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The effectiveness of impregnated bed net in malaria control in Laos

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Abstract

Impregnated bed net (IBN) were used in 366 villages in the central and southern three provinces of Lao PDR from 1999 to 2000. It was confirmed that 81.0% of 40 000 bed nets, which were donated by Japanese Grant Aid, were delivered within 2 years. The strengthening of information network systems in anti-malaria and strong relationship between community and local authorities ensured the success of operation in a short period. The number of patients and the slide positive rate of malaria decreased markedly in public health facilities in three provinces after the use of IBN. An entomological survey was conducted in Boualapha district, where malaria is endemic, to investigate the IBN efficacy on malaria vector. The density and parous rate of *Anopeles dirus,* which is the main malaria vector in the area, were markedly decreased in the village where IBN was used. This mosquito's behavior, which was baiting mainly humans during the time when the inhabitants sleep in the IBN, was considered to be advantageous in preventing malaria infection using by IBN. The area of distribution of *A. dirus* is similar to the high endemic area of malaria in Lao PDR. Thus, it is expected that the expansion of the IBN program in the southern provinces will lead to successful malaria control in subsequent years.

Keywords: Malaria; Laos; IBN; *Anopheles dirus*

1. Background of the impregnated bed net program

It has been reported that malaria is a serious public health problem in Lao PDR (Kobayashi et al., 1998; Singhasivanon, 1999; Pholsena, 1992). The Ministry of Health, Lao PDR, reported that the number of malaria cases was highest in patients in all public health facilities in 1995 (Table 1). The mortality rate from malaria was higher than that for other main diseases (Table 2). From 1996, the Lao government started a national malaria control program supported by several donors. Use of impregnated bed net (IBN), which was main strategy in this national program,

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Table 1
Mortality rate (per 100 000) of main diseases in Lao PDR (1995)

Malaria	7.62
Pneumonia	3.03
Meningitis	1.45
Diarrhea	1.23
Tuberculosis	0.75
Accident	0.51

Ministry of Health, Lao PDR in 1995.

Table 2
Number of cases in public health facilities in Lao PDR (1995)

Malaria	73831
Pneumonia	15962
Influenza	24110
Diarrhea	19699
Dengue fever	7781
Dysentery	7010
Tuberculosis	2711
Accident	2330

Ministry of Health, Lao PDR in 1995.

was carried out nation wide from 1999. In the Vientiane, Borikhamxay and Khammounae Province which are central and southeastern provinces (shown in Fig. 1) a total of 40 000 bed nets, with the support of Japanese grant aid, were delivered to 366 villages from 1999 to 2000. Half the bed nets was Olyset net, a long-lasting insecticidal bed net. There were delivered mainly to remote villages. All normal bed nets were impregnated by community volunteers under supervision of the anti-malaria team after operation of IBN program. Health education including guidance in use of long-lasting bed nets was carried out by health personnel and community volunteers in the villages where Olyset nets were delivered. A cost recovery system was operated except the poor families as authorized by the local government. The district authorities decided the price of the bed nets. The selling price was normally half the market price, which is US$ 2–4. It was confirmed that 81.0% (32 391/40 000) of bed nets were delivered within 2 years. The reports were submitted to Center of Malariology, Parasitology and Entomolgy (CMPE) as national referral center through the anti-malaria team in the provinces from the district malaria unit. In the Lao PDR, the accessibility of the center of district where the district malaria unit was located sometimes posed difficulties for communities. It was estimated that more than 60% of communities in three provinces were located in areas where it took more than 24 h to reach the district capital. Thus, it can be assumed that the real number of bed net delivered was higher than the reported number in the remote areas. When the bed nets were delivered, the district malaria officer might record the data except in cases of free delivering to the poor family or no collecting the money on the time. In these cases, village leader or volunteer had to report to the district malaria unit. However, sometimes no reported was issued due to poor accessibility. Thus, the majority of unrecorded bed nets were assumed to reach the communities. How can more than 80% of bed nets be distributed within 2 years under such difficult conditions? One reason was the strong information network system of the anti-malaria team, which was strengthened in the past 10 years, due to a reporting system using wireless telephone. Another important reason seems to be the strong relationship between community and local authorities in these provinces. A lot of village leaders played the leading role in encouraging community participation in this project. These assessments were conducted by focus group discussion in district health offices and communities as qualitative survey.

