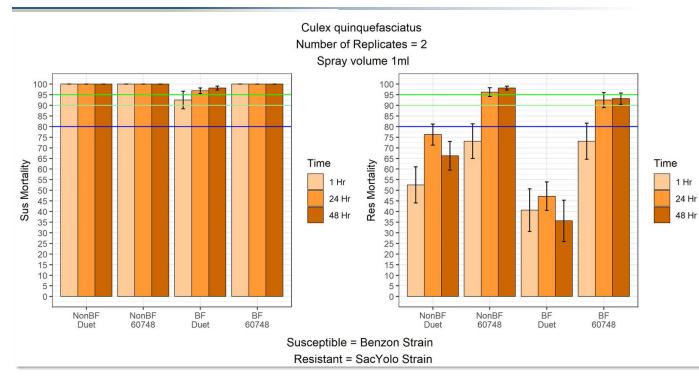
Nearly two times the amount of material is needed to kill mosquitoes 24-48 hours after a blood meal. Apparent Influence of the Stage of Blood Meal Digestion on the Efficacy of Ground Applied ULV aerosols for the Control of Urban *Culex* Mosquitoes. II: Laboratory Evidence.



ing a blood meal in 3 genera of mosquitoe represent 95% confidence levels for the p

Eliason et al., Journal of the American Mosquito Control Association. 6 (3) 371-376. 1990.

Wind-tunnel assays and post-bloodmeal resistance



Clifton, M.E. & Kesavaraju, B. Unpublished. 2021.

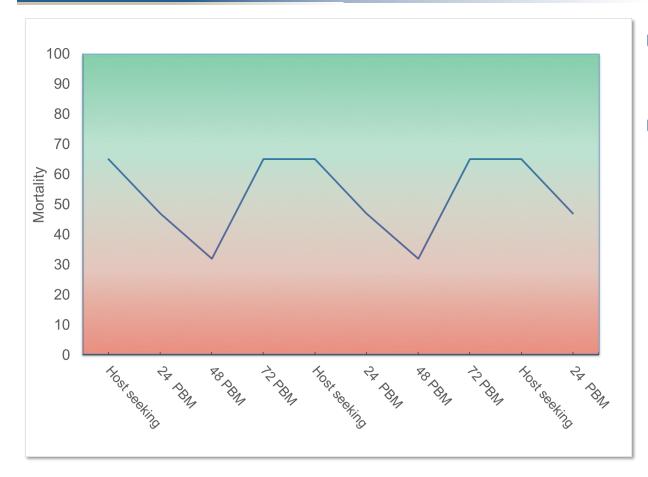
- Blood feeding had minor impacts on susceptible mosquitoes with PBO synergist/formulated product.
- Resistant mosquitoes showed reduced susceptibility to formulated/synergized product.
- □ 48 hours PBM mortality dropped from ~66% to ~35%.
- VB 60748 remained effective in gravid and resistant mosquitoes.

Post-bloodmeal mosquitoes exhibit half the mortality

	CDC Bottle Bioassay	Caged Field Trial	Wind Tunnel	Natural Population
Resistant Host- Seeking mosquito mortality	74%	53%	66%	65%
Resistant Post- bloodmeal mosquito mortality	-	-	35%	29%

□ When resistant mosquitoes are gravid they are <u>half</u> as susceptible to synergized pyrethroid.

Mosquitoes cycle through various levels of susceptibility



- Culex spp. mosquitoes spend about half of each gonotrophic cycle with reduced susceptibility.
- The mosquitoes most likely to be infected with a virus (postbloodmeal) are the least likely to be controlled.

Understanding the effect of gravid tolerance with a simple model

	New Mosquitoes	119	92	96	87	85	107	103	90	87	80	94	113	104
Age of Mosquito	Days in Model	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Newly Emerged Day 1	119	92	96	87	85	107	103	90	87	80	94	113	104
2	Newly Emerged Day 2		113	87	91	83	81	102	98	86	83	76	89	107
3	Blood Fed 24 hours			102	79	82	75	73	92	88	77	75	69	81
4	Blood fed 48 hours				87	68	71	64	62	79	76	66	64	59
5	Blood fed 72 hours					71	55	57	52	51	64	62	54	52
6	Return to Host-seeking 1						55	43	44	40	39	50	48	42
7	Return to Host-seeking 2							34	31	33	30	29	36	35
8	Blood Fed 24 hours								24	22	23	21	20	25
9	Blood fed 48 hours									16	15	15	14	13
10	Blood fed 72 hours										9	9	9	8
11	Return to Host-seeking 1											5	5	5
12	Return to Host-seeking 2												3	3
13	Blood Fed 24 hours													1
14	Blood fed 48 hours													
15	Blood fed 72 hours													
16	Return to Host-seeking 1													
17	Return to Host-seeking 2													
18	Blood Fed 24 hours													
19	Blood fed 48 hours													
20	Blood fed 72 hours													
	Total mosquitoes	574	565	559	545	529	537	536	530	522	506	507	527	537
	Potentially Infected Mosquitoes	360	360	376	367	362	350	331	342	349	344	337	324	326

ULV Model adapted from: Moore, C. G., et al. "Apparent influence of the stage of blood meal digestion on the efficacy of ground applied ULV aerosols for the control of urban Culex mosquitoes. III. Results of a computer simulation." *Journal of the American Mosquito Control Association* 6.3 (1990): 376-383.

