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IR3535® against *Aedes aegypti*

Aedes aegypti (vector of dengue) is widely used for cage testing of repellents. A very high biting pressure and relatively brief repellent protection times are characteristic for this day biting species. For these reasons, most laboratory repellency tests of IR3535® have been performed with *Aedes aegypti*. Both concentration response and single concentration studies provide measures of IR3535® repellency performance against *Aedes aegypti*. Most studies include DEET-based repellents for comparison. An overall review of available data suggests rough repellency equivalence for the two active ingredients.

Table 2: Mean Protection time results (h) of IR3535® and DEET against *Aedes aegypti* (vector of dengue)

Method	Test samples	Protection time IR3535®	Protection time DEET reference	Scientist, Year
Cage / human	Ethanol solution 10% - 30%	4.2 – 7.3	5.0 – 6.3	Liebisch, 1981
Cage / human	Ethanol solution 10% - 30%	1.1 – 3.6	1.6 – 4.3	Shashin, 1998
Cage / mice	Ethanol solution 20% - 30%	4 – 6	–	Coosemans, 1992
Cage / human	Cream 10% - 20%	1.9 – 3.0	2.2 – 3.3	Cilek, 2004*
Cage / human	Pump Spray 10% - 20%	2.0 – 2.8	2.6 – 2.9	Cilek, 2004*
Cage / rabbits	Hydro gel 10%	5.6	5.1	Milutinovic, 2000*
Cage / human	Ethanol solution 20%	9.8	9.7	Usavadee, 2001*

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IR3535® against *Aedes albopictus*

Aedes albopictus (Asian tiger mosquito) is an aggressive human-biting species that forages by day and is a vector of Dengue and Chikungunya. It is an invasive species displacing other mosquitoes, and although locally limited outside of Asia, it is already present on all continents. Field and cage studies show strong similarity of protection times for IR3535® vs. DEET against *Aedes albopictus*. Solutions of 20% - 25% provided protection for up to 8 hours.

Table 3: % Protection and protection times (h) of IR3535® and DEET against *Aedes albopictus* (vector of chikungunya) .

Method	Test samples	Protection time IR3535®	Protection time DEET reference	Scientist, Year
Field / 2 tests	Aerosol 2.5%, 3%, 5%	100% for 5 / 6 h	100% for 5 / 6 h	*1989 / 90 (Japan, Osaka)
Field	Ethanol solution 25%	100% / >90% for 4 h / 8h	100% / >90% for 6 h / 8h	Yap, 1998 (Malaysia),
Field/ 2 tests	Ethanol solution 20%	98.4% / 100% for 8 h	97.4% / 100% for 8 h	Usavadee, 2001 (Thailand)*
Cage/ human	Ethanol solution 25%	100% for 2 h	100% for 2 h	Yap, 1998

*name of scientist was not translated

*please find the respective publication reference under www.IR3535.com, „scientific publication“ button



IR3535® against *Anopheles*

Anopheles is vector of malaria. In field studies at a concentration of 25%, IR3535® showed **5 hours** protection against *Anopheles hyrcanus*, *An. minimus*, *An. sawad-wongporni*, and *An. maculatus*, similar to DEET (Table 5). However, DEET showed superior performance against *Anopheles dirus* in cage studies. In field studies, 15% formulations of IR3535® showed **5 hours** protection against *Anopheles darlingi*, *An. albitarsus*, and *An. braziliensis*. Performance thus varies with formulation and species, and advanced formulation can improve performance against *Anopheles* species.

Table 4: % Protection and mean protection times (h) of IR3535® vs. DEET against *Anopheles* species (vector of malaria)

Method	Species	Test samples	Protection time IR3535®	Protection time DEET reference	Scientist, Year
Field	<i>gambiae</i> and <i>funestus</i>	Ethanol solution 25%	96.3% for 6 h	99.3% for 6 h	Kuhlow, 1975 (West Africa)
Cage / human	<i>maculatus</i>	Ethanol solution 25%	64% (1 h) / 70-40% (2-8 h)	100% (1 h) / 70-40% (2-8 h)	Yap, 1998
Field (July)	<i>hyrcanus minimus</i> , <i>sawad-wongporni</i> , <i>maculatus</i>	Ethanol solution 20%	100% for 3 h (99%, 5 h)	100% for 1 h (98%, 5 h)	Usavadee, 2001 (Thailand)*
Field (August)	<i>hyrcanus minimus</i> , <i>sawad-wongporni</i> , <i>maculatus</i>	Ethanol solution 20%	100% for 4 h (99%, 5 h)	100% for 2 h (99%, 5 h)	Usavadee, 2001 (Thailand)*
Cage / human	<i>dirus</i>	Ethanol solution 20%	100% for 3.8 h	100% for 5.8 h	Usavadee, 2001 (Thailand)*
Field	<i>darlingi albitarsus</i> , <i>braziliensis</i>	Pump spray 15%	100% / 90% 3.8 h / 4.5 h	-	Hill, 2006** (Bolivian Amazon)
Field	<i>darlingi albitarsus</i> , <i>braziliensis</i>	Lotion 15%	100% / 90% 6.9 h / 7.7 h	-	Hill, 2006** (Bolivian Amazon)
Field	<i>darlingi albitarsus</i> , <i>braziliensis</i>	Lotion 15%	100% / 90% 6.0 h / 6.9 h	-	Hill, 2006** (Bolivian Amazon)

