



The Control of Dengue Hemorrhagic Fever Using Innovations for The Integrated Controlling *Aedes* Mosquitoes

Apiwat Tawatsin

Medical Science Technical Office, Department of Medical Sciences,
Nonthaburi 11000, Thailand

Usavadee Thavara

Consultant, Department of Medical Sciences,
Nonthaburi 11000, Thailand

Amara Yowang

Regional Medical Sciences Center 1/1 Chiang Rai,
Department of Medical Sciences, Chiang Rai 57100, Thailand

Udorn Jitphayak

Regional Medical Sciences Center 1/1 Chiang Rai,
Department of Medical Sciences, Chiang Rai 57100, Thailand

Navy Srivarom

Medical Science Technical Office, Department of Medical Sciences,
Nonthaburi 11000, Thailand

ABSTRACT

Dengue hemorrhagic fever (DHF) is an infectious disease transmitted to humans by *Aedes aegypti* and *Ae. albopictus* mosquitoes. The prevention and control of these vector mosquitoes are the main strategies to control the disease since no effective vaccine is available for prevention. This project aimed to reduce the *Aedes* mosquito populations in the study areas using the three innovations of the Department of Medical Sciences (LeO-Trap: lethal ovitrap, AZAI: *Aedes* larvicide, and RepelMos: mosquito repellent) with community participation. The study was conducted in Chiang Rai Province (Muang District) and Phrae Province (Muang District and Song District) as these provinces were predicted as the potentially epidemic areas of DHF in 2022. The study areas were 2 villages (approximately 100 houses/village) selected from each District; as a result, 815 houses from these 6 villages participated in this study. The owner of each house received 4 sets of LeO-Trap (2 traps for use inside the house and 2 traps for use outside the house), 4 bags (100 g.) of AZAI, and 2 bottles (40 ml.) of RepelMos. Overall, the village health volunteers collected the sponge sheets (substrate for egg laying of *Aedes* mosquitoes) from the total treated houses ranged from 78% to 100% while the houses positive for *Aedes* eggs were between 29.6% and 100%. The total number of *Aedes* eggs collected from inside and outside the houses of the 6 villages in this study was 282,160 eggs; therefore, it could be estimated that 70,540,000 *Aedes*

mosquitoes were rid of by the LeO-Trap in the study areas based on the assumption that a female mosquito could produce 500 offspring in her lifetime. Regarding the data collected by Sub-district, the highest numbers of *Aedes* eggs were collected from Nang Lae Sub-district in Muang District, Chiang Rai Province (117,557 eggs with an average 87 eggs/house), followed by Hua Muang Sub-district in Song District, Phrae Province (99,326 eggs with an average 97 eggs/house) and Mae Kam Mee Sub-district in Muang District, Phrae Province (65,277 eggs with an average 62 eggs/house). Overall, the number of *Aedes* eggs collected by the LeO-Trap inside the houses was higher than those obtained outside the houses in the three sub-districts. The results obtained from this study indicated that the innovations used in this project with community participation could substantially reduce *Aedes* mosquito populations in the study areas and reduce the incidence of DHF. This study could be a model for preventing and controlling *Aedes* mosquitoes in other areas.