- A random number of mosquitoes between 75 and 125 enters the model each day
- Mosquitoes move diagonally through the model
- Each mosquito has a 95% daily survival probability
- Mosquitoes cycle through gonotrophic states
- A ULV treatment can be simulated by assigned mortality values to each gonotrophic state.

Modeling the effect of ULV on susceptible mosquitoes with 95% efficacy

Stage	Mortality						UL	νт	rea	atm	nen	t tc) รเ	JS	cep	otib	le	mo	sa	uito	bes									
Host-seeking	95%														or a															
Blood fed 24hr	95%									,,,							g													
Blood fed 48hr	95%																													
Blood fed 72hr	95%																													
	New Mosquitoes	115	118 124	100	94	125	90	103	116	87	120	77	100	94	103	100	118	83	104	111	77	76	103	79	109	101	123	89	122	96
Age of Mosquito	Days in Model	1	2 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Newly Emerged Day 1	115	118 124	100	94	125	90	103	116	87	120	77	100		103		118	83	104	111	77	76	103	79	109	101	123	89	122	96
	Newly Emerged Day 2		109 112	118	95	89	119	86	98	110	83	114		5	4	98	95	112	79	99	105	73	72	98	75	104	96	117	85	116
	Blood Fed 24 hours		99	101	106	86	81	107	77	88	99	75	103	3	4	4	88	86	101	71	89	95	66	65	88	68	93	87	105	76
	Blood fed 48 hours			85	87	91	74	69	92	66	76	85	64	4	3	4	3	76	74	87	61	76	82	57	56	76	58	80	74	90
-	Blood fed 72 hours				69	71	74	60	56	75	54	62	69	3	4	2	3	3	62	60	71	50	62	66	46	46	62	47	65	60
	Return to Host-seeking 1					53	55	57	46	44	58	42	48	3	2	3	2	2	2	48	46	55	38	48	51	36	35	48	37	50
	Return to Host-seeking 2						34	40	42	34	32	43	31	2	2	1	2	1	2	2	35	34	40	28	35	38	26	26	35	27
	Blood Fed 24 hours							24	28	29	24	22	30	1	1	1	1	1	1	1	1	24	24	28	20	25	26	18	18	24
	Blood fed 48 hours								16	19	20	16	15	1	1	1	1	1	1	1	1	1	16	16	19	13	16	18	12	12
	Blood fed 72 hours									9	11	12	9	0	1	0	0	1	0	1	0	0	0	10	9	11	8	10	10	7
	Return to Host-seeking 1										5	6	(0	0	0	0	0	0	0	0	0	0	0	6	5	6	4	6	6
	Return to Host-seeking 2											3	3	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	2	3
	Blood Fed 24 hours												1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	1
	Blood fed 48 hours Blood fed 72 hours													U		0	0	0	0	0	0	0	0	0	0	0	0			
16	Return to Host-seeking 1														0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	Return to Host-seeking 2															0		0	0	0	0	0	0	0	0	0	0	0	0	0
	Blood Fed 24 hours																0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Blood fed 48 hours																	0	lõ	0	0	0	0	0	0	0	0	0	0	õ
	Blood fed 72 hours																		0	lõ	0	0	0	0	0	0	0	0	0	0
20	Total mosquitoes	 570	587 609	604	591	609	586	582	592	573	587	559	555	27	125	215	315	366	426	480	488	485	505	496	515	524	555	549	575	572
	Potentially Infected Mos	 	360 372												18	18												343		