Fig. 1. Three provinces where IBN program was operated.

Table 3 shows the coverage of village in the target districts in three provinces in a 2-year period. High risk area of malaria infection was chosen for delivery of the IBN. All villages in Boualapha district were covered

Table 3
The number of villages and populations where IBN was operated supported by Japanese Grant Aid (1999–2000)

Province	District	No. of villages	No. of villages where IBN was operated			Rate of no. villages where IBN was operated	Total population of district	Total population of villages where IBN was operated	Rate of population of IBN villages in districts
			Operated Olyset net	Operated normal bed net	Total				
Vientiane	Feuang	63		29	29	46.0	40548	11134	27.5
	Xanakham	51		15	15	29.4	32973	8970	27.2
	Hinheub	48	15	5	20	41.7	22796	7532	33.0
	Met	41	18	2	20	48.8	14283	7977	55.8
	Total	203	33	51	84	41.4	110600	35613	32.2
Borikhamxay	Thaphabat	32		10	10	31.3	22662	5428	24.0
	Bolikhan	42		4	4	9.5	25871	2257	8.7
	Pakkading	51		12	12	23.5	33901	6024	17.8
	Khamkeut	110	49	34	83	75.5	54695	23286	42.6
	Viangthong	36	9		9	25.0	17041	1882	11.0
	Total	271	58	60	118	43.5	154170	38877	25.2
Khammouane	Hinboon	199	2	6	8	4.0	55817	2367	4.2
	Mahaxay	89		9	9	10.1	25692	2276	8.9
	Nongbock	72	6	7	13	18.1	40524	6739	16.6
	Xebangphay	50	15	22	37	74.0	22316	16300	73.0
	Xaibatong	65	24	13	37	56.9	17102	9244	54.1
	Boualapha	82	73	9	82	100.0	20926	20926	100.0
	Total	557	120	66	186	33.4	182377	57852	31.7

Table 4
Number and coverage of IBN in the communities

Province	Distirict	Total population where IBN was operated	No. of Olyset nets	No. of Normal nets	Total No. of bed net	No. of old net treated	Total No. of IBN	Person/IBN
Vientiane	Feuang	11134	0	3389	3389	1953	5342	2.08
	Xanakham	8970	0	3055	3055	909	3964	2.26
	Hinheub	7532	1102	779	1881	1062	2943	2.56
	Met	7977	1722	104	1826	642	2468	3.23
	others		35		35			
	Total	35613	2859	7327	10186	4566	14717	2.42
Borikhamxay	Thaphabat	5428	0	874	874	895	1769	3.07
	Bolikhan	2257	0	300	300	0	300	7.52
	Pakkading	6024	0	1329	1329	17	1346	4.48
	Khamkeut	23286	3596	2905	5433	166	5599	4.58
	Viangthong	1882	904		904	0	904	2.08
	Others		143		143			
	Total	38877	4643	5408	8983	1078	9918	3.92
Khammouane	Hinboon	2367	150	690	840	3	843	2.81
	Mahaxay	2276	0	548	548	88	636	3.58
	Nongbock	6739	660	676	1336	86	1422	4.74
	Xebangphay	16300	1097	2054	3151	1843	4994	3.26
	Xaibatong	9244	1310	988	2298	0	2298	4.02
	Boualapha	20926	4676	756	5432	0	5432	3.85
	Others		23	17	40			
	Total	57852	7916	5729	13645	2020	15625	3.70

Others: delivering to provincial staff or hospital.

