1. INTRODUCTION

There is a long history of antimalarial operations in northern Thailand, commencing in 1930 when the first malaria unit was opened in Chiangmai to carry out limited malaria surveys and to administer quinine. In 1949 the Government, with WHO/UNICEF assistance, initiated a malaria control pilot project in the plains of Chiangmai Province, based on DDT house spraying. Subsequent to the encouraging results obtained, these activities were expanded into a country-wide control programme in 1951, with US government assistance. From 1965 to 1974 an eradication strategy was followed, initially with WHO/USAID assistance and later with WHO help only. Since 1975 malaria control has again become the objective of the programme in areas of medium and high receptivity, while eradication has been the goal in areas of low receptivity and in those parts of the country where the programme has already been phased into partial integration with the General Medical Services.

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The Thai antimalaria programme has been beset by many technical problems, as well as some administrative and financial difficulties. Technical problems include:

- *Plasmodium falciparum* resistance to 4-aminquinolines, which began as early as 1960 and now includes over 90% of isolates from throughout the country (WHO, 1981);

- *P. falciparum* resistance to sulfadoxine-pyrimethamine which is found in as many as 80% of infections and is spreading very rapidly due to internal migration (Pinichpongse et al., 1982);

- Exophilic behaviour on the part of the principal vectors, *Anopheles dirus* (balabacensis) and *An. minimus* (Ismail et al., 1974). Preliminary data further indicate that *An. minimus* in the forested foothills of northern Thailand is strongly deterred from resting on DDT-sprayed surfaces but that DDT does, nevertheless, afford considerable protection by causing divergence to cattle biting, despite the limited contact with the insecticide (Nutsathapana, 1982);

- Uncontrolled forest clearance for agriculture (and illicit mining and logging operations), where the population live in temporary, usually unsprayed, shelters and are thus exposed to *An. dirus* without adequate (or any) protection.

Despite these setbacks and difficulties, malaria control activities in Region 2 (northern Thailand) have generally been remarkably successful (Ministry of Public Health - Malaria Division, 1979). During the period 1975-1980 the annual parasite index varied between 4.5% and 6.0% only. Had it not been for limited outbreaks, this figure would always have been at or below the lower end of the range. Whenever outbreaks have occurred, it has been the delay in recognizing the accelerating incidence, during the early stages, that has resulted in failure to implement the necessary remedial measures in time. Thus, quite severe outbreaks have built up in fairly small areas, from a very few to hundreds of cases per year. This is clearly shown in Table 1 which gives a summarized picture of the incidence in two districts of the northern region for the years 1973-1981.

**TABLE 1. EVOLUTION OF MALARIA OUTbreakS IN TWO DISTRICTS OF NORTHERN THAILAND**

<table>
<thead>
<tr>
<th>District</th>
<th>Number of cases per year *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li</td>
<td>402</td>
</tr>
<tr>
<td>Mae Ai</td>
<td>55</td>
</tr>
</tbody>
</table>

* Slide positive for *P. falciparum* or *P. vivax*. 
Even though the monthly number of cases per District may be available at Sector level within a period of 3-4 weeks following the end of each month, the reasons for delay in recognizing an outbreak are easy to understand. They include:

- absence of a yardstick against which the current month's data can be measured;
- lack of epidemiological expertise at Sector and Zone levels;
- long delays in reporting from Sector, through Zone, to Regional level, where decisions concerning action are taken;
- an over-burdened Regional Epidemiology Section. As a result there is considerable delay in comparing yearly malaria incidences, District by District.

Therefore the need for an early warning system is evidently urgent in order to overcome these difficulties, as well as to enable a more rational application of control measures. Ideally, such a system should be simple enough to be applied at the lowest level of the malaria control organization, i.e. at Sector level, reliable enough to indicate abnormal numbers of cases in limited areas and sensitive enough to give timely warning of impending outbreaks.

The following epidemiological monitoring system developed for introduction in northern Thailand appears to meet these criteria.