Keywords: *Aedes aegypti*, Dengue, Lethal ovitrap, Control

INTRODUCTION

Aedes aegypti and *Ae. albopictus* mosquitoes are the primary vectors for dengue hemorrhagic fever, chikungunya, and Zika viruses [1-4]. These mosquito species are known for their role in transmitting arboviruses, including dengue, chikungunya, and Zika, which have significant public health implications due to their global spread and associated health consequences [3]. Studies have shown that *Aedes aegypti* and *Aedes albopictus* are highly competent in transmitting these arboviruses, highlighting the importance of understanding the factors affecting virus transmission from mosquitoes to humans for effective public health interventions. The presence of these vectors in urban environments poses a significant risk for the transmission of these diseases, emphasizing the need for targeted vector control strategies to mitigate the impact of dengue, chikungunya, and Zika infections. Understanding the factors influencing virus transmission from these vectors to humans is essential for public health interventions and targeted control measures. Additionally, controlling these mosquito vectors through strategies like biological insecticides can help break the transmission chain of dengue hemorrhagic fever. The main strategies to control *Ae. aegypti* and *Ae. albopictus* include integrated vector management, sterile insect technique (SIT), and the use of larvicides, insecticides, and biological control methods [5-6]. Integrated vector management, as promoted by the World Health Organization, emphasizes a holistic approach considering biological, genetic, chemical, physical, and cultural control methods tailored to the local context [7]. Additionally, the use of larvicides, and insecticides, has been shown to effectively reduce the population of *Ae. aegypti*, at the beginning of each seasonal period being identified as a cost-effective control strategy. The lethal ovitrap (LO) has shown significant effectiveness in controlling *Aedes* mosquitoes. Studies have demonstrated that the application of lethal ovitraps led to a decline in *Aedes* mosquito density, with some experiments showing a reduction in mosquito populations by attracting gravid mosquitoes and killing newly emerged larvae [8-9]. Additionally, a novel durable dual-action lethal ovitrap (DDALO) designed for *Aedes aegypti* displayed high adult mosquito mortality and prevented successful hatching of eggs, making it a promising tool for controlling wild vector populations [10]. Community participation plays a crucial role in *Aedes* mosquito control efforts. Studies have shown that engaging communities through various methods such as workshops, seminars, and knowledge sharing can lead to a significant reduction in *Aedes* larval indices. Additionally, community perceptions and involvement can help in identifying challenges and implementing effective solutions for

mosquito control projects [11]. Furthermore, community members' knowledge, attitudes, and practices toward mosquito management influence their behaviors, highlighting the importance of addressing misconceptions and promoting appropriate control methods [12]. Overall, community participation is essential for sustainable *Aedes* mosquito control by fostering awareness, cooperation, and effective implementation of preventive measures. This study aimed to reduce the *Aedes* mosquito populations in the study areas using the three innovations of the Department of Medical Sciences (LeO-Trap: lethal ovitrap, AZAI: *Aedes* larvicide, and RepelMos: mosquito repellent) with the community participation approach.

MATERIALS AND METHODS

The study was carried out in 2 Provinces, Chiang Rai and Phrae. In Chiang Rai, 2 villages: Village-8 (151 houses) and Village-13 (282 houses) in Nang Lae Sub-district, Muang District, were chosen for the experiment. As for Phrae, the experiment was conducted in 4 villages: Village-2 (68 houses) and Village-7 (112 houses) of Hua Muang Sub-district, Song District, and Village-9 (103 houses) and Village-10 (99 houses) of Mae Kam Mee Sub-district, Muang District. These villages were selected as the study areas according to what they were forecasted as risk areas of the DHF epidemic in 2021 by the Department of Disease Control, Ministry of Public Health, Thailand. Before the initiation of the project, the village health volunteers (VHVs) of each village were educated on the etiology of DHF and the biology and ecology of the mosquito vectors that transmit the disease: *Ae. aegypti* and *Ae. albopictus*. The prevention and control of the disease and the mosquito vectors were also elaborated clearly. In this study, we used 3 innovations developed by the scientists of the Department of Medical Sciences, Ministry of Public Health, Thailand to reduce the *Aedes* populations in the areas. These innovations were LeO-Trap (lethal ovitrap), AZAI (*Aedes* larvicide, containing 1% temephos as the active ingredient), and RepelMos (mosquito repellent, containing 20% DEET as the active ingredient) (Figure 1), and they were implemented in areas with community participation driven by VHVs of each village. All VHVs were trained on how to use these innovations properly. LeO-Trap is a lethal ovitrap filled with about 500 ml of water and had an attractant (carpet shell extract) to lure gravid *Aedes* females to lay their eggs on the sponge sheet (substrate for egg laying of *Aedes* mosquitoes) in the trap and about 1 g of AZAI was also added in the trap to kill all larvae hatched from eggs. The owner of each house received 4 sets of LeO-Trap (2 traps for use inside the house and 2 traps for use outside the house), 4 bags (100 g.) of AZAI, and 2 bottles (40 ml.) of RepelMos (Figure 1). The owners of the houses were informed to use LeO-Trap properly, refill the water in each trap every two weeks, and replace the AZAI in the trap every three months. The AZAI would be used in water-storage containers infested with *Aedes* larvae to get rid of the larvae while the RepelMos would be applied on bodies to prevent *Aedes* biting. The VHVs collected the sponge sheets from the owner of the treated houses once a month and the number of mosquito eggs on each sheet was counted and recorded. During this study, we used the LINE application to communicate with VHVs in all villages. This is an effective social media to provide knowledge and help them to solve the problems that might occur during their contact with the villagers.