Modeling the effect of ULV on resistant mosquitoes with variable efficacy

StageMortalityHost-seeking65%Blood fed 24hr47%Blood fed 24hr29%Blood fed 72hr65%New MosquitoesAge of MosquitoDays in Model1Newly Emerged Day2Newly Emerged Day3Blood Fed 24 hours4Blood Fed 24 hours5Blood fed 72 hours6Return to Host-seekin7Return to Host-seekin																															
Blood fed 24hr 47% Blood fed 48hr 29% Blood fed 72hr 65% Age of Mosquito Days in Model 1 Newly Emerged Day 2 Newly Emerged Day 3 Blood fed 24 hours 4 Blood fed 72 hours 5 Blood fed 72 hours 6 Return to Host-seekin 7 Return to Host-seekin										_						_															
Blood fed 48hr 29% Blood fed 72hr 65% New Mosquitoes Age of Mosquito Days in Model 1 Newly Emerged Day 2 Newly Emerged Day 3 Blood Fed 24 hours 4 Blood fed 48 hours 5 Blood fed 72 hours 6 Return to Host-seekin 7 Return to Host-seekin								l	JLV	Tr	ea	tme	ent	to	res	sist	tan	t													
Blood fed 48hr 29% Blood fed 72hr 65% New Mosquitoes Age of Mosquito Days in Model 1 Newly Emerged Day 2 Newly Emerged Day 3 Blood Fed 24 hours 4 Blood fed 48 hours 5 Blood fed 72 hours 6 Return to Host-seekin 7 Return to Host-seekin								n	າວຣ	qu	itoe	es	wit	h a	va	ria	ble	m	orta	ality	y										
Blood fed 72hr 65% New Mosquitoes Age of Mosquito 1 Newly Emerged Day 2 Newly Emerged Day 3 Blood Fed 24 hours 4 Blood fed 48 hours 5 Blood fed 72 hours 6 Return to Host-seekin 7 Return to Host-seekin								p	ost	-bl	00	dm	ea							-											
New MosquitoesAge of MosquitoDays in Model1Newly Emerged Day2Newly Emerged Day3Blood Fed 24 hours4Blood fed 48 hours5Blood fed 72 hours6Return to Host-seekin7Return to Host-seekin								1-		-		-			➡																
Age of MosquitoDays in Model1Newly Emerged Day2Newly Emerged Day3Blood Fed 24 hours4Blood fed 48 hours5Blood fed 72 hours6Return to Host-seekin7Return to Host-seekin																															
1 Newly Emerged Day 2 Newly Emerged Day 3 Blood Fed 24 hours 4 Blood fed 48 hours 5 Blood fed 72 hours 6 Return to Host-seekin 7 Return to Host-seekin		85	117	114	83	100	98	106	99	98	102	121	119	90	115	75	106	113	120	95	123	95	79	125	113	122	90	76	99	109	106
2 Newly Emerged Day 3 3 Blood Fed 24 hours 4 Blood fed 48 hours 5 Blood fed 72 hours 6 Return to Host-seekin 7 Return to Host-seekin		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
3 Blood Fed 24 hours 4 Blood fed 48 hours 5 Blood fed 72 hours 6 Return to Host-seekin 7 Return to Host-seekin	1	85	117	114	83	100	98	106	99	98	102	121	119	00	40	75	106	113	120	95	123	95	79	125	113	122	90	76	99	109	106
4 Blood fed 48 hours 5 Blood fed 72 hours 6 Return to Host-seekin 7 Return to Host-seekin	2				108	79	95	93	101	94	93	97	115			38	71	101	107	114	90	117	90	75	119	107	116	86	72	94	104
5 Blood fed 72 hours 6 Return to Host-seekin 7 Return to Host-seekin					100	98	71	86	84	91	85	84	87		-	27	35	64	91	97	103	81	105	81	68	107	97	105	77	65	85
6 Return to Host-seekin 7 Return to Host-seekin						86	84	61	74	72	78	73	72	75	63	46	23	30	55	78	83	88	70	90	70	58	92	83	90	66	56
7 Return to Host-seekin						51	70	68	50	60	59	63	59	59	21	51	38 1		24	45	63	68	72	57	74	57	47	75	68	73	54
The full to Hose Seekin	<u> </u>						39	54	53	38	46	45	49	46	16	17	40	29	15	19	35	49	52	56	44	57	44	37	58	52	57
	ng 2							34	40	39	28	34	33	36	12	12	12	29	21	11	14	26	36	38	41	32	42	32	27	43	38
8 Blood Fed 24 hours									24	28	27	20	24	23	13	8	8	8	20	15	7	10	18	25	27	29	23	29	23	19	30
9 Blood fed 48 hours										16	18	18	13	16	11	9	5	5	6	14	10	5	6	12	17	18	19	15	19	15	12
10 Blood fed 72 hours											9	11	11	8	3	7	5	3	3	3	8	6	3	4	7	10	11	11	9	12	9
11 Return to Host-seekin												5	6	6	2	2	4	3	2	2	2	5	3	2	2	4	6	6	6	5	7
12 Return to Host-seekin	ng 2												3	3	1	1	1	2	2	1	1	1	2	2	1	1	2	3	3	3	3
13 Blood Fed 24 hours 14 Blood fed 48 hours														1		1	0	1	1	1	1	1	1	1	1	0	1	1	2	2	2
15 Blood fed 72 hours																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 Return to Host-seekin	ng 1															0	lõ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 Return to Host-seekin																	0	lõ	0	0	0	0	0	0	0	0	0	0	0	0	0
18 Blood Fed 24 hours	ng z																	0	l o	0	0	0	0	0	0	0	0	0	0	0	0
19 Blood fed 48 hours																			0	l õ	0	0	0	0	0	0	õ	0	0	0	õ
20 Blood fed 72 hours																					0	0	0	0	0	0	0	0	0	0	õ
Total mosquitoes		540	557	572	554	554	552	562	560	556	557	577	595	582	268	294	349	408	468	494	541	551	539	569	583	604	589	559	554	559	563
Potentially Infected	Mosquitoes																														