2. METHODS

The antimalaria programme in Thailand is a Division of the Communicable Diseases Control Department of the Ministry of Public Health. The Malaria Division is divided into five Regions each under the control of a Regional Director. Operationally, Region 2 of the Malaria Division is divided into Zones and Sectors, and is at the same time administratively divided into Provinces and Districts. The numbers of these divisions, together with the relevant population figures, are summarized in Table 2.

**TABLE 2. MALARIA DIVISION AND GOVERNMENT ADMINISTRATIVE ORGANIZATION OF NORTHERN THAILAND (POPULATION: 7 251 600)**

<table>
<thead>
<tr>
<th>Malaria Division</th>
<th>Government Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational unit</td>
<td>No.</td>
</tr>
<tr>
<td>Zone</td>
<td>6</td>
</tr>
<tr>
<td>Sector</td>
<td>62</td>
</tr>
</tbody>
</table>

The population of a Sector was considered too large and spread over too great an area for use as the basic epidemiological unit. Outbreaks in these areas of unstable malaria transmission, which have been under malaria eradication/control operations for 20 years or more, often occur in very limited foci, sometimes in a cluster of only a few villages. When this happens, their significance is frequently overlooked if they are grouped in the data for the entire Sector. Fortunately, the record keeping in Region 2 has been excellent and the number of malaria cases by District and by month is available, usually for as far back as 1973. Further, the Sectors normally are constituted by a number of discrete Districts, and, as common boundaries are used, this permits analysis of District data at Sector level. Since there are, on average, only two Districts per Sector, this is not an onerous task. Administrative Districts are further divided into Cantons (average population 7550), but with
the degree of endemicity present in northern Thailand it is not necessary to attempt
evaluation at cantonal level. However, such evaluation would be important in areas of higher
endemicity, where outbreaks in one Canton might be masked by normal, or lower than normal,
transmission in other Cantons of the same District.

The monthly data for the two Districts of Li and Mae Ai for the years 1973-1981 are
presented in Table 3. From a study of these figures it is seen that malaria was reasonably
well controlled in Li District during the years 1973-1976 and that an outbreak occurred in
1977-1978. In Mae Ai District control was excellent during the period 1973-1978 with an
outbreak beginning in 1979 and recurring at a higher level in 1980.

Thus, statistics for the "base years", 1973-1976 for Li District and 1973-1978 for Mae Ai
District, were considered to indicate levels of malaria endemicity acceptable by control
standards. Using the data from these years, a system of analysis could be developed that
would provide a timely indication of any significant increase in monthly malaria cases and a
warning of the possible onset of an outbreak.

Several methods of data analysis were assessed, all of which were variations of means
and means plus (and minus) 2 standard deviations (SD). If the "base years" data are used to
establish these means and SD, then it can be expected that 95% of "normal" (acceptable control
level incidence) monthly totals of cases will fall within plus or minus 2 SD limits. In
effect, this can be reduced to the statement that 97.5% of monthly normal figures will fall
below the mean plus 2 SD. Further, only 1% would be expected to surpass the 2.3 SD limit and
only 0.1% to go above the 3.1 SD.

The method chosen for use in northern Thailand is as follows. The base years of a
District are selected and the data from these years are used to calculate the mean, the SD and
the mean + 2 SD for each District. Data are analysed using a small hand calculator with mean
and SD functions, which makes these computations very simple.

The monthly means are joined to establish the lower line of the graph and the means + 2 SD
form the upper line. The area between the lines is shaded to assist with interpretation.
The resulting graph is the annual "normal" distribution for the District. Figure 1a and b
shows examples for Li and Mae Ai District, respectively. The annual graph is repeated
across the graph paper for as many years as can be accommodated. In northern Thailand,
semilog paper with 3 cycles X 150 divisions is being used, so that, allowing for two divisions
per month, data for 76 months can be presented.

The normal graph of each District is prepared by the Epidemiology Section of the
Regional Headquarters for the years January 1981-April 1987, if 4 or more base years of data
are available. When only 3 base years of data can be used (the other years having too high
an incidence), the normal graph is prepared for January 1981 to December 1983 only, at which
time the data will be re-examined and, if possible, re-analysed to prepare new normal graphs.
Finally, the staff of the Epidemiology Section plot the observed monthly numbers of cases for
1981, as a guide for the Sector Chiefs.