Figure 1: The 3 innovations: LeO-Trap, AZAI, and RepelMos were used in this study.

RESULTS

Table 1 shows the results of the houses infested with *Aedes* mosquito eggs using LeO-Trap in the areas of Village-8 (151 houses) and Village-13 (282 houses) of Nang Lae Sub-district, Muang District, Chiang Rai Province, including a total of 433 houses during the study period of 6 months. It was found that the VHVs were able to collect the sponge sheets from the trapped houses of both 2 villages as compared to all surveyed houses ranging from 81.1% to 95.4%. The houses infested with *Aedes* mosquito eggs ranged from 31.3% to 78.3%. Regarding each village, the VHVs in Village-8 were able to collect sponge sheets from the trapped houses as compared to all surveyed houses with the range from 84.8% to 100% with infested rates of mosquito eggs ranging between 34.4% and 91%. On the other hand, the VHVs in Village-13 could collect sponges from the trapped houses as compared to all surveyed houses from the range of 78% to 100%. The infested rates of houses infested with *Aedes* mosquito eggs were between 29.6% and 82.7% (Table 1).

Table 1: The total number of surveyed houses and *Aedes* eggs-infested houses employing LeO-trap in Village-8 and Village-13 of Nang Lae Sub-district, Muang District, Chiang Rai Province during the study period of 6 months.

Places	Houses	Total number of surveyed houses and <i>Aedes</i> eggs-infested houses (%) by month						Total
		Month-1	Month-2	Month-3	Month-4	Month-5	Month-6	
Village-8	Surveyed houses	151 (100%)	131 (86.8%)	134 (88.7%)	136 (90.1%)	150 (99.3%)	128 (84.8%)	830 (91.6%)
	Infested houses	79 (52.3%)	75 (57.3%)	122 (91%)	104 (76.5%)	74 (49.3%)	44 (34.4%)	498 (60.0%)
Village-13	Surveyed houses	220 (78%)	282 (100%)	276 (97.9%)	262 (92.9%)	223 (79.1%)	223 (79.1%)	1,486 (87.8%)
	Infested houses	182 (82.7%)	157 (55.7%)	199 (72.1%)	145 (55.3%)	110 (49.3%)	66 (29.6%)	859 (57.8%)
Total	Surveyed houses	371 (85.7%)	413 (95.4%)	410 (94.7%)	398 (91.9%)	373 (86.1%)	351 (81.1%)	2,316 (89.1%)
	Infested houses	261 (70.4%)	232 (56.2%)	321 (78.3%)	249 (62.6%)	184 (49.3%)	110 (31.3%)	1,357 (58.6%)

A total of 117,557 *Aedes* mosquito eggs (average 87 eggs/house) were collected from 2 villages of Nang Lae Sub-district, Muang District, Chiang Rai Province for the study period of 6 months (Table 2). The total number of eggs trapped in the LeO-Trap (both inside and outside houses) collected from the 2 villages was the highest number of 37,629 eggs in month 1 (average 144 eggs/house) and the lowest number of 9,684 eggs in month 5 (average 53 eggs/house) (Table. 2). Regarding the areas, it was found that the Village-8 had the highest number of 10,097 eggs in month 3 (average 83 eggs/house) and the lowest number of *Aedes* mosquito eggs at 5,351 eggs (average 72 eggs/house) in month 5, while the Village-13 had the highest 28,621 eggs in month 1 (average 157 eggs/house) and the lowest 4,079 eggs in month 6 (average 62 eggs/house) as shown in Table 2. In the total of the 2 villages, the number of *Aedes* mosquito eggs in the LeO-Trap placed inside the houses was the highest (19,351 eggs) in month 1, and the lowest (3,860 eggs) in month 6 (Table 2). Village-8 had the highest at 5,402 eggs in month 3, and the lowest number of *Aedes* mosquito eggs at 1,868 eggs in month 6. In Village-13, it was found that the highest (14,303 eggs) was in month 1 and the lowest number of *Aedes* mosquito eggs was 1,992 eggs in month 6 (Table 2).

