EFFICACY OF AROSURF® MSF (MONOMOLECULAR SURFACE FILM) BASE FORMULATIONS OF *BACILLUS THURINGIENSIS* VAR. *ISRAELENSIS* AGAINST MIXED POPULATIONS OF MOSQUITO LARVAE AND PUPAE: BIOASSAY AND PRELIMINARY FIELD EVALUATIONS[1]

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ABSTRACT. Efficacy of Arosurf® MSF base formulations of 3 commercial preparations of *Bacillus thuringiensis* var. *israelensis* (*B.t.i.*) in controlling mosquito larvae, pupae, and emerging adults was determined in bioassay and preliminary field evaluations. Results of tests of the combinations at application rates that were at and below label recommendations for each product indicated that formulations of Arosurf MSF and commercial *B.t.i.* would produce significantly better general control of mixed developmental stages of mosquitoes than either of the formulation components. Techniques for utilization of the Arosurf MSF-*B.t.i.* formulations for operational mosquito control are discussed.

INTRODUCTION

Arosurf® MSF (Monomolecular Surface Film)[2] is the designation for the two mole ethoxylate of isostearyl alcohol. This product was shown to be safe and effective in controlling immature mosquitoes in ground and aerial field trials in the U. S. and overseas (Levy et al. 1980a, 1980b, 1981; 1982a, 1982b, 1982c; Mulla et al. 1983, Webber 1983, Webber and Cochran 1983, White et al. 1977), and was recently registered for use as a mosquito larvicide and pupicide in all classes of water by the U. S. Environmental Protection Agency (EPA Registration No. 42943-8).

Arosurf MSF kills mosquito larvae, pupae and emerging adults by the physicochemical modification of the water interface of a mosquito habitat (Garrett 1976, Garrett and White 1977). It can also be used to entrap and drown ovipositing females and resting males as well as sink and inhibit the eclosion of floating eggs and egg rafts of certain species (Levy et al. 1982a).

Under field conditions, the rate of kill (i.e., 90%+ mortality) at label application rates of 0.2–0.5 gal/surface acre has been shown to be rapid for pupae (i.e., within 24 hr post-treatment); however, larvicidal action has been shown to be delayed (i.e., usually within 24–72 hr), and therefore its overall effectiveness as a larvicide is dependent upon the persistence of a monomolecular surface film on the habitat. Because control of 1st-4th instar larvae is usually slow, environmental/climatological factors such as persistent unidirectional winds of moderate to high velocity, run-off, overflow or drainage can disrupt surface film integrity over most or all of a habitat before effective larvicidal action has been obtained. For these reasons, an Arosurf MSF monitoring system employing the use of Adol® indicator oil[3] for determining the presence or absence of the surface film on the water was developed and shown to be an effective tool for back-checking a mosquito habitat to determine when retreatment was necessary (Levy et al. 1980b).

Because delayed kill of larvae is a typical characteristic of the physical mode of action of Arosurf MSF, a series of bioassays were conducted to determine if blends of Arosurf MSF and commercial formulations of *Bacillus thuringiensis* var. *israelensis* (*B.t.i.*) would produce better and more rapid control of mixed stages of immature mosquitoes than either of the formulation components (Levy et al. 1982c). Commercial formulations of *B.t.i.* such as Teknar®, Bactimos® and Vectobac® are known to exhibit rapid (toxic) larvicidal action within 24 hr; however, they possess no pupicidal properties and do not usually persist under field conditions at label rates for longer than 24 hr after treatment. Arosurf MSF, on the other hand, exhibits both a delayed larvicidal and rapid pupicidal response and has been shown to persist at recommended application rates for 2–10 days post-treatment. Therefore, it was expected that combinations of these 2 environmentally compatible products would also

[1] Mention of a brand name or proprietary product does not constitute a guarantee or warranty by Lee County Mosquito Control District, and does not imply its approval to the exclusion of other products that may also be suitable.