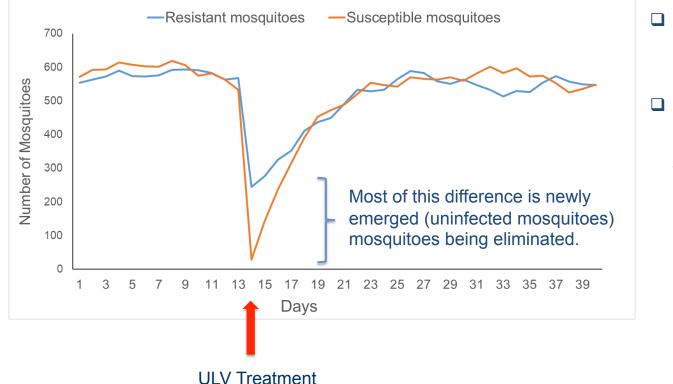
Susceptible vs resistant mosquitoes with gravid tolerance

		1		101	100		105		100	110		100 7	-		100			0.0	101			70	100	70	100		100	0.0	100	0.0
	New Mosquitoes	115		124			125	90		116		120 7		00 94		3 100	_	_	104		-	76	103				123			_
Age of Mosquito		1	2	3	4	5	6	/	8	-	10			3 14	15	16	17	18	19	20	21	22	23	24	25	26	27		_	30
1	Newly Emerged Day 1	115		124			125					120 7		00 5	103			83	104			76	103		109				122	
2	Newly Emerged Day 2		109	112			89	119	86					3 5	4	98	95	112	79	99	105		72	98	75	104				116
3	Blood Fed 24 hours			99		106		81	107					03 3	4	4	88	86	101	71	89	95	66	65	88	68	93		105	
4	Blood fed 48 hours				85	87	91	74	69				_	4 4	3	4	3	76	74	87	61	76	82	57	56	76	58			90
5	Blood fed 72 hours					69	71	74	60				_	9 3	4	2	3	3	62	60	71	50	62	66	46	46	62			60
6	Return to Host-seeking 1						53	55	57					8 3	2	3	2	2	2	48	46	55	38	48	51	36	35			50
7	Return to Host-seeking 2							34	40				3 3		2	1	2	1	2	2	35	34	40	28	35	38	26			27
8	Blood Fed 24 hours								24	_			_	30 1	1	1	1	1	1	1	1	24	24	28	20	25	26			24
9	Blood fed 48 hours													5 1	1	1	1	1	1	1	1	1	16	16	19	13	16			12
10	Blood fed 72 hours												2 9	0	1	0	0	1	0	1	0	0	0	10	9	11	8			7
11	Return to Host-seeking 1											5 6		0	0	0	0	0	0	0	0	0	0	0	6	5	6	4		6
12	Return to Host-seeking 2											3	3	5 0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	2	3
13	Blood Fed 24 hours												1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	1
14	Blood fed 48 hours													0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
15	Blood fed 72 hours														0	0	0	0	0	0	0	0	0	0	0	0	0	0	•	0
16	Return to Host-seeking 1															0	0	0	0	0	0	0	0	0	0	0	0	0	•	0
17	Return to Host-seeking 2																0		0	0	0	0	0	0	0	0	0	0	× .	0
18	Blood Fed 24 hours																	0	0	0	0	0	0	0	0	0	0	0	· ·	0
19	Blood fed 48 hours																		0	0	0	0	0	0	0	0	0	0	-	0
20	Blood fed 72 hours																			0	0	0	0	0	0	<u> </u>	0	0	0	0
	Total mosquitoes			609	604	591	609	586	582	592	573	587 5	59 5	55 27	125	215	315	366	426	480	488	485	505	496	515	524				
	Potentially Infected Mosquitoes	360	360	372	386	402	395	377	394	378	376	385 3	68 3	882 18	18	18	102	171	243	270	305	336	330	319	331	320) 336	343	368	360
			-																											
	New Mosquitoes	85		114	_	100		106				121 1			75	-	113			123			125	_	_		76			106
Age of Mosquito	Days in Model	85 1	2	3	4	5	6	106 7	8	9	10	11 1	2 1	3 14	15	106 16	113 17	120 18	95 19		21		125 23	113 24	122 25	90 26	76 27	28	29 3	30
1	Days in Model Newly Emerged Day 1			3	4 83	5 100	6 98	7 106	8 99	9 98	10 102	11 1 121 1	2 1 19 9	3 14 0 40	15 75	-	17	18	19			22 79	23 125	_	_			28 99	29 3 109 1	30 106
1 2	Days in Model Newly Emerged Day 1 Newly Emerged Day 2	1	2	3 114 111	4 83 108	5 100 79	6 98 95	7 106 93	8 99 101	9 98 94	10 102 93	11 1 121 1 97 1	2 1 19 9 15 1	3 14 0 40 13 30	15 75 38	16 106 71	17 113 101	18	19	20	21	22	23	24	25	26	27	28 2 99 2 72 9	29 3 109 1 94 1	30 106 104
1 2 3	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours	1	2	3 114	4 83 108 100	5 100 79 98	6 98 95 71	7 106	8 99	9 98 94 91	10 102 93 85	11 1 121 1 97 1 84 8	2 1 19 9 15 1 7 1	3 14 0 40 13 30 04 54	15 75 38 27	16	17 113 101 64	18	19	20 123	21	22 79	23 125	24 113	25	26	27 76	28 2 99 2 72 9	29 3 109 1 94 1 65 8	30 106 104 85
1 2 3 4	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours	1	2	3 114 111	4 83 108	5 100 79 98 86	6 98 95 71 84	7 106 93 86 61	8 99 101 84 74	9 98 94 91 72	10 102 93 85 78	11 1 121 1 97 1 84 8 73 7	2 1 19 9 15 1 7 1 2 7	3 14 0 40 13 30 04 54 5 63	15 75 38 27 46	16 106 71	17 113 101 64 30	18	19	20 123	21 95 117 81 88	22 79	23 125	24 113 119	25	26	27 76	28 2 99 7 72 9 77 90	29 3 109 1 94 1 65 8 66 5	30 106 104 85 56
1 2 3	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours	1	2	3 114 111	4 83 108 100	5 100 79 98	6 98 95 71	7 106 93 86 61 68	8 99 101 84 74 50	9 98 94 91 72 60	10 102 93 85 78 59	11 1 121 1 97 1 84 8 73 7 63 5	2 1 19 9 15 1 7 1 2 7 9 5	3 14 0 40 13 30 04 54 5 63 9 21	15 75 38 27	16 106 71 35	17 113 101 64	18 120 107 91	19	20 123	21 95 117	22 79 90 105	23 125 75 81	24 113 119 68	25 122 107 107	26 90 116 97	27 76 86 105	28 2 99 7 72 9 77 90	29 3 109 1 94 1 65 8 66 5 73 5	30 106 104 85 56 54
1 2 3 4 5 6	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 48 hours Return to Host-seeking 1	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84	7 106 93 86 61 68 54	8 99 101 84 74 50 53	9 98 94 91 72 60 38	10 102 93 85 78 59 46	11 1 121 1 97 1 84 8 73 7 63 5 45 4	2 1 19 9 15 1 7 1 2 7 9 5 9 4	3 14 0 40 13 30 04 54 5 63 9 21 6 16	15 75 38 27 46 51 17	16 106 71 35 23 38 40	17 113 101 64 30 19 29	18 120 107 91	19	20 123	21 95 117 81 88	22 79 90 105 70 72 52	23 125 75 81 90 57 56	24 113 119 68	25 122 107 107 58 57 57	26 90 116 97 92 47 44	27 76 86 105 83 75 37	28 2 99 7 72 9 77 9 68 7 58 9	29 3 109 1 94 1 65 8 66 5 73 5	30 106 104 85 56 54 57
1 2 3 4 5 6 7	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39	10 102 93 85 78 59 46 28	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3	2 1. 19 9 15 1 7 1 2 7 9 5 9 4 3 3	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12	15 75 38 27 46 51	16 106 71 35	17 113 101 64 30 19	18 120 107 91 55 24	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32	26 90 116 97 92 47 44 42	27 76 86 105 83 75 37 32	28 2 99 72 77 9 90 6 58 2	29 3 109 1 94 1 65 8 66 5 73 5 52 5 43 3	30 106 104 85 56 54 57 38