The prepared graph is then sent to the Sector where the Chief is thereafter responsible
for continuing to plot the actual monthly numbers of cases as soon as they become available.
He is instructed to inform both the Zone Chief and the Regional Director and/or Epidemiologist
immediately if the plot of actual cases crosses the upper line.

Whenever the plot crosses the upper line, an evaluation will be made by the Regional
authorities, together with the Zone Chief. As a first step, they will examine three aspects
of the occurrence, namely;

(a) the amount by which the actual plot exceeds the upper line or, to be more precise,
the number of SD by which the actual number of cases is greater than the predicted
mean for that month;

<table>
<thead>
<tr>
<th>YEAR</th>
<th>LI DISTRICT</th>
<th>MAE AI DISTRICT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jan</td>
<td>Feb</td>
</tr>
<tr>
<td>1973</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>1974</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>1975</td>
<td>21</td>
<td>15</td>
</tr>
<tr>
<td>1976</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>1977</td>
<td>48</td>
<td>15</td>
</tr>
<tr>
<td>1978</td>
<td>82</td>
<td>28</td>
</tr>
<tr>
<td>1979</td>
<td>46</td>
<td>40</td>
</tr>
<tr>
<td>1980</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>1981</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

**Sum x**  
* 63  36  18  34  72  137  298  264  217  147  192  177  1655  

**Mean**  
* 15.8  9.0  4.5  8.5  18.0  34.3  74.5  66.0  54.3  36.8  48.0  44.3  34.5  

**SD**  
* 7.9  5.2  2.9  4.4  9.0  14.4  18.7  29.2  17.4  15.6  26.0  23.7  27.2  

**Mean plus 2 SD**  
* 32  19.3  10.3  17.2  36  63  112  124  89  68  100  92  89  

* Years 1973-1976 only (n = 4 years)  

* Years 1973-1978 only (n = 6 years)
(b) the frequency of breakthrough, i.e. the number of times the actual plot has surpassed the upper line in the last 2 years; and

(c) the trend of the actual plot in the months immediately preceding the occurrence.

If it is concluded that an outbreak is beginning, then further evaluation is necessary. This involves a thorough analysis of the situation and an examination of the control measures to be applied, for both the short-term control of the current epidemic and the long-term prevention of a recurrence as well as an evaluation of the measures applied (Molineaux, 1981). If, on the other hand, it is believed that there is insufficient evidence to characterize an outbreak, the Sector Chief is instructed to maintain extra vigilance and report actual plots that approach the upper limit, as well as those that do in fact exceed it. A continuous upward trend or another breakthrough within a few months would be indication of the beginning of an outbreak.

3. DATA ANALYSIS

Examples of data analysis are shown in Figure 2 a for Li District with a normal graph for the base years 1973-1976 and the actual plot for 1973-1981, and in Figure 3 for Mae Ai District for the base years 1973-1978 and the actual plot for 1973-1981.

When the data for Li District are examined (Figure 2 a), it can be seen that the number of positive cases for January 1977 is significantly higher than expected. A more detailed study of this month's data (Table 3 and Figure 2 b, a laterally expanded graph) reveals that the expected mean is 15.8, the SD 7.9 and the actual number of positives is 48. This is 4 SD beyond the mean ((48-16)/7.9) and must, therefore, be considered highly significant.

Visual examination of the graph for Li District shows a reasonably good fit during 1973, 1974 and 1975, but there are signs of an upward trend during the last few months of 1976. Taken together with the 48 cases in January 1977, these indications would normally be sufficient to initiate immediate remedial action. However, even if the trend were ignored and the February and March return to normal limits noted, the re-emergence above the upper line in April (3.5 SD above the mean) should be sufficient to remove any lingering doubts that an outbreak was actually beginning.

Had the situation been evaluated in May–June 1977, when the January and April figures were available at the Sector level, and the significance realized, remedial measures could have been introduced at once, instead of in February 1979, nearly 2 years later.