[2] Arosurf® MSF (= ISA-20E = Arosurf® 66-E2) is a product of Sherex Chemical Company, Inc., P.O. Box 646, Dublin, OH 43017.

[3] Adol® (= Adol® 85) is an oleyl alcohol indicator oil manufactured by Sherex Chemical Company for use in conjunction with Arosurf® MSF.

produce environmentally compatible formulations that would have a significantly greater range of effectiveness in controlling mixed populations of larvae and pupae than either of the formulation components. By virtue of the known field performance characteristics of Arosurf MSF (physical kill mechanism) and *B.t.i.* (toxic kill mechanism), formulations of the 2 products were expected to produce joint action properties that had fewer limiting factors than each component, and therefore could kill mosquito larvae and pupae quickly, persist in a mosquito habitat and kill larvae, pupae, emerging adults and ovipositing females for extended periods, provide improved coverage during application by virtue of the spontaneous spreading action on the surface of the water, and be rapidly effective against organophosphate and organochlorine resistant mosquitoes.

METHODS AND MATERIALS

A series of laboratory bioassays against mixed larvae and pupae of *Culex quinquefasciatus* Say was conducted with formulations of Arosurf MSF and Teknar, Arosurf MSF and Vectobac, and Arosurf MSF and Bactimos to determine the spectrum of compatibility and efficacy of the Arosurf MSF-*B.t.i.* blends at label rates when compared to the label rate performance of each of the formulation components. In addition, joint action tests at lower than label rates for each *B.t.i.* product were used to determine if a "synergistic-like" larvicidal response would occur when compared to the larvicidal response of each product at comparable rates. *Culex quinquefasciatus* was used as the main target as prior bioassays by Levy et al. (1982a) against 1st-4th instar larvae of this species with Arosurf MSF at an application rate of 0.26 gal/acre in clean, highly oxygenated water always produced little or no kill of larvae within 24 hr of treatment. Bioassays against pupae of this species showed 95–100% control would not occur until 48 hr post-treatment. It should be noted that under natural field conditions control of larvae or pupae of *Cx. quinquefasciatus* was significantly more accelerated than was observed under bioassay conditions.

Tests were conducted against mixed populations of five 2nd-3rd or 4th instar larvae and 5 pupae of *Cx. quinquefasciatus* in 250 ml reverse osmosis (RO) water (3 replications/formulations). Each of the commercial preparations of *B.t.i.* was evaluated singly and combined with Arosurf MSF as an agitated water-base suspension for application of the technical products at or below label recommendations. Potency of *B.t.i.* for Teknar, Vectobac and Bactimos was 1500, 2000 and 3500 AA units/mg, respectively. Arosurf MSF application rate was standardized in all water base formulations at 0.26 gal/acre. Formulations of *B.t.i.* were added to the water or water and Arosurf MSF at desired rates in 400 ml disposable plastic beakers and mixed at 10,000 rpm for 20–30 sec with a Bamix (M100) biomixer (Biospec Products, Bartlesville, OK 74003) equipped with an impeller stirring tip. Arosurf MSF was mixed with water in a similar manner.

All water-base formulations were pipetted into the beakers containing 5 larvae and 5 pupae with 0.2 ml glass pipettes at a final application rate of 5.02 gal/acre. This manner of bioassay was chosen to simulate procedures, product mixing ratios and application rates recommended for use in conventional roadside ditch and aerial larviciding operations. Prior to introduction of the test formulations, larvae were fed 2 drops of finely ground rabbit chow-RO water suspension. All bioassays were conducted in a room maintained at ca. 26–27°C (ambient) and 80% RH.

Cumulative mean percentage mortality of larvae and pupae was recorded at 24 hr post-treatment intervals. Cumulative percentage adult emergence was also recorded for each test formulation. These criteria were the basis for evaluating the general mosquito-controlling efficacy of the formulations and their components. Results were statistically analyzed using z and t tests.