The total number of *Aedes* mosquito eggs in the LeO-Trap placed outside the house (2 villages) was the highest number at 18,278 eggs in month 1 and the lowest at 4,355 eggs in month 5 as shown in Table 2. Village-8 had the highest at 4,695 eggs in month 3, and the lowest number of *Aedes* mosquito eggs at 2,368 eggs in month 5, while the highest at 14,318 eggs of *Aedes* mosquito eggs in month 1 in Village-13, and the lowest number was 1,987 eggs in month 5 (Table 2).

Table 2: The total number of *Aedes* mosquito eggs trapped in the LeO-Trap collected from Village-8 and Village-13 of Nang Lae Sub-district, Muang District, Chiang Rai Province for the study period of 6 months (both inside and outside houses).

Places	Locations of traps in houses	Number of mosquito eggs collected in the LeO-Trap by month						Total
		Month-1	Month-2	Month-3	Month-4	Month-5	Month-6	
Village-8	Inside	5,048	4,432	5,402	5,050	2,983	1,868	24,783
	Outside	3,960	3,510	4,695	4,423	2,368	4,453	23,409
	Total	9,008	7,942	10,097	9,473	5,351	6,321	48,192
	Average/house	114	106	83	91	72	144	97
Village-13	Inside	14,303	5,510	4,904	6,813	2,346	1,992	35,868
	Outside	14,318	5,784	5,381	3,940	1,987	2,087	33,497
	Total	28,621	11,294	10,285	10,753	4,333	4,079	69,365
	Average/house	157	72	52	74	39	62	81
Total	Inside	19,351	9,942	10,306	11,863	5,329	3,860	60,651
	Outside	18,278	9,294	10,076	8,363	4,355	6,540	56,906
	Total	37,629	19,236	20,382	20,226	9,684	10,400	117,557
	Average/house	144	83	63	81	53	95	87

Table 3 shows the results of the houses infested with *Aedes* mosquito eggs using LeO-Trap in the areas of Village-2 (68 houses) and Village-7 (112 houses) of Wang Fon Sub-district, Song

District, Phrae Province, including a total of 180 houses during the study period of 6 months. Overall, the VHVs were able to collect the sponge sheets from the trapped houses of both 2 villages as compared to all surveyed houses ranging from 97.8% to 99.4%. The houses infested with *Aedes* mosquito eggs ranged from 94.3% to 98.9%. Regarding each village, the VHVs in Village-2 were able to collect sponge sheets from the trapped houses as compared to all surveyed houses with the range from 98.5% to 100% with infested rates of mosquito eggs ranging between 92.5% and 100%. On the other hand, the VHVs in Village-7 could collect sponges from the trapped houses as compared to all surveyed houses from the range of 97.3% to 99.1%. The infested rates of houses infested with *Aedes* mosquito eggs were between 95.4% and 99.1% (Table 3).

Table 3: The total number of surveyed houses and *Aedes* eggs-infested houses employing LeO-trap in Village-2 and Village-7 of Hua Muang Sub-district, Song District, Phrae Province during the study period of 6 months.

Places	Houses	Total number of surveyed houses and <i>Aedes</i> eggs-infested houses (%) by month						Total
		Month-1	Month-2	Month-3	Month-4	Month-5	Month-6	
Village-2	Surveyed houses	67 (98.5%)	67 (98.5%)	67 (98.5%)	68 (100%)	68 (100%)	68 (100%)	405 (99.3%)
	Infested houses	67 (100%)	62 (92.5%)	62 (92.5%)	66 (97.1%)	64 (94.1%)	65 (95.6%)	386 (95.3%)
Village-7	Surveyed houses	111 (99.1%)	109 (97.3%)	110 (98.2%)	111 (99.1%)	110 (98.2%)	111 (99.1%)	662 (98.5%)
	Infested houses	109 (98.2%)	104 (95.4%)	105 (95.5%)	107 (96.4%)	109 (99.1%)	108 (97.3%)	642 (97.0%)
Total	Surveyed houses	178 (98.9%)	176 (97.8%)	177 (98.3%)	179 (99.4%)	178 (98.9%)	179 (99.4%)	1,067 (98.8%)
	Infested houses	176 (98.9%)	166 (94.3%)	167 (94.4%)	173 (96.1%)	173 (96.1%)	173 ((96.1%)	1,028 (96.3%)

