MALARIA PAST AND PRESENT: THE CASE OF NORTH SULAWESI, INDONESIA

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Abstract. The incidence and impact of malaria in North Sulawesi have declined both in the short term during the 1990s, and over a much longer timespan (though perhaps less continuously) since the end of the colonial period. The improvement already seems to have been well underway before deliberate vector control activities became extensive in the second half of the 1970s, and environmental changes affecting the *Anopheles* mosquito fauna, in particular the replacement of primary and secondary forest by permanent farmland, are probably the principal reasons for the long-term trend; other possible factors include the increasing use of antimalarial drugs. The well-documented decline in malaria incidence over the years 1991-1997, nevertheless, probably reflects the unprecedented scale of residual insecticide spraying in the province during that period, while the slight resurgence of the disease in the last three years corresponds to the subsequent cessation of house spraying as a result of the current economic crisis. Despite the evident importance of environmental change as a factor ameliorating the malaria situation in the long term, experience from the colonial era suggests that the prospects for deliberate environmental management (species sanitation) as an alternative malaria control strategy are poor.

INTRODUCTION

The recent resurgence of malaria in Indonesia and elsewhere has made it especially useful to reconsider historical trends in the prevalence of this disease with a view to identifying the environmental, medical, and institutional factors controlling them. In the course of broader research on the demographic and environmental history of northern Sulawesi (Henley, 2001), much information was uncovered on malaria and malaria control in the period up to about 1930. During fieldwork in Indonesia in July-September 2000, it was possible to supplement this historical data with information on recent and contemporary developments in the same region obtained from doctors and other health workers, libraries, and official reports in Manado and Jakarta.

State malaria control efforts in Indonesia have been scaled down dramatically in recent years. Nationally, the scale of house spraying with residual insecticides was already falling by the mid-1990s as a result of the cost escalation which followed the controversial ban on the use of DDT for mosquito control purposes in 1990. The last DDT stock was used up by 1993, and thereafter the Health Department was obliged to use chemicals which were both less long-lasting, and several times more expensive (S Gunawan and MJ Bangs, interviews, 25/7 and 11/8/00). A second and greater blow to the malaria control program, however, was delivered by the economic crisis of 1997. In the budget year 1999/2000 the extent of government funding for malaria control, even in Rupiah terms, was barely 20% of what it had been three years earlier. Since 1997 the Department of Health in Jakarta has been unable to supply insecticide to the provinces other than for emergency purposes during severe outbreaks; for routine purposes the provincial governments were instructed to buy their own, but many (including that of North Sulawesi) were unable or unwilling to do so (FJ Laihad, interview, 13/8/00).

These developments have brought to a head long-standing controversies regarding the most effective, and above all the most cost-

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effective, strategies for malaria control. Residual insecticide spraying, even when DDT was still available, was expensive, consuming approximately 70% of the total malaria control budget (HA Marwoto, interview, 11/8/00), and under the present circumstances a drastic reduction in this particular pratice is inevitable. A shift to alternative strategies is also supported by the current WHO guidelines for malaria control, which since 1993 have deemphasized insecticide use in favor of early diagnosis, prompt and universal medical treatment of sufferers, personal protection (particularly the use of bed nets), and more selective programs of vector control, including various types of biological and environmental management aimed at eliminating local mosquito breeding sites (WHO, 1993). In many respects the proposed new strategy recalls that followed with some success in Indonesia during the late colonial period, when the Dutch authorities relied for malaria control on environmental "species sanitation" measures (Snellen, 1990) combined with the distribution of antimalarial medicine (quinine) and mosquito nets (Boomgaard, 1987; Netherlands Indies Medical and Sanitary Service, 1929).

The current WHO guidelines, on the other hand, were criticized by some as too heavily based on African experience, and too little appreciative of the considerable success achieved in other parts of the world - including Java and Bali in Indonesia (Soemarlan and Gandahusada, 1990) - by mass insecticide use during the optimistic "malaria eradication" campaigns of the 1950s and 1960s (Baird, 2000; Roberts *et al*, 1997). Among Indonesian experts there are some who recommend that mosquito control (other than individual protection by means of bed nets and repellants) should now be abandoned altogether except where it can be shown that the local vector population is small and isolated enough to preclude rapid recolonization from neighboring areas. Others, however, believe that attempts must be made to maintain a broad strategy, including the use of insecticides in order to keep the mosquitos out of dwellings.

MALARIA IN NORTH SULAWESI

North Sulawesi is a mountainous province occupying the terminal section of the northern peninsula of the eponymous island (the *kabupaten* of Gorontalo, Bolaang-Mongondow and Minahasa), together with the Sangir and Talaud island groups between Sulawesi and the Philippines (Fig 1). A long history of European political intervention, economic involvement, and missionary activity in this region has produced rich archival and other sources which facilitate the reconstruction of past health and medical conditions (Henley, 2001).