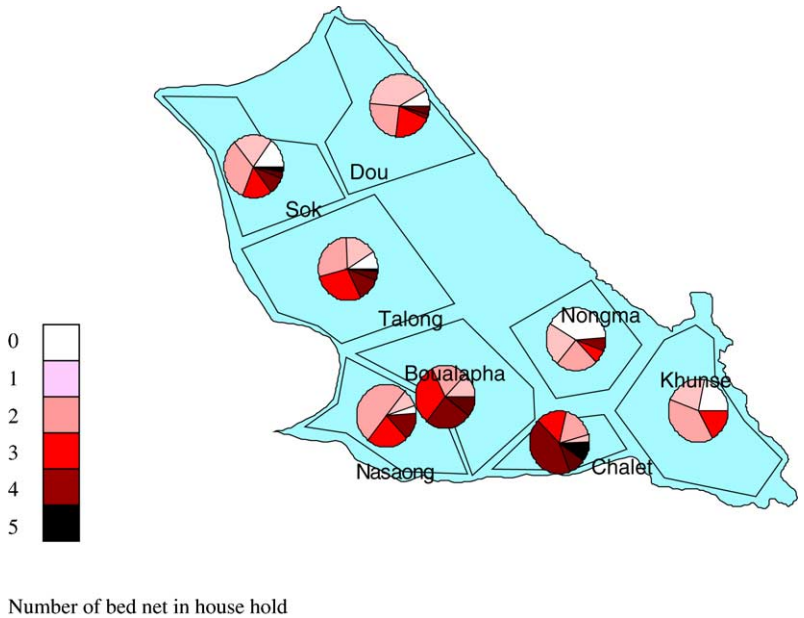

Fig. 2. Comparison of the number of bed nets in each household among sub-district in Boualapha district.

as model district to be located in highest endemic area. The coverage of IBN in the communities is shown in Table 4. The number of person per IBN (total population/number of IBN) was used to estimate coverage in the community. The national IBN program aims at 80% coverage. This was set as an indicator to evaluate the coverage. The average of person per net was under 3.7 in Vientiane and Khammouane Provinces. In the first year, the person per net ratio in Borikamxay Province appeared high due to a misunderstanding in the project plan. After the monitoring of the project in the first year, the remaining nets were delivered to the communities where the indicator of coverage was low. The indicator fell to 3.92 by the end of 2000 in Borikhamxay Province.

The person per IBN ratio is an indicator which shows the degree of coverage, however, the actual coverage cannot be determined without a survey of each household. The household survey was conducted in Boualapha district, where IBN was used all villages, and almost 80% of population was covered. Three villages were randomly selected in each sub district of the survey. Fig. 2 shows the number of bed nets per household in each sub district. The capital of Boualapha district is located in Talong sub district. Sek, Dou, Nonama and Khunse are located in an area where it takes more than 24 h to reach the center of district using any form transportation. In these rural areas neither, IBN nor normal bed net was found in a lot of households. Bed net was not used in all households, and especially poor family might be received any bed net. Whereas indicators showed a satisfactory level in the district unit, some area; especially rural area was not always able to benefit from the project. It is recommended that the supervision in rural communities, which are highest endemic of malaria, is necessary in next phase of the project.