Another series of bioassays were conducted to determine whether Arosurf MSF in an Arosurf MSF-*B.t.i.* formulation would effectively disperse a water dispersible *B.t.i.* concentrate (Teknar) and a wettable powder *B.t.i.* formulation (Bactimos) over the surface of the water prior to sedimentation, and rapidly kill larvae at a site that was distant from the point of initial application, when compared to the *B.t.i.* formulations containing no Arosurf MSF. Each *B.t.i.* preparation was mixed with Arosurf MSF and water with a Bamix biomixer for application of the technical products at and below label recommendations as a water-base suspension. Bioassays were conducted in stainless steel trays (68.6 × 25.4 cm) containing RO water (7570 ml). Water temperature throughout the tests ranged from 26–27°C. All water-base suspensions were dispensed onto the surface of the water along the narrow side of a tray margin with a glass pipette at a final application rate of 5.02 gal (19,001 ml) water-Arosurf MSF-*B.t.i.*/surface acre. Two drops of ground rabbit chow-water suspension were added along the margin on the opposite side of the tray as a source of food.

Approximately 5 min after application of the test formulations, a submerged nylon mesh screen that was attached to the sides of each tray at a distance of 7.62 cm from the opposite side from where the formulations were applied was raised above the water level. The barrier was provided to assure that larvae would be restricted to an area that was on the side opposite from where the test formulations were introduced. After securing the nylon mesh, 10 3rd-4th instar larvae of *Cx. quinquefasciatus* were introduced through the surface of the water with a wide mouth pipette to insure that the larvae would not contact a surface-active formulation (2 replications/formulations). Air movement across the surface of the water in each tray was slight and was attributed to general air conditioner circulation. Percentage mortality of each formulation was recorded at 6 and 24 hr post-treatment.

Additional tests were also conducted to determine the mixing compatibility and spraying ability of formulations of technical Arosurf MSF and the 3 technical *B.t.i.* preparations at application rates recommended for each product. Field observations of the mosquito-controlling efficacy of the Arosurf MSF-*B.t.i.* formulations were also conducted under operational conditions to determine the reliability of the bioassay results.

RESULTS AND DISCUSSION

BIOASSAYS. Bioassays (Tables 1–4) against immature stages of *Cx. quinquefasciatus* with water-base blends of Arosurf MSF and Teknar, Vectobac or Bactimos at and below label recommendations resulted in combined larvicidal and pupicidal action that was significantly better than each of the formulation components. Tests with all formulations of Arosurf MSF combined with each of the 3 *B.t.i.* products resulted in 100% control of 2nd-4th instar larvae and pupae within 48 hr post-treatment. With Arosurf MSF alone, this level of mortality was not achieved until 72 or 96 hr post-treatment. As expected, control of mixed larvae and pupae at all *B.t.i.* application rates ranged from 37 to 50% (i.e., equivalent to 74–100% control of larvae only) and resulted in adult emergence of the remaining pupae that were not affected by the *B.t.i.* exposure. The labels caution that Teknar, Vectobac and Bactimos are ineffective against late 4th instar larvae that have ceased to feed and pupae, and therefore *B.t.i.* cannot be used for general control of mixed populations of larvae and pupae.

Larval instar (Tables 1–2) and instar and pupal age (Table 3) were factors contributing to

Table 1. Efficacy of water-base formulations of Arosurf® MSF and *Bacillus thuringiensis* var. *israelensis (B.t.i.)* against mixed larvae and pupae of *Culex quinquefasciatus.*[1]