1 2 3 4 5 6 7 8	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53	9 98 94 91 72 60 38 39 28	10 102 93 85 78 59 46 28 27	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8	17 113 101 64 30 19 29	18 120 107 91 55 24	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52	23 125 75 81 90 57 56	24 113 119 68	25 122 107 107 58 57 57	26 90 116 97 92 47 44 42 23	27 76 86 105 83 75 37 32 29	28 2 99 72 77 9 68 7 58 2 23 2	29 3 109 1 94 1 65 8 66 5 73 5 52 8 43 3 19 3	30 106 104 85 56 54 57 38 30
1 2 3 4 5 6 7 8 9	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood Fed 48 hours	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8 5	17 113 101 64 30 19 29	18 120 107 91 55 24 15 21 20 6	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32	26 90 116 97 92 47 44 42 23 19	27 76 86 105 83 75 37 32	28 99 72 97 90 68 58 27 23 19	29 3 109 1 94 1 65 8 66 5 73 5 52 5 43 3 19 3 15 1	30 106 104 85 56 54 57 38 300 112
1 2 3 4 5 6 7 8 9 10	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8	17 113 101 64 30 19 29	18 120 107 91 55 24	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32	26 90 116 97 92 47 44 42 23	27 76 86 105 83 75 37 32 29	28 2 99 7 72 9 77 9 68 7 58 2 23 1 9 9	29 3 109 1 94 1 65 8 66 5 73 5 52 5 43 3 19 3 15 1 12 9	30 106 104 85 56 54 57 38 30
1 2 3 4 5 6 7 8 9 10 11	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 24 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood fed 72 hours Return to Host-seeking 1	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1 5 6	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8 5	17 113 101 64 30 19 29	18 120 107 91 55 24 15 21 20 6	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32	26 90 116 97 92 47 44 42 23 19	27 76 86 105 83 75 37 32 29	28 2 99 72 77 9 68 7 58 2 27 4 90 9 68 7 90 9 68 7 90 9 60 9 60 9 60 9	29 3 109 1 94 1 65 8 66 5 52 5 43 3 19 3 15 1 12 9 5 1	30 106 104 85 56 54 57 38 30 12 9 7
1 2 3 4 5 6 7 8 9 10 11 12	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8 5	17 113 101 64 30 19 29	18 120 107 91 55 24 15 21 20 6	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32	26 90 116 97 92 47 44 42 23 19	27 76 86 105 83 75 37 32 29	28 2 99 72 77 9 68 7 23 23 19 9 6 3	29 3 109 1 94 1 65 8 66 5 52 5 43 3 19 3 15 1 5 7 3 3	30 106 104 85 56 57 38 30 12 9 7 3
1 2 3 4 5 6 7 8 9 10 11 12 13	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood fed 72 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1 5 6	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8 5	17 113 101 64 30 19 29	18 120 107 91 55 24 15 21 20 6	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32	26 90 116 97 92 47 44 42 23 19	27 76 86 105 83 75 37 32 29	28 2 99 72 77 9 68 7 23 23 19 9 6 3	29 3 109 1 94 1 65 8 66 5 52 5 43 3 19 3 15 1 5 7 3 3	30 106 104 85 56 54 57 38 30 12 9 7
1 2 3 4 5 6 7 8 9 10 11 12 13 14	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 24 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood Fed 24 hours Blood Fed 24 hours	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1 5 6	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8 5 5 4 1 0 0	17 113 101 64 30 19 29	18 120 107 91 55 24 15 21 20 6	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32	26 90 116 97 92 47 44 42 23 19	27 76 86 105 83 75 37 32 29	28 2 99 72 77 9 68 5 27 2 19 9 6 3 2 1	29 3 109 1 94 1 65 8 66 5 52 5 43 3 19 3 15 1 5 7 3 3 2 2 1 1	30 106 104 85 56 57 38 30 12 9 7 3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood Fed 24 hours Blood Fed 24 hours Blood Fed 24 hours Blood Fed 72 hours	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1 5 6	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8 5	17 113 101 64 30 19 29	18 120 107 91 55 24 15 21 20 6	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32	26 90 116 97 92 47 44 42 23 19	27 76 86 105 83 75 37 32 29	28 2 99 72 77 9 68 5 27 2 19 9 6 3 2 1 0 0	29 3 109 1 94 1 65 8 66 5 52 5 19 3 15 1 55 1 3 2 2 2 1 1 0 0	30 106 104 85 56 57 38 30 12 9 7 3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood fed 48 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood fed 48 hours Blood fed 48 hours Blood fed 72 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 1	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1 5 6	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8 5 5 4 1 0 0	17 113 101 64 30 19 29	18 120 107 91 55 24 15 21 20 6	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32	26 90 116 97 92 47 44 42 23 19	27 76 86 105 83 75 37 32 29	28 2 99 72 77 90 68 27 23 19 9 6 3 2 1 0 0 0	29 3 109 1 94 1 65 8 66 5 52 5 19 3 15 1 55 7 3 3 2 2 10 0 0 0	30 1 106 104 85 9 57 38 30 12 9 7 3 2 1 0 0 0
$\begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16 \\ 17 \\ \end{array}$	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 1 Return to Host-seeking 2	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1 5 6	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8 5 5 4 1 0 0	17 113 101 64 30 19 29	18 120 107 91 55 24 15 21 20 6	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32	26 90 116 97 92 47 44 42 23 19	27 76 86 105 83 75 37 32 29 15 11 6 3 1 0 0 0 0 0	28 2 99 72 77 90 68 27 23 19 9 6 3 2 1 0 0 0	29 3 109 1 94 1 65 8 66 5 52 5 43 3 19 3 2 2 1 1 0 0 0 0	30 3 106 104 85 56 56 57 57 38 30 12 9 7 3 2 1 0 0 0 0 0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood Fed 24 hours Blood Fed 72 hours Return to Host-seeking 1 Return to Host-seeking 1 Return to Host-seeking 1 Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1 5 6	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8 5 5 4 1 0 0	17 113 101 64 30 19 29	18 120 107 91 55 24 15 21 20 6	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 57 32 29 18 10 4 1 0 0 0 0 0 0 0 0 0 0 0	26 90 116 