A total of 99,326 *Aedes* mosquito eggs (average 97 eggs/house) were collected from 2 villages of Wang Fon Sub-district, Song District, Phrae Province for the study period of 6 months (Table 4). The total number of eggs trapped in the LeO-Trap (both inside and outside houses) collected from the 2 villages was the highest number of 31,800 eggs in month 1 (average 91 eggs/house) and the lowest number of 10,371 eggs in month 5 (average 31 eggs/house) (Table 4). Regarding the areas, it was found that Village-2 had the highest number of 13,086 eggs in month 1 (average 195 eggs/house) and the lowest number of *Aedes* mosquito eggs at 3,670 eggs (average 57 eggs/house) in month 5, while the Village-7 had the highest 18,714 eggs in month 1 (average 172 eggs/house) and the lowest 6,701 eggs in month 5 (average 62 eggs/house) as shown in Table 4. In the total of the 2 villages, the number of *Aedes* mosquito eggs in the LeO-Trap placed inside the houses was the highest (16,000 eggs) in month 1, and the lowest (5,359 eggs) in month 5 (Table 4). Village-2 had the highest number of 6,728 eggs in month 1, and the lowest number of *Aedes* mosquito eggs at 1,852 eggs in month 6. In Village-7, it was found that the highest (9,272 eggs) was in month 1 and the lowest number of *Aedes* mosquito eggs was 3,355 eggs in month 4 (Table 4). The total number of *Aedes* mosquito eggs in the LeO-Trap placed outside the house (2 villages) was the highest number at 15,800 eggs in month 1 and the lowest at 5,012 eggs in month 5 as shown in Table 4. Village-2 had the highest at 6,358 eggs in month

1, and the lowest number of *Aedes* mosquito eggs at 1,811 eggs in month 5, while the highest at 9,442 eggs of *Aedes* mosquito eggs in month 1 in Village-7, and the lowest number was 3,201 eggs in month 5 (Table 4).

Table 4: The total number of *Aedes* mosquito eggs trapped in the LeO-Trap collected from Village-2 and Village-7 of Hua Muang Sub-district, Song District, Phrae Province for for the study period of 6 months (both inside and outside houses).

Places	Locations of traps in houses	Number of mosquito eggs collected in the LeO-Trap by month						Total
		Month-1	Month-2	Month-3	Month-4	Month-5	Month-6	
Village-2	Inside	6,728	4,018	3,154	2,279	1,859	1,852	19,890
	Outside	6,358	2,452	3,589	1,906	1,811	2,217	18,333
	Total	13,086	6,470	6,743	4,185	3,670	4,069	38,223
	Average/house	195	104	109	63	57	63	99
Village-7	Inside	9,272	4,857	6,159	3,355	3,500	3,903	31,046
	Outside	9,442	4,913	5,298	3,352	3,201	3,851	30,057
	Total	18,714	9,770	11,457	6,707	6,701	7,754	61,103
	Average/house	172	94	109	63	62	72	95
Total	Inside	16,000	8,875	9,313	5,634	5,359	5,755	50,936
	Outside	15,800	7,365	8,887	5,258	5,012	6,068	48,390
	Total	31,800	16,240	18,200	10,892	10,371	11,823	99,326
	Average/house	91	53	56	33	31	33	97

Table 5 shows the results of the houses infested with *Aedes* mosquito eggs using LeO-Trap in the areas of Village-9 (103 houses) and Village-10 (99 houses) of Mae Kam Mee Sub-district, Muang District, Phrae Province, including a total of 202 houses during the study period of 6 months. Overall, the VHV's were able to collect the sponge sheets from the trapped houses of both villages as compared to all surveyed houses ranging from 97.5% to 100%. The houses infested with *Aedes* mosquito eggs ranged from 74.8% to 95%. Regarding each village, the VHV's in Village-9 were able to collect sponge sheets from the trapped houses as compared to all surveyed houses with the range from 97.1% to 100% with infested rates of mosquito eggs ranging between 76.7% and 96.1%. On the other hand, the VHV's in Village-10 could collect sponges from the trapped houses as compared to all surveyed houses from the range of 98% to 100%. The infested rates of houses infested with *Aedes* mosquito eggs were between 72.7% and 97% (Table 5).