Water-base formulation (dosage-active ingredients)[2]	Larval instar	Cumulative mean percentage mortality of larvae[3], pupae, and/or emerging adults at indicated post-treatment time period: 24 hr	48 hr	72 hr	Cumulative percentage adult emergence from surviving pupae
Arosurf MSF and *B.t.i.*	2nd-3rd	73.3	100	—	0
(0.26 gal/acre + 1.0 pt/acre)	4th	66.7	100	—	0
Arosurf MSF + *B.t.i.*	2nd-3rd	83.3	100	—	0
(0.26 gal/acre + 0.5 pt/acre)	4th	66.7	100	—	0
Arosurf MSF + *B.t.i.*	2nd-3rd	66.7	100	—	0
(0.26 gal/acre + 0.25 pt/acre)	4th	66.7	100	—	0
B.t.i.	2nd-3rd	50	50	50	50
(1.0 pt/acre)	4th	36.7[4]	36.7	36.7	63.3
B.t.i.	2nd-3rd	50	50	50	50
(0.5 pt/acre)	4th	26.7[5]	36.7[7]	36.7	63.3
B.t.i.	2nd-3rd	50	50	50	50
(0.25 pt/acre)	4th	46.7[6]	46.7	46.7	53.3
Arosurf MSF	2nd-3rd	33.3	83.3	100	0
(0.26 gal/acre)	4th	16.7	66.7	100	0
Control	2nd-3rd	0	0	0	100
	4th	3.3	3.3	3.3	96.7

[1] Water dispersable concentrate of *B.t.i.* used in all tests is a product (Teknar®) of Sandoz, Inc. (1500 AA units/mg).
[2] All water-base formulations applied at total application rate of 5.02 gal/acre.
[3] 50% control of mixed larvae and pupae with *B.t.i.* alone = 100% control of larvae and 0% control of pupae.
[4, 5, 6] Some 4th instar larvae molted to pupae within 1 hr after introduction to beakers.
[7] One dead pupa from molted larva recorded.

Table 2. Comparative efficacy of water-base formulations of Arosurf® MSF and two commercial wettable powder preparations of *Bacillus thuringiensis* var. *israelensis (B.t.i.)* against mixed fourth instar larvae and pupae of *Culex quinquefasciatus*.[1]

Water-base formulation (dosage-active ingredients)[2]	Cumulative mean percentage mortality of larvae[3], pupae, and/or emerging adults at indicated post-treatment time period: 24 hr	48 hr	72 hr	Cumulative percentage adult emergence from surviving pupae
		Vectobac®		
Arosurf MSF + *B.t.i.* (0.26 gal/acre + 1.0 lb/acre)	53.3	100	—	0
Arosurf MSF + *B.t.i.* (0.26 gal/acre + 0.5 lb/acre)	56.7	100	—	0
Arosurf MSF + *B.t.i.* (0.26 gal/acre + 0.25 lb/acre)	60	100	—	0
Arosurf MSF + *B.t.i.* (0.26 gal/acre + 0.125 lb/acre)	56.7	100	—	0
B.t.i. (1.0 lb/acre)	50	50	—	50
B.t.i. (0.5 lb/acre)	50	50	—	50
B.t.i. (0.25 lb/acre)	50	50	—	50
B.t.i. (0.125 lb/acre)	50	50	—	50
Arosurf MSF (0.26 gal/acre)	10	76.7	100	0
Control	0	0	0	100
		Bactimos®		
Arosurf MSF + *B.t.i.* (0.26 gal/acre + 4 oz/acre)	70	100	—	0
Arosurf MSF + *B.t.i.* (0.26 gal/acre + 2 oz/acre)	50	100	—	0
Arosurf MSF + *B.t.i.* (0.26 gal/acre + 1 oz/acre)	53.3	100	—	0
B.t.i. (4 oz/acre)	50	50	—	50
B.t.i. (2 oz/acre)	46.7[4]	46.7	—	53.3
B.t.i. (1 oz/acre)	46.7[5]	46.7	—	53.3
Arosurf MSF (0.26 gal/acre)	23.3	83.3	100	0
Control	0	0	3.3	96.7