97 92 47 44 42 23 19	27 76 86 105 83 75 37 32 29 15 11 6 3 1 0 0 0 0 0 0 0 0	28 3 99 72 77 90 68 58 27 23 19 9 6 3 2 1 0 0 0 0	29 3 109 1 94 1 94 1 66 8 73 8 52 8 43 3 19 3 55 7 33 2 21 1 0 0 00 0 00 0	30 3 106 104 85 56 54 57 38 30 12 9 7 3 2 1 0 0 0 0 0 0 0 0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood fed 48 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 2 Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 2 Blood fed 72 hours Return to Host-seeking 2 Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood Fed 24 hours Blood Fed 24 hours	1	2	3 114 111	4 83 108 100	5 100 79 98 86	6 98 95 71 84 70	7 106 93 86 61 68 54	8 99 101 84 74 50 53 40	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1 5 6	2 1 19 9 15 1 7 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13	15 75 38 27 46 51 17	16 106 71 35 23 38 40 12 8 5 5 4 1 0 0	17 113 101 64 30 19 29	18 120 107 91 55 24 15 21 20 6	19	20 123	21 95 117 81 88 68	22 79 90 105 70 72 52 36	23 125 75 81 90 57 56 38	24 113 119 68 70 74 44 41	25 122 107 107 58 57 32 29 18 10 4 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 90 116 97 92 47 44 42 23 19	27 76 86 105 83 75 37 32 29 15 11 6 3 1 0 0 0 0 0 0 0 0 0 0 0	28 3 99 72 9 77 0 0 90 6 8 58 27 23 19 9 6 3 2 1 1 0 0 0 0 0 0 0 0	29 3 109 1 94 1 65 8 66 5 73 52 43 3 19 3 12 2 21 2 3 2 20 2 00 0 00 0 00 0 00 0	30 3 106 104 85 56 56 57 57 38 30 12 9 7 3 2 1 0 0 0 0 0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood Fed 72 hours Blood fed 72 hours Blood Fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood fed 48 hours Blood fed 72 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 1 Return to Host-seeking 1 Blood Fed 24 hours Blood Fed 24 hours Blood Fed 24 hours Blood Fed 48 hours Blood Fed 48 hours Blood Fed 72 hours Blood Fed 72 hours	1 85	2 117 81	3 114 111 73	4 83 108 100 62	5 100 79 98 86 51	6 98 95 71 84 70 39	7 106 93 86 61 68 54 34	8 99 101 84 74 50 53 40 24	9 98 94 91 72 60 38 39 28 16	10 102 93 85 78 59 46 28 27 18 9	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 21 18 11 1 5 6 3 3	2 1 19 9 15 1 7 9 5 9 4 2 3 3 4 2 3 1 8 6 3 3 1 8 6 3 1 1	3 14 0 40 13 30 04 54 5 63 9 21 3 13 6 12 3 13 6 12 3 13 6 11 3 2 1 1	15 75 38 27 46 51 17 12 8 9 7 2 1 1 0 0	16 106 71 35 23 38 40 12 8 5 5 5 4 1 0 0 0 0	17 113 101 64 30 19 29 8 5 3 3 2 1 0 0 0 0	18 120 107 91 55 24 15 21 20 6 3 2 2 1 0 0 0 0 0 0	19 95 114 97 78 45 19 11 15 14 3 2 1 1 1 0 0 0 0 0 0 0	20 123 90 103 83 63 35 14 7 10 8 2 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	21 95 117 81 88 68 49 26 10 5 6 5 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	22 79 90 105 70 72 52 36 18 6 3 3 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	23 125 75 81 90 57 56 38 25 12 4 2 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	24 113 119 68 70 74 44 41 27 7 2 1 1 1 0 0 0 0 0 0 0 0 0 0 0	25 122 107 107 58 57 32 29 18 10 4 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 90 116 97 92 47 44 42 23 19 11 6 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	27 76 86 105 83 75 37 32 29 15 11 6 3 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	28 3 99 72 9 77 90 6 58 58 23 23 1 9 6 3 2 1 0 0 0 0 0 0 0 0	29 3 109 1 94 1 65 8 66 5 73 5 43 3 19 3 15 1 12 5 3 2 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0	30 106 104 85 85 56 56 57 38 33 7 1 33 2 10 0 00 0 00 0 00 0 00 0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	Days in Model Newly Emerged Day 1 Newly Emerged Day 2 Blood Fed 24 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood fed 48 hours Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 2 Blood fed 48 hours Blood fed 72 hours Return to Host-seeking 2 Blood fed 72 hours Return to Host-seeking 2 Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood fed 72 hours Return to Host-seeking 1 Return to Host-seeking 2 Blood Fed 24 hours Blood Fed 24 hours Blood Fed 24 hours	540	2 117 81 557	3 114 111 73 572	4 83 108 100 62 554	5 100 79 98 86 51 51	6 98 95 71 84 70 39	7 106 93 86 61 68 54 34 34	8 99 101 84 74 50 53 40 24	9 98 94 91 72 60 38 39 28 16 16 5556	10 102 93 85 78 59 46 28 27 18 9	11 1 121 1 97 1 84 8 73 7 63 5 45 4 34 3 20 2 18 1 11 1 5 6 5 7 577 5	2 1 19 9 15 1 2 7 9 5 9 4 3 3 4 2 3 1 1 8 6 3 1 95 5 5	3 14 0 40 13 30 04 54 5 63 9 21 6 16 6 12 3 13 6 13 2 1 1 1 82 268	15 75 38 27 46 51 17 12 8 9 7 2 1 1 0 0	16 106 71 35 23 38 40 12 8 5 5 5 4 1 0 0 0 0 0 0 349	17 113 101 64 30 19 29 29 8 5 3 3 2 1 0 0 0 0 0 0	18 120 107 91 55 24 15 21 20 6 3 2 1 0 0 0 0 0 0 0 468	19 95 114 97 78 45 19 11 15 14 3 2 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0	20 123 90 103 83 63 35 14 7 10 8 2 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	21 95 117 81 88 68 49 26 10 5 6 5 1 1 0 0 0 0 0 0 0 0 0 0 0 5 51	22 79 90 105 70 72 52 36 18 6 3 3 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	23 125 75 81 90 57 56 38 25 12 4 2 2 4 2 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	24 113 119 68 70 74 44 41 27 7 2 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	25 122 107 58 57 57 32 29 18 10 4 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 90 116 97 92 47 44 42 23 19 11 6 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	27 76 86 105 83 75 37 32 29 15 11 6 3 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	28 2 99 72 9 77 90 6 58 23 2 23 1 9 6 3 2 1 0 0 0 0 0 0 0 0 0 0 0	29 3 109 1 94 1 95 8 65 8 666 5 73 5 52 5 112 5 12 5 12 5 11 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	30 30 106 104 85 1 56 54 538 330 330 2 12 2 9 7 32 2 10 0 00 1 00 1 00 1 00 1 00 1 00 1 00 1 00 1 00 1