Table 5: The total number of surveyed houses and *Aedes* eggs-infested houses employing LeO-trap in Village-9 and Village-10 of Mae Kam Mee Sub-district, Muang District, Phrae Province during the study period of 6 months.

Places	Houses	Total number of surveyed houses and <i>Aedes</i> eggs-infested houses (%) by month						Total
		Month-1	Month-2	Month-3	Month-4	Month-5	Month-6	
Village-9	Surveyed houses	103 (100%)	100 (97.1%)	102 (99.0%)	103 (100%)	103 (100%)	103 (100%)	614 (99.3%)

	Infested houses	79 (76.7%)	89 (89.0%)	86 (84.3%)	91 (88.3%)	97 (94.2%)	99 (96.1%)	541 (88.1%)
Village-10	Surveyed houses	99 (100%)	97 (98.0%)	99 (100%)	99 (100%)	99 (100%)	99 (100%)	592 (99.7%)
	Infested houses	72 (72.7%)	81 (83.5%)	89 (89.9%)	96 (97.0%)	89 (89.9%)	93 (93.9%)	520 (87.8%)
Total	Surveyed houses	202 (100%)	197 (97.5%)	201 (99.5%)	202 (100%)	202 (100%)	202 (100%)	1,206 (99.5%)
	Infested houses	151 (74.8%)	170 (86.3%)	175 (87.1%)	187 (92.6%)	186 (92.1%)	192 (95.0%)	1,061 (88.0%)

A total of 65,277 *Aedes* mosquito eggs (average 62 eggs/house) were collected from 2 villages of Mae Kam Mee Sub-district, Muang District, Phrae Province for the study period of 6 months (Table 6). The total number of eggs trapped in the LeO-Trap (both inside and outside houses) collected from the 2 villages was the highest number of 12,644 eggs in month 2 (average 74 eggs/house) and the lowest number of 10,101 eggs in month 6 (average 53 eggs/house) (Table 6). Regarding the areas, it was found that Village-9 had the highest number of 6,512 eggs in month 2 (average 73 eggs/house) and the lowest number of *Aedes* mosquito eggs at 5,108 eggs (average 59 eggs/house) in month 3, while the Village-10 had the highest 6,132 eggs in month 2 (average 76 eggs/house) and the lowest 4,451 eggs in month 1 (average 62 eggs/house) as shown in Table 6.

In the total of the 2 villages, the number of *Aedes* mosquito eggs in the LeO-Trap placed inside the houses was the highest (6,992 eggs) in month 2, and the lowest (4,736 eggs) in month 6 (Table 6). Village-9 had the highest number of 3,747 eggs in month 2, and the lowest number of *Aedes* mosquito eggs at 2,267 eggs in month 6. In Village-10, it was found that the highest (3,247 eggs) was in month 4 and the lowest number of *Aedes* mosquito eggs was 2,077 eggs in month 1 (Table 6).

The total number of *Aedes* mosquito eggs in the LeO-Trap placed outside the house (2 villages) was the highest number at 5,652 eggs in month 2 and the lowest at 5,029 eggs in month 3 as shown in Table 6. Village-9 had the highest at 2,923 eggs in month 1, and the lowest number of *Aedes* mosquito eggs at 2,494 eggs in month 3, while the highest at 2,887 eggs of *Aedes* mosquito eggs in month 2 in Village-10, and the lowest number was 2,210 eggs in month 5 (Table 6).

Table 6: The total number of *Aedes* mosquito eggs trapped in the LeO-Trap collected from Village-9 and Village-10 of Mae Kam Mee Sub-district, Muang District, Phrae Province during the study period of 6 months (both inside and outside houses).