[1] Vectobac and Bactimos are products of Abbott Laboratories and Biochem Products, respectively (2000 and 3500 AA units/mg, respectively).
[2] All water-base formulations applied at a total application rate of 5.02 gal/acre.
[3] 50% control of mixed larvae and pupae with *B.t.i.* alone = 100% control of larvae and 0% control of pupae.
[4, 5] Some 4th instar larvae molted to pupae within 1 hr after introduction to beakers.

the susceptibility of the immatures to the Arosurf MSF-*B.t.i.* formulations. Labels for the 3 *B.t.i.* products indicate that larval susceptibility to *B.t.i.* decreases as the instar level increases from 1st to 4th. However, the converse to this trend has been shown to be generally true for Arosurf MSF, i.e., older larvae are usually more susceptible than younger larvae. Relationships between age within an instar, molting, and larval susceptibility to Arosurf MSF have also been reported, as well as observed differences in the rate of pupicidal action between white (young) and dark (old) pupae. The data indicated that the aforementioned factors that contributed to the susceptibility of larvae and/or pupae to the individual products were generally the same when the 2 products were blended together as a formulation. Differences observed in 24 hr joint action kill of larvae and pupae were related to variations in mixing compatibility and dispersibility of the wettable powders and water dispersible concentrate of *B.t.i.* in Arosurf MSF and water and to differences in acute susceptibility based on variations in stage, instar, and age variations within a test series, and not directly to the application rates utilized. In general, data from the beaker tests against larvae and pupae of *Cx. quinquefasciatus* indicated that there were no significant differences between the acute larvicidal or pupicidal action from the Arosurf MSF-*B.t.i.* formulations applied at label and lower than label recommended rates of *B.t.i.* This was also true when each of the *B.t.i.* products was evaluated alone.

The effective joint action by the formulations was related to the differences in modes of action of each of the formulation components (toxic vs. physical) and to differences in stage

Table 3. Effect of age of fourth instar larvae and pupae of *Culex quinquefasciatus* on the efficacy of water-base formulations of Arosurf® MSF and wettable powder preparations of *Bacillus thuringiensis* var. *israelensis (B.t.i.)*[1].

Instar/pupal age (days)	Water-base formulation (dosage-active ingredient)[2]	Cumulative mean percentage mortality of larvae[3], pupae, and/or emerging adults at indicated post-treatment time period				Cumulative percentage adult emergence of surviving pupae
		24 hr	48 hr	72 hr	96 hr	
9/9	Arosurf MSF + *B.t.i.* (0.26 gal/acre + 0.125 lb/acre)	46.7	100	—	—	
	B.t.i. (0.125 lb/acre)	36.7[4]	36.7	—	—	63.3
	Arosurf MSF (0.26 gal/acre)	23.3	93.3	100	—	0
	Control	0	3.3	3.3	—	96.7
8/10	Arosurf + *B.t.i.* (0.26 gal/acre + 0.25 lb/acre)	93.3	100	—	—	0
	Arosurf MSF + *B.t.i.* (0.26 gal/acre + 0.25 lb/acre)	93.3	100	—	—	0
	Arosurf MSF + *B.t.i.* (0.26 gal/acre + 0.125 lb/acre)	93.3	100	—	—	0
	B.t.i. (0.25 lb/acre)	46.7[5]	46.7	—	—	53.3
	B.t.i. (0.125 lb/acre)	50	50	—	—	50
	Arosurf MSF (0.26 gal/acre)	53.3	66.7	90	100	0
	Control	0	0	0	0	100

[1] Wettable powder formulation of *B.t.i.* used in all tests is a product (Vectobac®) of Abbott Laboratories.
[2] All water-base formulations applied at total application rate of 5.02 gal/acre.
[3] 50% control of mixed larvae and pupae with *B.t.i.* alone = 100% control of larvae and 0% control of pupae.
[4, 5] Some 4th instar larvae molted to pupae within 1 hr after introduction to beakers.

susceptibility (larval vs. pupal). The bioassay data suggest that, at the dosages evaluated, joint larvicidal/pupicidal action is additive rather than synergistic. This was particularly evident when lower than label rates of *B.t.i.* were formulated with Arosurf MSF and compared to the larvicidal and/or pupicidal response of each component. Therefore, larvicidal action via *B.t.i.* plus pupicidal action via Arosurf MSF resulted in a joint action that was observed to produce effective simultaneous control of mixed larval and pupal stages without the use of a petroleum larvicidal oil.

