Insecticide resistance status of the Asian Tiger Mosquito in the US

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Background

- *Aedes albopictus* (ATM) is the principal vector of Chikungunya worldwide and is an introduced invasive species in the US where it was first detected in 1985. ATM is now a common pest in 36 US states and responsible for a significant proportion of service requests that result in insecticide applications.
- In this study we examined the insecticide resistance status of ATM populations sampled in New Jersey, Pennsylvania and Florida and investigated the possible mechanisms involved in resistant field populations. We tested larvicides and adulticides from all the main classes of public health insecticides.
- We characterized the susceptibility of an ATM colony established in 1995 to use as a control (ATM95). This reference strain is available to others.

Aedes albopictus

Methods & Results

Larval bioassays

- ✓ WHO protocols were followed
- ✓ We compared the insecticidal activity of conventional and newer insecticides on wild ATM populations using our susceptible reference strain (ATM95).
- ✓ All the populations tested were **fully susceptible** to the insecticides used (Table 1).

Table 1. Insecticidal activity.

	Bti		Temephos		Propoxur		Spinosad		Methoprene		Pyriproxyfen	
Population	LC_{50}	RR_{50}	LC_{50}	RR_{50}	LC_{50}	RR_{50}	LC_{50}	RR_{50}	LC_{50}	RR_{50}	LC_{50}	RR_{50}
ATM95	0.07	*	5.4E-03	*	1.02	*	0.10	*	1.4E-04	*	9.4E-06	*
FL1	0.07	0.99	5.3E-03	0.93	2.87	2.82	0.15	1.51	-	-	1.5E-05	1.57
FL2	0.06	0.84	5.0E-03	0.99	2.83	2.77	0.16	1.56	5.1E-04	3.72	2.2E-05	2.36
NJMon1	0.12	1.78	4.7E-03	0.87	1.50	1.47	0.14	1.42	1.6E-04	1.15	4.7E-06	0.50
NJMon2	0.11	1.68	6.1E-03	1.14	1.62	1.59	0.10	1.01	7.4E-05	0.54	3.6E-06	0.38
NJMer1	0.08	1.16	6.1E-03	1.13	1.72	1.69	0.14	1.38	1.7E-04	1.22	5.7E-06	0.60
NJMer2	0.08	1.19	6.3E-03	1.17	2.09	2.05	0.08	0.79	9.9E-05	0.71	1.3E-05	1.37
NJBer	0.05	0.76	6.9E-03	1.27	2.13	2.09	0.16	1.56	4.5E-05	0.33	1.7E-05	1.81
PA	0.08	1.13	7.6E-03	1.41	1.94	1.90	0.18	1.73	1.1E-04	0.78	1.0E-05	1.11

LC_{50} : Concentration that kills 50% of mosquitoes tested (mg/L); Resistant Ratio: RR_{50} = LC_{50} wild population / LC_{50} ATM95

Adults bioassays

- ✓ **WHO tube tests** were used. We compared the mortality of adult wild ATM vs. ATM95 after exposure to insecticides at diagnostic dose.
- ✓ All populations tested were **susceptible to deltamethrin** (Figure 1)
- ✓ Two populations from Florida showed **resistance to DDT** and resistance is suspected in a population from New Jersey (Figure 2)
- ✓ **Resistance to malathion** is suspected in Florida and New Jersey (Figure 3)

WHO tube tests

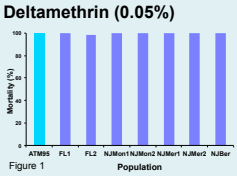


Figure 1

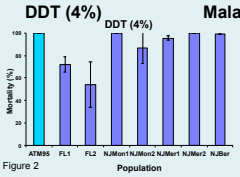


Figure 2

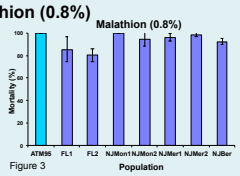
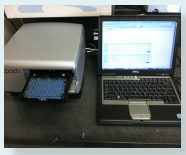


Figure 3

Figures. ATM adult mortality rates after exposure to insecticides at diagnostic doses .

Biochemical assays

- ✓ We compared the global activities of the 3 main **detoxification enzyme** families (P450, α and β esterases, and GSTs) between the wild populations and ATM95 in larvae and adults.
- ✓ No significant differences were found in P450 or esterase activities in adults (Figure 4 and 5) or esterase activities in larvae, but we found **significantly upregulated P450** activities in **larvae** (Figure 4a) .
- ✓ **Significantly higher GST activities** were measured in both larvae and adults from DDT resistant populations in Florida (Figure 4d and 5d).



Spectrophotometer

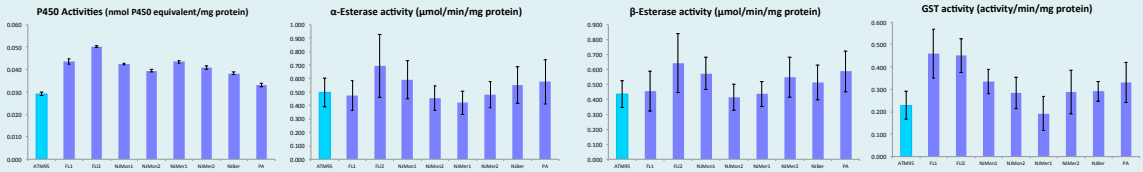
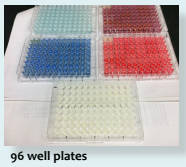


Figure 4. Global activities of the main detoxification enzyme families in larvae. Sample size is 47 specimens. Confidence intervals are 1 standard deviation of the mean.



96 well plates

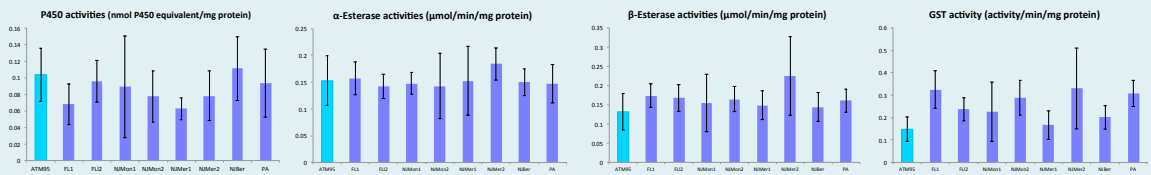


Figure 5. Global activities of the main detoxification enzyme families in adults. Sample size is 47 specimens. Confidence intervals are 1 standard deviation of the mean.

Conclusion

- This study shows that standard larvicides used for mosquito control (temephos, *Bti*, and methoprene) as well as spinosad and pyriproxyfen, which are increasingly being used for larval control, are still efective against US *Aedes albopictus*.
- The resistance to DDT we observed in populations from New Jersey and Florida is alarming because of the known cross resistance pattern between DDT and pyrethroids, which are theadulticides of choice for ATM control in many states of the US. GSTs appear to be involved in DDT resistance in *Ae. albopictus* mosquitoes from Florida.
- This study demonstrates the importance of research on insecticide resistance in *Ae. albopictus* and the need to develop new tools, new insecticides, and innovative strategies to prevent the development of insecticide resistance in these critical chikungunya vectors.

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