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IR3535® against *Culex*

Culex is vectors of Japanese encephalitis and West Nile Virus. Review of available data indicates equivalent performance of IR3535® and DEET against *Culex* species. In cage tests, 20% ethanolic solutions of IR3535® provided protection ranging from **3 – 13.7 hours**, while 20 – 25% ethanolic solutions provided at least **8 hours** protection in the field (Yap 1998; Usavadee 2001) In cage tests, IR3535® protected against *Culex* species for twice as long as *Aedes* species

Method	Species	Test samples	Protection time IR3535®	Protection time DEET reference	Scientist, Year
Cage / human	<i>pipiens</i>	Ethanolic solution 10% - 30%	100% for 1.9 – 5.0 h	100% for 2.5 – 5.9 h	Shashin, 1998
Cage / human	<i>quinquefasciatus</i>	Cream 10% - 20%	100% for 5.7 – 6.6 h	100% for 5.7 – 6.2 h	Cilek, 2004*
Cage / human	<i>quinquefasciatus</i>	Pump Spray 10% - 20%	100% for 5.4 – 6.5 h	100% for 5.7 – 6.1 h	Cilek, 2004*
Cage/ human	<i>quinquefasciatus</i>	Ethanolic solution 20%	100% for 13.7 h	100% for 12.7 h	Usavadee, 2001*
Cage/ human	<i>tritaeniorhynchus</i>	Ethanolic solution 20%	100% for 14.8 h	100% for 14.5 h	Usavadee, 2001*
Field	<i>quinquefasciatus</i>	Ethanolic solution 25%	>98% for 8h	>98% for 8h	Yap, 1998 (Malaysia),
Field (April)	<i>sitiens</i> <i>tritaeniorhynchus</i>	Ethanolic solution 20%	100% for 5h	100% for 5h	Usavadee, 2001* (Thailand)
Field (May)	<i>gelidus</i> <i>quinquefasciatus</i> <i>tritaeniorhynchus</i>	Ethanolic solution 20%	100% for 5h	100% for 5h	Usavadee, 2001* (Thailand)
Field (July)	<i>tritaeniorhynchus</i> <i>sitiens</i>	Ethanolic solution 20%	99% for 5h	100% for 5h	Usavadee, 2001* (Thailand)

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IR3535[®] against *Ixodes* (Ticks)

Ticks (*Ixodes scapularis* and *Ixodes ricinus*) are vectors of Lyme Disease and tick-borne Encephalitis. Only two IR3535[®] studies shown in Table 6 investigated the difference compared to DEET. In Benzon's (1995) *in vitro* study without human volunteers, 15% IR3535[®] in ethanol showed greater repellency than 15% ethanolic DEET at all time intervals. Cilek's (1995) study with human volunteers showed 15% IR3535[®] in ethanol equaled or outperformed 15% ethanolic DEET for repellency at most time intervals over a period of 4 hours, and 30% IR3535[®] in ethanol or outperformed 60% ethanolic DEET for repellency at most time intervals over 8 hours. Ethanolic solutions with 10% IR3535[®] provided 93-95% protection against *Ixodes scapularis* for 4 h (Cilek 1995).

Additional studies examined IR3535[®] performance without a DEET comparison. Testing IR3535[®] against *Ixodes scapularis*, Carroll (2008) found 10% lotion provided 9 hours of protection, 20% pump spray provided 12 hours protection, and 20% aerosol provided 11 hours protection. Testing IR3535[®] on rabbits against *Ixodes ricinus*, Bucsek (1996) found 10%, 20%, and 30% hydro-ethanolic solutions all provided 95% or better protection for the 4 hour duration of the test.

The excellent performance of IR3535[®] pump spray formulations at 20% was confirmed by a recent study with Lone Star Ticks (*Amblyomma americanum*) using 33% DEET lotion (EDTIAR) (J. F. Carroll, 2010). The scientist stated that "Formulations containing $\geq 20\%$ active ingredient were highly effective, with 10% of the ticks crossing through treatment bands for any challenge during 12 h". The 10% lotion with IR3535[®] was less effective than the formulations with higher concentrations. Thus higher IR3535[®] concentrations and advanced formulation technology offer improved protection against ticks.