The indications of a breakdown in control in Mae Ai (Figure 3) are even more pronounced. Firstly, the data are calculated from 6 base years instead of only four and, therefore, have more validity. Once again there was an apparent upward trend, visible on the graph, during the latter months of 1978. In February 1979 there were 14 cases (7 SD above the mean) and in March 11 cases (4.75 SD), ample evidence that an outbreak was beginning, even considering the drop that occurred in April and May.

In view of the small sample sizes used in computing the normal graphs, it may also be helpful to consider the student t distribution when analysing data to determine the significance of breakthroughs. In Li District (base-years n = 4 years), both the January and April 1977 numbers of cases are found to lie between t.075 and t.99 (t.075 = 3.182 and t.99 = 4.541). Thus, both the levels of significance and their juxtaposition must still be considered to be strong indications for intervention. As would be expected, the case of Mae Ai District is more highly significant. Both the February and March 1979 figures exceed the t.995 (n = 6 : t.995 = 4.032), and are confirmation of the beginning of an outbreak.
Despite the small sample sizes, it has been thought advisable to maintain the mean + 2 SD for the upper limit, even though breakthroughs do occur that are only false alarms. An analysis of data from 114 Districts, from which the months of actual outbreaks have been excluded, to determine the number and level of breakthroughs not associated with epidemics, is shown in the following Table 4.

**TABLE 4. ANALYSIS OF BREAKTHROUGHS NOT ASSOCIATED WITH EPIDEMICS, IN 114 DISTRICTS DURING THE 9 YEARS 1973-1981**

<table>
<thead>
<tr>
<th>Mean annual number of cases in District</th>
<th>Total number of &quot;effective control&quot; months</th>
<th>Number of observed breakthroughs exceeding the mean + 2SD (number of expected breakthroughs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 50</td>
<td>3 232</td>
<td>&lt; 2.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>57 (49)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>62 (29)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>126 (81)</td>
</tr>
<tr>
<td>51-100</td>
<td>1 744</td>
<td>2.3-3.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33 (27)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23 (15)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>61 (44)</td>
</tr>
<tr>
<td>&gt; 100</td>
<td>4 140</td>
<td>&gt; 3.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 (63)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 (37)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 (4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 (104)</td>
</tr>
<tr>
<td>Total</td>
<td>9 116</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td></td>
<td>116 (137)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>99 (81)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22 (9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>237 (229)</td>
</tr>
</tbody>
</table>

While the total number of observed breakthroughs is close to the expected, i.e. 237 and 228 respectively, there is considerable variation depending on the mean annual number of cases of the District and also on the level of the breakthrough.

In those Districts with a low incidence of malaria, i.e. with less than 50 and between 51-100 cases/year, the observed numbers of breakthroughs greatly exceed the expected, 126(81) and 61(44), respectively. This result is not surprising. When the monthly mean number of cases is low, and the variance is correspondingly small, then an increase of even 1 case can assume a spurious statistical significance. The epidemiologist should have no difficulty in determining the real importance of the observation(s) and deciding what action to take. When the incidence is high, over 100 cases/year, the situation is reversed (except at the > 3.1 SD level).

The question of the excess number of breakthroughs at the > 3.1 SD level is perhaps more serious and may present the epidemiologist with some problems. However, of the 22 observations, 7 were late in 1981 and might have been first indications of epidemics, 4 were associated with abnormal slide collections (malaria surveys, perhaps) and 2 were associated with very low transmission rates. It would seem, therefore, that a careful study of all the data, including the plot of the preceding months and the juxtaposition of other breakthroughs, both before and after the observation concerned, can help to resolve these difficulties.

The several methods of statistical analysis evaluated are given below:

**Overall mean - Fig. 1 a**

The mean number of cases per month was calculated from all the months of the base years (e.g. Li District: n = 48 months; Mae Ai District: n = 72 months), together with the SD. This gives straight lines for both the mean and the mean + 2 SD limits.