Results of bioassays on the effect of Arosurf MSF-induced spreading on the rate of larvicidal action of 2 commercial *B.t.i.* formulations are presented in Table 4. The data indicate that the enhanced spreading potential produced by the Arosurf MSF in the Arosurf MSF-*B.t.i.* formulations will result in significantly more rapid larval control (as well as potential pupal control) throughout a mosquito habitat than can be expected with commercial *B.t.i.* formulations containing no Arosurf MSF. These data suggest that when control is targeted to only the larval population, *B.t.i.*-Arosurf MSF formulations containing less than label rates of Arosurf MSF can enhance field application and general larvicidal action throughout a mosquito habitat.

MIXING COMPATIBILITY. Arosurf MSF blended together satisfactorily with Teknar water dispersible concentrate and Vectobac and Bactimos wettable powder preparations as water-base suspensions when vigorous (high sheer) agitation was applied to mix the components; however, some differences in the ease of mixing were observed, particularly at the

Table 4. Effect of Arosurf® MSF-induced spreading on the rate of larvicidal action of 2 commercial *B.t.i.* preparations against 3rd-4th instar larvae of *Culex quinquefasciatus*.[1]

Water-base formulation (dosage-active ingredients)[2]	Cumulative mean percentage mortality of larvae at indicated post-treatment time period	
	6 hr	24 hr
	Teknar®	
Arosurf MSF + *B.t.i.* (0.26 gal/acre + 0.5 pt/acre)	100	—
B.t.i. (0.5 pt/acre)	0	100
Control	0	0
	Bactimos®	
Arosurf MSF + *B.t.i.* (0.26 gal/acre + 4 oz/acre)	95	100
B.t.i. (4 oz/acre)	0	100
Control	0	0

[1] Teknar and Bactimos are products of Sandoz, Inc. and Biochem Products, respectively.
[2] All water-base formulations applied at a total application rate of 5.02 gal/acre.

higher *B.t.i.* concentrations. The inert ingredients of the *B.t.i.* products and specific gravities of the 3 components in each formulation are significantly different, and therefore stratification (separation) of the formulation components will result if they are not thoroughly agitated prior to use. Casual mixing or hand-shaking of the Arosurf MSF, each of the *B.t.i.* products and water in glass bottles at recommended application rates resulted in poorly mixed formulations that readily separated and tended to congeal or form globules at the surface of the water. These non-homogeneous formulations could not be accurately pipetted and resulted in poor larvicidal and pupicidal efficacy at all recommended application rates.

Each of the 3 *B.t.i.* products mixed with Arosurf MSF satisfactorily at all recommended application rates as technical products via vigorous hand-shaking to form a homogeneous suspension; however, a combined formulation of Arosurf MSF and Vectobac mixed at the highest recommended application rates for each product resulted in a syrup-like suspension that was too viscous to be sprayed from a hand-pump (22 oz) plastic sprayer. Mixtures of Arosurf MSF with Vectobac at all other recommended application rates produced sprayable formulations. Handshaken formulations of Teknar or Bactimos and Arosurf MSF were sprayable at all recommended application rates; however, ease of mixing and sprayability was related to *B.t.i.* concentration. Frequent agitation of the technical *B.t.i.*-Arosurf MSF formulations is necessary to maintain a homogeneous suspension. Bioassays against *Cx. quinquefasciatus* with these formulations produced results that were comparable to efficacy of the water-base formulations.