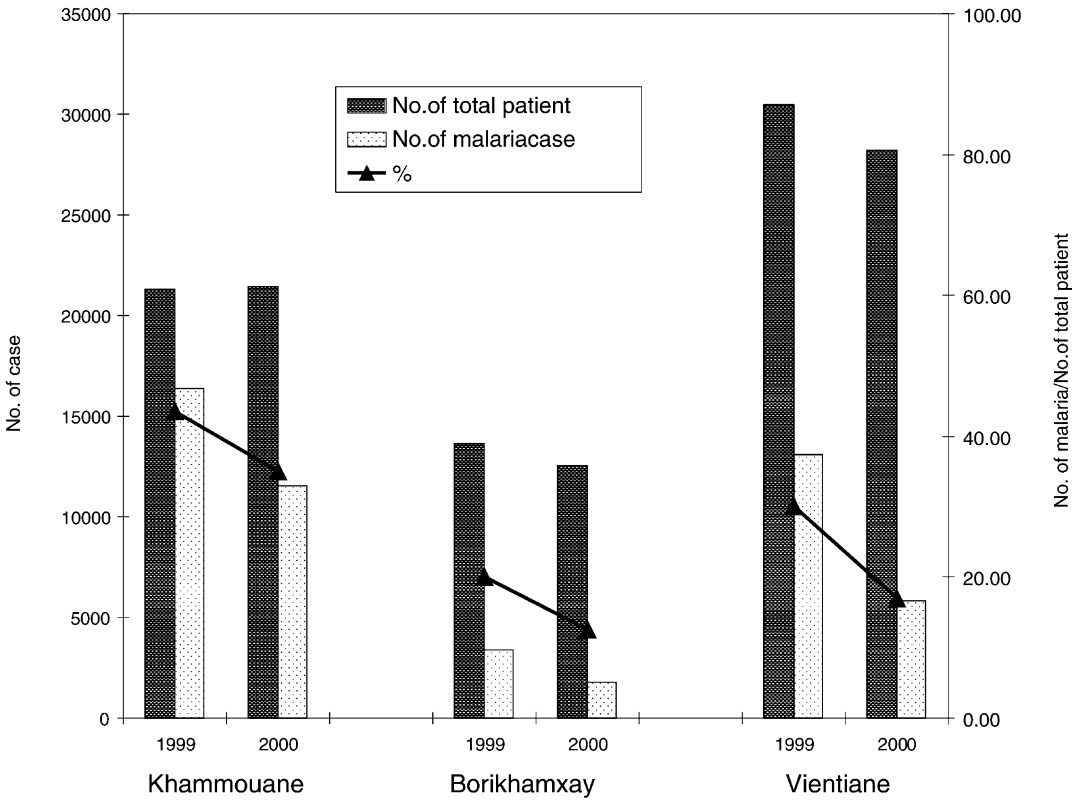

Fig. 3. Comparison of number of malaria patients between 1999 and 2000 in three provinces.

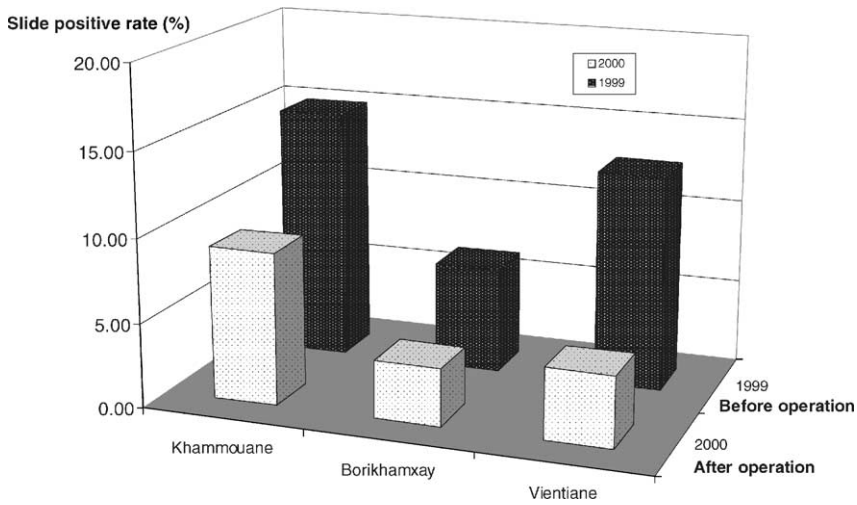

Fig. 4. Comparison of slide positive rate between 1999 and 2000 in the health facilities in three provinces.

2. Evaluation by passive case detection

The total number of malaria patients in all public health facilities in 2000 markedly decreased in all three provinces as compared with 1999 (shown in Fig. 3). The rate of malaria patients in the total number of patients also decreased. It was assumed from these results that all malaria patients including those from the area where the inhabitants were not able to gain access health facilities had also decreased. Fig. 4 showed