While this method has the advantage of extreme simplicity, particularly from the Sector Chief's point of view, the SD is unacceptably high. Actual plots of highly significant increases (e.g. Li District in January 1977) still may fall within the normal limit of the straight line graph when they are within normal limits on the seasonal monthly mean graph.
Moving mean - Fig. 1 d

The data were analysed using a 3-month moving mean in an attempt to smooth the curve somewhat, while maintaining seasonality. The SD was still too high and, if one considers also the errors likely to arise from calculation of the moving means at Sector level, the method was not considered promising.

Cumulative mean - Fig. 1 e

Monthly means were successively cumulated, and the respective SDs calculated. Although this method takes some account of seasonality, it is subject to considerable distortion by unusually large, or small, observed numbers of cases occurring early in the year. It was, therefore, also discarded.

4. DISCUSSION AND CONCLUSIONS

The warning system described above is an adaptation to malaria of an old principle used in the definition of epidemic indices (see, for example, Stallybrass, 1931). The most commonly used time unit is the month (as here) and various "averages" may be used, namely the mean (as here), the median or some combination of both, and sometimes the average is adjusted for time-trend. Several measures of deviation from the average may be used: the observed numbers may be expressed in per cent of the average, in percentile of the actual distribution or, as here, in standard deviations.

The monthly mean method used here has given excellent indications of the beginnings of outbreaks in Districts where retrospective analysis has been carried out. In the 114 Districts for which data are available, 95 outbreaks occurred for which the system would have given early warnings. These outbreaks involved some 71 000 "excess" cases (i.e. above the normal annual means), or 23% of the total number of cases during the period 1973-1981. If the early warning system would have resulted in a reduction of only half these "excess" cases, this would have meant an overall decrease of more than 11% in malaria incidence.

The system, which will be operational in all districts of northern Thailand by June 1982, also focuses attention on those Districts now requiring improved control activities and having a level of endemicity already too high to be really acceptable. Moreover, whenever improved control is achieved, a revision of the baseline data will need to be made. Thus, it is hoped that application of the system will lead to a more rational allocation of preventive measures, within budget limitations, and an eventual overall reduction in malaria.

Direct evaluation of the impact of the early warning system may prove difficult. Exact comparisons with previous histories are virtually impossible because of the differing aetiology of each outbreak. This would be particularly true, for example, when the appearance of drug-resistant strains of plasmodia is wholly, or only partly, responsible for an increase in transmission. An outbreak due entirely to such resistance would presumably be of lesser dimensions than one where the appearance of resistance coincided with a real increase in vectorial capacity.

However, prompt evaluation of every indicated breakthrough and the immediate application of appropriate control measures should both flatten and narrow the observed plot above the line. When implemented in all Districts this must lead to improved control and a corresponding reduction in malaria incidence.

Changes in the methods or performance of case detection will undoubtedly introduce biases into the warning system considered. It is important, therefore, to try to be aware of such changes and to take them into account in setting up, using or revising the system.

The incorporation of other parameters, such as those described by Onori & Grab (1980) using direct (man-biting rates, daily survival rates, etc.) and indirect (mostly meteorological) observations could add further to the usefulness of the system. Whilst the indirect factors can easily be managed, the entomological parameters may require a sophistication of techniques and of interpretation not always available.
The early warning system shows considerable promise for northern Thailand and most of the remainder of the country within the limitations already discussed. Its application in other countries will depend on the level and quality of the surveillance, the degree of transmission, the number of years of retrospective data available for analysis and, possibly, the principal vector(s) responsible for transmission.

Finally, it should be repeated that the early warning system described is only the first step in preventing epidemics. Once careful analysis of the data has been made and it has been decided that an outbreak is beginning, a full epidemiological investigation is then necessary to establish the location and extent, the parasite and vector species involved, the likely cause(s) and the appropriate measures required to control the epidemic.