Susceptible mosquitoes with 95% mortality have older cohorts eliminated for up to10 days.

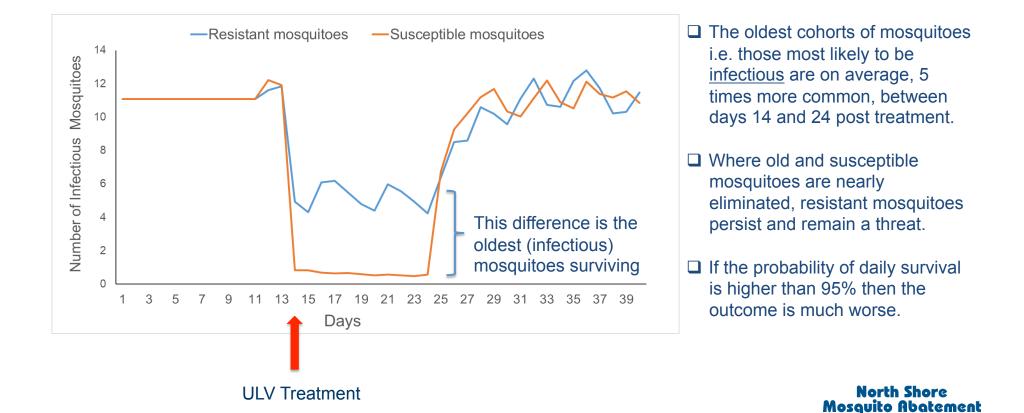
Resistant mosquitoes with variable gravid susceptibility continue to produce older and infectious cohorts of mosquitoes.