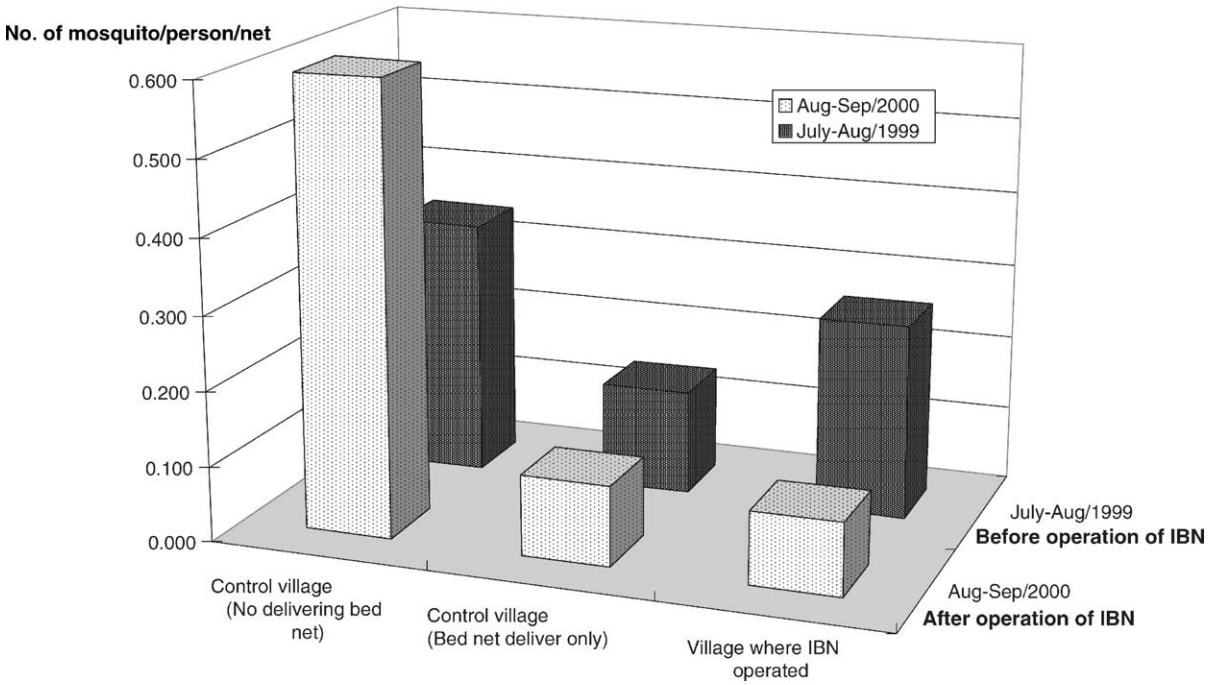

Fig. 5. Comparison of density of *A. dirus* before and after operation of IBN.

the reduction in malaria positive case in patients who presented with fever in all public health facilities in three provinces. Early treatment in the communities was conducted from 1993 to 1995 in Khammouane Province operating of drug revolving fund. After 1995, there was no expansion of this fund and no other activities related to early treatment in the area where IBN operated after 1999. Thus, IBN operation was claimed to be main factor in reducing the fall in the rate of cases in 2000.

3. Mosquito biting behavior in the pilot area

It has been reported the delivery of untreated bed nets could also protect against malaria (Clarke et al., 2001), but nevertheless, that IBN operation has not influenced the reduction of morbidity, caused by malaria, when coverage of IBN was low. Thus, a survey was conducted to evaluate the direct efficacy of IBN against malaria vector mosquitoes since the direct efficacy of IBN can be proved by studying the variation of malaria vector mosquitoes.

Three villages in Bourapha district, one of most serious malaria endemic areas, were selected for the survey. From July to August 1999, when IBN operated, and August–September 2000 (1 year after IBN operation), *Anopheles dirus* suspected main vector in this area, was collected by human bait in three villages (Toma et al., 2003). Olyset net was used in Napoung village. At least one Olyset net was delivered to total 60 households. As a control, the new untreated bed net was delivered to Koutboun village. In this village, at least one untreated bed net was used in 40 households. As the other control, no bed net was delivered in Thapachone village. In these villages, no other vector control activities were conducted. Fig. 5 shows the mosquito density calculated by number of mosquitoes per hour per person. The decrease of mosquito density was found in the village where IBN scheme was operated, however, the density did not decrease in the other two control villages. All *A. dirus*, were dissected