Places	Locations of traps in houses	Number of mosquito eggs collected in the LeO-Trap by month						Total
		Month-1	Month-2	Month-3	Month-4	Month-5	Month-6	
Village-9	Inside	3,031	3,747	2,614	2,576	3,531	2,267	17,766
	Outside	2,923	2,765	2,494	2,734	2,860	2,851	16,627
	Total	5,954	6,512	5,108	5,310	6,391	5,118	34,393
	Average/house	75	73	59	58	66	52	64

Village-10	Inside	2,077	3,245	2,487	3,247	2,362	2,469	15,887
	Outside	2,374	2,887	2,535	2,477	2,210	2,514	14,997
	Total	4,451	6,132	5,022	5,724	4,572	4,983	30,884
	Average/house	62	76	56	60	51	54	59
Total	Inside	5,108	6,992	5,101	5,823	5,893	4,736	33,653
	Outside	5,297	5,652	5,029	5,211	5,070	5,365	31,624
	Total	10,405	12,644	10,130	11,034	10,963	10,101	65,277
	Average/house	69	74	58	59	59	53	62

DISCUSSION

The LINE application was used in this study to provide essential information and help the VHVs during their operation in the villages. One significant issue lies in the incapacity of the VHVs to retrieve sponge sheets from LeO-Traps placed in certain households within the vicinity. This difficulty arises when the homeowner relocates to a different area beyond the village for employment purposes or misplaces the trap during its operation. Coupled with the challenge posed by the COVID-19 pandemic in the region, the retrieval of sponge sheets from traps in specific houses became unfeasible. Hence, village health volunteers play a crucial role as key figures in the management of diseases within specific regions. Oversight of the activities aimed at preventing and managing these diseases falls under the responsibility of the officials at the Subdistrict Health Promotion Hospital within the responsible areas. Guidance on addressing challenges and hindrances in the operations was closely offered by the personnel at the Department of Medical Sciences.

In this study, LeO-Trap was used to collect *Aedes* mosquito eggs and the emerged larvae were killed eventually by AZAI (1% temephos larvicide). LeO-Trap is a novel lethal ovitrap designed to attract gravid female *Ae. aegypti* and *Ae. albopictus* mosquitoes and kill the emerged larvae, significantly increasing oviposition efficacy and reducing adult populations in field experiments [8]. The trap combines a physically attractive design with a biochemical attractant from carpet shell extract and a larvicide (AZAI) to effectively lure mosquitoes to lay eggs inside, leading to the eventual elimination of larvae [8]. The LeO-Trap was used for surveillance and control for *Ae. aegypti* and *Ae. albopictus* in many places in Thailand [12-14].

Overall, the number of *Aedes* eggs collected by the LeO-Trap inside the houses was higher than those obtained outside the houses in the three sub-districts. Some *Aedes* eggs collected inside the houses were identified as *Ae. aegypti* only, while some of those retrieved from outside the houses were identified as *Ae. aegypti* for 80-90% and *Ae. albopictus* for 10-20%. The total number of *Aedes* eggs collected from inside and outside the houses of the 6 villages in this study was 282,160 eggs; therefore, it could be estimated that 70,540,000 *Aedes* mosquitoes were rid of by the LeO-Trap in the study areas based on the assumption that a female mosquito could produce 500 offspring in her lifetime. Regarding the data collected by Sub-district, the highest numbers of *Aedes* eggs were collected from Nang Lae Sub-district in Muang District, Chiang Rai Province (117,557 eggs with an average 87 eggs/house), followed by Hua Muang Sub-district in Song District, Phrae Province (99,326 eggs with an average 97 eggs/house) and Mae Kam Mee Sub-district in Muang District, Phrae Province (65,277 eggs with an average 62 eggs/house). As can be seen, a large number of *Aedes* eggs were collected from the 6 villages, and they were decreased gradually over the study period. The people in all the villages have been satisfied

with the decrease in *Aedes* mosquitoes in their houses. It is interesting to note that there was no case of dengue or DHF in the 6 villages during the study period and even a year after that. Therefore, implementing vector control interventions based on oviposition behavior to reduce mosquito populations and pathogen transmission is crucial. Monitoring and controlling vector species like *Aedes aegypti* using ovitraps, which are effective tools in epidemiological studies and long-term mosquito control is thus important. Ovitrap with biological larvicide, *Bacillus thuringiensis israelensis* (Bti) were also effective and safe for controlling *Ae. aegypti* and *Ae. albopictus*, considering the number of eggs laid and the selectivity of pathogens for mosquitoes [16].