Modeling the effect of ULV on resistant and susceptible mosquitoes- entire population



- Resistant mosquitoes are nearly 9 times more abundant on the day after treatment.
- Most mortality in resistant mosquitoes is in the earliest host-seeking stages and not the older infected mosquitoes.

Modeling the effect of ULV on resistant and susceptible mosquitoes- oldest cohorts(>11 days)



Conclusions

□ Resistance to synergized pyrethroid products is widespread in the NSMAD and Illinois.

□ Post-bloodmeal mosquitoes develop a further transient resistance that affects the age structure of the population.

□ A reduction in treatment effectiveness due to resistance is only the most superficial effect.

- Age-structure of the population is not important when only considering the treatment effect on total abundancemost mosquitoes eliminated in a population are newly emerged and uninfected.
- Age-structure of a mosquito population is vital when considering the public health impact of a treatment- older, and gravid mosquitoes are most likely to be infectious and least likely to be controlled.
- A modest reduction in control effectiveness due to resistance is more serious because of the failure to impact the age-structure of a population.

Acknowledgements **Midwest Center** of Excellence Mark Clifton PhD. North Shore Mosquito Abatement District

Mark Clifton PhD· North Shore Mosquito Abatement District Chris Xamplas· North Shore Mosquito Abatement District Roger Nasci PhD· Vector-Borne Disease Consulting LLC Justin Harbison PhD· Loyola University-Chicago

Mosquito Abata