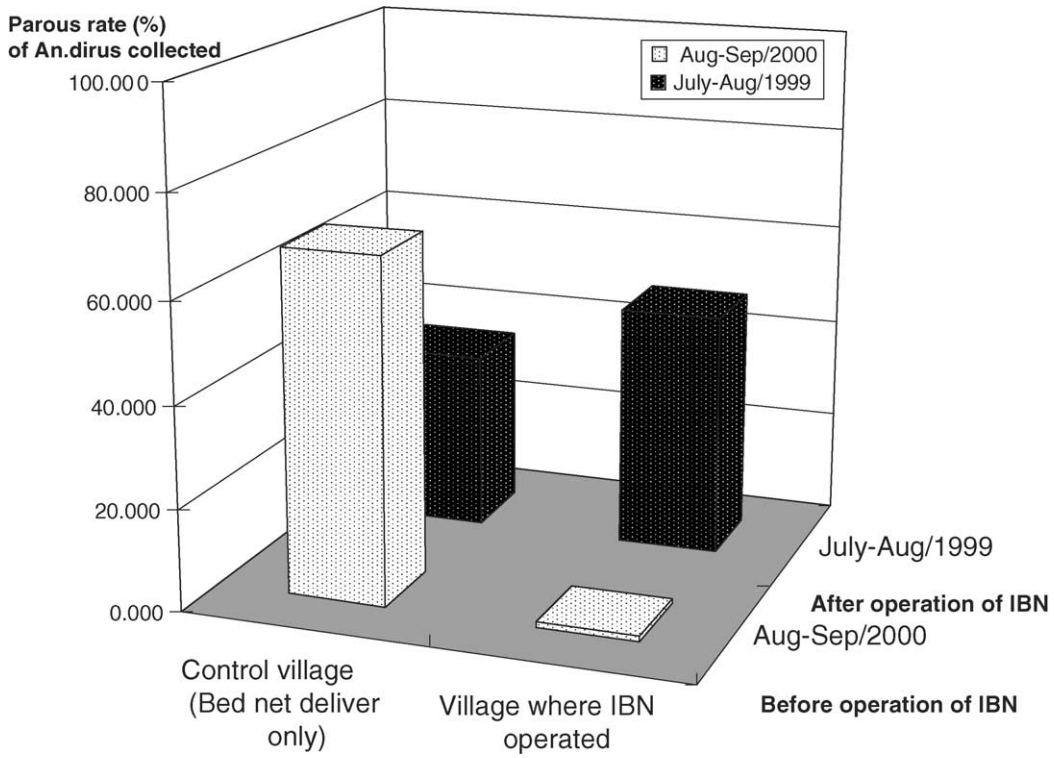

Fig. 6. Comparison of the parous rate of *A. dirus* before and after operation of IBN program.

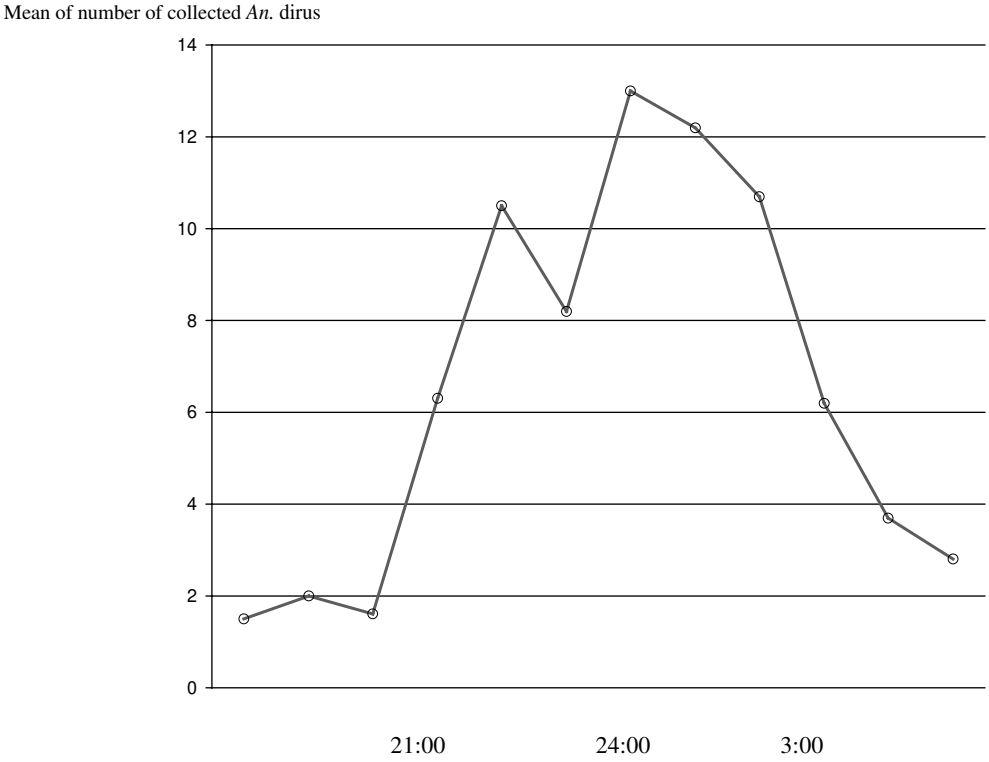

Fig. 7. Mean of number of *A. dirus* which were collected by human bait collection in Boualapha district.