The AZAI larvicide was also applied in some water-storage containers in the villages when the VHVs or homeowners found *Aedes* larvae in the containers. A large number of containers infested with *Aedes* larvae are usually found in the rainy season. Hidden larval habitats, potentially created by rainwater in inconspicuous places, contributed to the mosquito population. Therefore, it is important to get rid of the breeding places of *Aedes* mosquitoes as much as possible to reduce *Aedes* populations. The use of RepelMos to prevent mosquito biting is an important intervention to minimize vector-human contact. The application of repellent lotion serves as a method to disrupt the interaction pattern between individuals and *Aedes* mosquitoes, thereby offering an additional approach to dengue fever prevention. Furthermore, it can deter the feeding activities of various mosquito vectors, including bothersome mosquitoes and *Anopheles* mosquitoes. This could be the best way to prevent mosquito-borne diseases via pathogen transmission as well as to reduce mosquito populations when the mosquitoes lack blood meal. The villagers in this study were satisfied with the repellent application when they had to be exposed to mosquitoes.

Dengue fever is always prevalent across all regions of Thailand. Consequently, efforts are implemented to oversee and manage disease prevention. This undertaking must encompass comprehensive coverage of all territories, particularly in regions with heightened susceptibility to outbreaks. This involves the implementation of disease surveillance protocols and the supervision of *Aedes* mosquito breeding sites in high-risk locations like residential areas, educational institutions, religious sites, public parks, and tourist destinations. Effective risk communication plays a crucial role in raising public awareness regarding the prevention of dengue fever, particularly in anticipation of the upcoming rainy season. Such proactive communication efforts are essential in averting extensive outbreaks and mitigating the severity of cases during the epidemic period. To achieve this objective, a collaborative approach involving multiple stakeholders is necessary, encompassing both public and governmental entities.

The successful prevention and control of *Aedes* mosquitoes through the utilization of all three innovations developed by the Department of Medical Sciences are highlighted in this study. This achievement is attributed to the collaborative efforts of village health volunteers within the community, who work in conjunction with homeowners assigned to each volunteer in every village (approximately 10-15 houses per person). Furthermore, the active participation of the homeowners plays a crucial role in this endeavor. The primary consideration in the management of *Aedes* mosquitoes through the utilization of LeO-Trap pertains to the necessity of replenishing the trap with water on a biweekly basis and replacing the AZAI that kills *Aedes* larvae every three months. In the absence of these aforementioned procedures, the efficacy of

Leo-Trap in attracting *Aedes* mosquitoes for oviposition and eradicating the hatched larvae will be compromised. Consequently, the employment of LeO-Trap serves as a preventive measure against the reproduction of mosquitoes that have previously ingested blood.

Effective communication of risks is essential in raising awareness about the prevention of dengue fever, particularly in anticipation of the onset of the rainy season. Such efforts play a crucial role in averting large-scale outbreaks and mitigating the impact of the disease during epidemic periods. This initiative has engaged village health volunteers, who share collective responsibility for its implementation. Utilizing the LINE application as a consistent and frequent means of imparting information and addressing operational challenges within the community. Communication is utilized to disseminate information regarding dengue fever and the innovative strategies employed for the prevention and control of *Aedes* mosquitoes. The promotion of enhanced comprehension among village residents is facilitated through the dissemination of periodic audiovisual content reflecting local sounds. Achievement of these objectives necessitates collaborative efforts from all sectors, encompassing both public and governmental entities.

CONCLUSION

In conclusion, it was evidenced that the three innovations, especially the LeO-Trap used in this study with community participation could substantially reduce *Aedes* mosquito populations in the study areas. Close communication using the LINE application would be an effective tool to provide important information for VHVs and villagers and solve problems that occur promptly, especially during the COVID-19 epidemic period. It could affect the reduction of the disease. This could be an effective model for the prevention and control of *Aedes* mosquitoes in other areas.

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