FIELD OBSERVATIONS AND RECOMMENDATIONS. Preliminary field observations with paddle-agitated (100–200 rpm) water-based tank mixes of Arosurf MSF and commercial *B.t.i.* applied at recommended application rates from a roadside ditch truck at 5–6 gal/acre, resulted in 100% control of mixed larval and pupal populations of *Culex, Psorophora* and *Aedes* spp. in 24 or 48 hr. Commercial *B.t.i.* can also be formulated with Arosurf MSF in hand sprayers for application at recommended rates by vigorously hand-shaking the 2 components. Frequent hand-shaking is necessary to maintain a homogeneous suspension. The mosquito-controlling efficacy of the technical blends of *B.t.i.* and Arosurf MSF for use in hand sprayers has been demonstrated under field conditions. Field observations of rapid kill of larvae in areas that were far removed from the point of initial application agreed with bioassay observations, and indicated that the spreading action of Arosurf MSF could effectively disperse commercial *B.t.i.* across the surface of the water prior to its sedimentation throughout the mosquito habitat. Field observations also indicated that the spreading action of Arosurf MSF in the Arosurf MSF-*B.t.i.* formulations would also inhibit large numbers of salt-marsh larvae from accumulating in "balls" or "rafts" throughout a mosquito habitat, thereby producing more effective larvicidal action over *B.t.i.* alone by allowing the more evenly distributed larvae greater feeding access to the more evenly distributed *B.t.i.*

In summary, results of bioassays and preliminary field observations have indicated that improved overall mosquito-controlling efficacy will be obtained with Arosurf MSF-*B.t.i.* formulations as compared to the control of immature mosquitoes that can be expected from the use of each commercial *B.t.i.* product or Arosurf MSF alone. Joint water-base or technical formulations of any of the *B.t.i.* products and Arosurf MSF applied on an operational basis at recommended application rates for each product are expected to be an environmentally acceptable, efficient, and cost-effective alternative to the use of diesel-base oils that are typically applied at application rates of 5–10 gal/acre for the control of mixed populations of larvae and pupae. Potential utilization of lower than label rates for one or both products in the field would greatly enhance the cost-effectiveness of the Arosurf MSF-*B.t.i.* formulations. Field tests to determine the mosquito-controlling efficacy of these formulations are in progress.

Until additional research on the storage compatibility and post-storage mosquito-controlling efficacy of water-base and technical blends of Arosurf MSF and commercial *B.t.i.* products is conducted, it is recommended that the 2 products be formulated as a tank mix in quantities that are expected to be used on a daily basis. The need for high-sheer spray system agitation (e.g., paddle) for satisfactory application of water-base formulations of Arosurf MSF and *B.t.i.* cannot be overemphasized. Failure to properly mix the 2 products in water to form a homogeneous suspension can result in improper application rates, adverse product interactions (eg., gelling), and generally poor mosquito control. Frequent vigorous agitation of technical blends of Arosurf MSF and commercial *B.t.i.* is also necessary for proper application and efficacy.

To eliminate the requirement of vigorous high-sheer agitation for utilization of water-base suspensions of Arosurf MSF and *B.t.i.* on an operational basis, research is currently being conducted on the use of several types of injection values for metering low recommended concentrations of Arosurf MSF and/or *B.t.i.* directly into a stream of water for vehicle application of the water-base suspensions at high spray pressures and volumes. The injection system is also being evaluated for possible helicopter adaptation.

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MARCO ENRICO GIGLIOLI FUND

At the AMCA Board of Directors meeting in Toronto, Ontario during March 1984, a memorial fund was established in memory of Dr. Marco Giglioli who passed away on March 3, 1984. The monies from this fund will help to support the publication of papers by authors from abroad who do not have institutional support to cover publication costs. Donations should be sent to the AMCA Central Office, 5545 East Shields Avenue, Fresno, California 93727 USA. Names of donors will be published annually in the *Journal of the American Mosquito Mosquito Control Association.*