Table 5
Percentage of collection for major Anopheline mosquitoes in three villages, Boualapha district, in August 1999

Species	Human bait	Animal bait
(Celia)		
A. aconitus	5.3	0.9
A. dirus	27.5	0.6
A. kochi	4.5	11
A. maculatus	1.6	0.3
A. minimus A	11.8	1.4
A. nivipes	25.3	36.6
A. philippinensis	2.7	4.6
A. sawadwongporni	1.6	0.3
A. tesselatus	1.1	0.6
A. vagus	1.1	3.3
Anopheles		
A. barbirostris g.	3.2	1.5
A. peditaeniatus	0.8	1.8
A. sinensis	12	36.3

to exam the parity of mosquito. The parous rate decreased to almost 0% in the village where IBN was operated (Fig. 6), however, in the other control villages the parous rate of *A. dirus* was not very different between 1999 and 2000. This indicated that the operation of IBN provided protection against most mosquito bites.

The biting behavior of *A. dirus* was studied to make clear the reason why IBN is an effective to controling the malaria vector in this area. Table 5 shows a comparison of the proportion of Anopheline mosquitoes which were collected by human bait and by animal bait in the three villages in 1999. A large number of *A. dirus* were collected by human bait; however, only a few *A. dirus* were found in animal bait collection. Thus, *A. dirus* showed the behavior of anthorophilic mosquito in this area. Fig. 7 shows other biting behavior of vector mosquito in this same area, and the number of *A. dirus* in each hour collected by human bait in the Thapachone village in 2000. The majority of mosquito bit human in around midnight; from 21:00

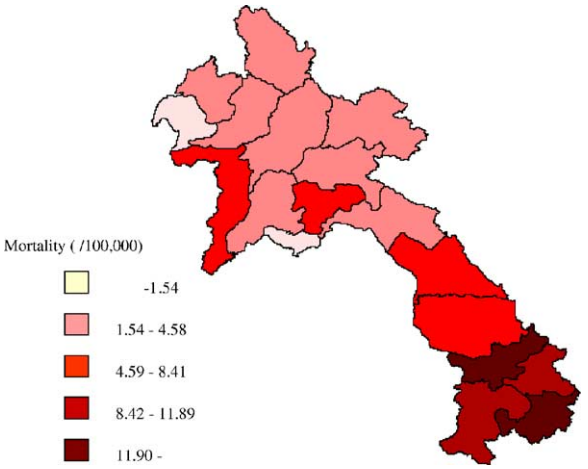

Fig. 8. Malaria mortality among provinces in Lao PDR (2000) by Ministry of Health, Lao PDR.

to 03:00 h. These biting behaviors assist the transmission of malaria to humans. On the other hand, when control vector was considered, these biting behaviors were also advantageous to prevent malaria infection using by IBN.

A. dirus is found in the central and southern provinces in Lao PDR (Vythilingam et al., 2001; Vythilingam et al., 2003). Ministry of Health, Lao PDR reported a high malaria mortality in central to southern province (Fig. 8). It explained generally that human behavior and the poor economic situation of the minority group, named "Lao thung" influence high mortality in southern provinces. However, the result of our study suspects other factors in this area. The area of distribution of *A. dirus* corresponded to the high endemic area of malaria in Lao PDR. Thus, it is expected that the expansion of the IBN program in the southern provinces may lead to the success of malaria control in future years. However, it is known that the mosquitoes are able to change their baiting behavior. It is recommended therefore that monitoring of mosquito behavior is an important measure to controlling malaria in Lao PDR (Table 6).

Table 6
Number of bed nets supported by project and number of bed nets delivered by confirmation in report

	No. of bed nets supported	No. bed nets delivered	Rate of delivering bed nets
Vientiane			
Olyset net	3500	2859	81.7
Normal net	8000	7327	91.6
Borikhamxay			
Olyset net	6000	4643	77.4
Normal net	4800	5408	112.7
Khammouane			
Olyset net	10500	7916	75.4
Normal net	7200	5729	79.6
Total	40000	32391	81.0

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