5. SUMMARY

Parasitological data for the years 1973-1981 were examined to determine the years of "acceptable" or "normal" transmission, for each District (average population 60 430) of northern Thailand. The data of the selected years were analysed to develop an annual graph for each District. This was made up of 2 lines, the lower of which represented the monthly mean number of cases and the upper the mean plus 2 standard deviations (SD). The resulting annual graphs were repeated 6 times across 3-cycle semilog graph paper and distributed to the Malaria Sector Offices (normally 2 Districts per Sector). Sector Chiefs will be responsible for plotting the monthly observed number of cases as the data become available, and for informing the Zone and Regional Malaria Offices if the observed plot crosses the mean + 2 SD line. Retrospective analysis of data in Districts where malaria outbreaks have occurred indicates that the method provides effective warning of impending epidemics. It is expected that the resulting earlier implementation of appropriate remedial control measures will lead to a reduction of malaria incidence in the Region.

ACKNOWLEDGEMENTS

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RESUME

LA LUTTE ANTIPALUDIQUE DANS LE NORD DE LA THAILANDE :
L'ANALYSE EPIDEMIOLOGIQUE COMME SYSTEME D'ALERTE PRECOCE

L'action antipaludique en Thaïlande incombe à un organisme du Département de la lutte contre les maladies transmissibles du Ministère de la Santé, la Malaria Division. Cette dernière est articulée en 5 Régions, dont la Région 2, qui correspond au nord du pays, est partagée en Zones et Secteurs du point de vue opérationnel et en Provinces et Districts du point de vue administratif. La conception du système de surveillance épidémiologique destiné à être introduit dans le nord de la Thaïlande répond à un triple souci : simplicité, de sorte qu'il puisse être mis en application à la base même de l'organisation de lutte contre le paludisme (au niveau du Secteur); fiabilité, pour qu'il puisse révéler toute anomalie du nombre de cas dans des zones limitées, et sensibilité, pour qu'il puisse signaler à temps une poussée épidémique imminente. Ce système a été établi sur la base des données parasitologiques pour les années 1973 à 1981. On a sélectionné, pour chaque District du nord de la Thaïlande (60 430 habitants en moyenne), les années où la transmission semblait "acceptable" ou "normale". L'analyse des données correspondantes a permis d'obtenir pour chaque District un graphique annuel comportant deux courbes : une courbe inférieure représentant la moyenne mensuelle du nombre de cas et une courbe supérieure représentant la même moyenne majorée de deux écarts types. Les graphiques annuels ainsi obtenus ont été regroupés par six sur du papier semi-logarithmique à 3 modules et distribués.
aux Bureaux de Secteur (deux Districts par Secteur en général). Les chefs de Secteur auront pour tâche de porter sur le graphique le nombre de cas observés chaque mois dès que le chiffre leur est communiqué, et d'informer les Bureaux de la Zone et de la Région si le point représentatif tombe au-dessus de la courbe supérieure (m + 2 q). L'analyse rétrospective des données dans les Districts où des flambées de paludisme se sont déclarées montre que cette méthode constitue un moyen d'alerte efficace en cas d'épidémie imminente. On espère qu'en rendant plus précoce la mise en œuvre des mesures de lutte appropriées, cette méthode entraînera une baisse de l'incidence du paludisme dans la Région.

REFERENCES


FIG. 1
METHODS OF STATISTICAL ANALYSIS EVALUATED FOR THE EPIDEMIOLOGICAL EARLY WARNING SYSTEM IN NORTHERN THAILAND
Li District

Base years (1973-76) normal graph, repeated annually, and observed number of cases 1973-81

Lower line = monthly mean number of cases
Upper line = monthly mean plus 2 SD
Area between lower and upper lines shaded for ease of interpretation
Heavy line = observed number of cases, monthly, for the years 1973-81

Fig. 2a

Fig. 2b
Detail of December 1976 to June 1977 on an expanded lateral scale
FIG. 3
Mae Ai District

BASE YEARS (1973-78) NORMAL GRAPH, REPEATED ANNUALLY, AND OBSERVED NUMBER OF CASES 1973-81

Lower line = monthly mean number of cases
Upper line = monthly mean plus 2 SD
Area between lower and upper lines shaded for ease of interpretation
Heavy line = observed number of cases, monthly, for the years 1973-81