In colonial times, malaria was usually regarded as the biggest single health problem in this part of Indonesia. Uplanders in nineteenth-century Minahasa, for example, were considered to be risking their lives every time they visited malarial Manado (Riedel, 1872), and on Talaud in 1914 almost half of the population was estimated to be suffering from malaria (Roep, 1917). In 1929, every schoolchild in the coastal settlement of Marisa in Gorontalo had an enlarged spleen (Dutrieux, 1930), and in Bolaang-Mongondow during the 1930s, endemic malaria was blamed for the sparse and apparently declining populations of Bintauna on the north coast and the Dumoga valley in the western interior (Tammes, 1940).

Today, although still a common disease, malaria no longer causes the same concern. As many inhabitants of Bolaang-Mongondow died in accidents as of malaria in 1999, while tuberculosis and heart failure were both considerably more important as overall causes of death (Profil kesehatan Bolaang Mongondow 2000). In 1994-1995, malariometric surveys in eight villages of Sangir and Talaud where the number of (clinically identified) malaria sufferers was particularly high found an average parasite rate, among children aged 0-9 years, of 7.4%; in no individual village was the figure higher than 14.3%. In eight reportedly malaria-prone Minahasan villages, the equivalent average was 6.9% (Sekar Tuti *et al*, 1999). These surveys were monochronic, taking no account of seasonal variations, and poor microscopy

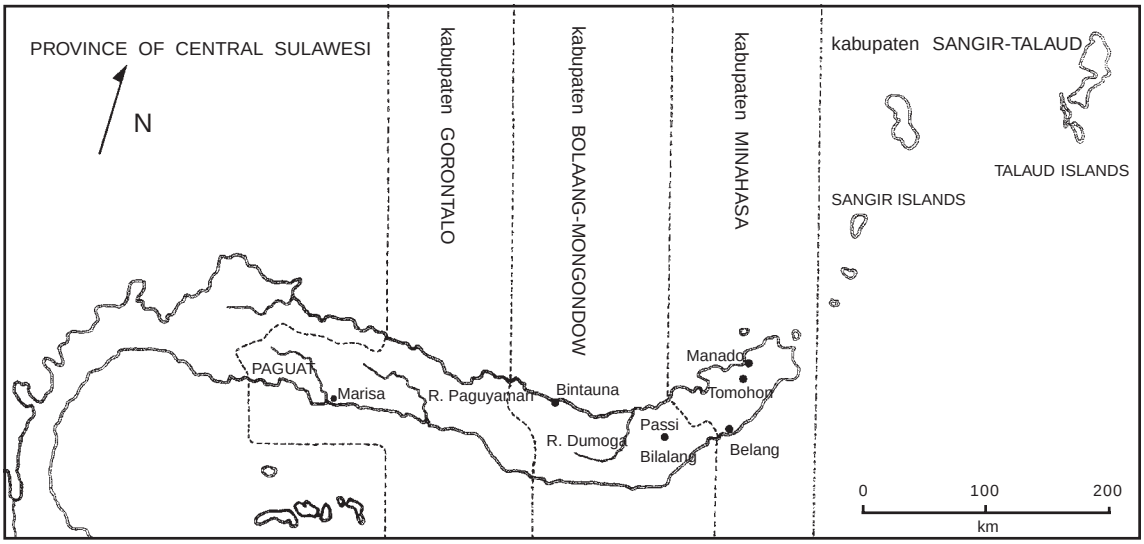

Fig 1–Map of North Sulawesi, showing administrative divisions in 2000.

may also have been a source of distortion. The results of earlier research by investigators from both the US Navy and the Indonesian National Institute of Health Research and Development, however, seem to confirm that a dramatic improvement on the situation in colonial times had already taken place in North Sulawesi by the early 1970s. Out of 2,495 blood smears collected from nine Minahasa and Bolaang-Mongondow villages in 1975, only two contained malaria parasites (Cross *et al*, 1977); a parallel study of three coastal settlements in Gorontalo found only one malaria infection among 263 blood samples (Stafford *et al*, 1976).

Particularly telling in terms of the "rolling back" of malaria in North Sulawesi since the end of the colonial period has been the success of frontier colonization efforts. Since 1953 approximately 55,000 immigrants have been settled in the province under state-sponsored transmigration schemes (Buku data, 1999), while much intra-provincial migration to the same frontier areas has also occurred. Many of the sites chosen for transmigrant settlement located in areas formerly notorious for malaria. The Paguat area near Marisa, where large numbers of migrant gold miners died of "fevers" every year in the eighteenth and early nineteenth centuries (Henley, 1997), is now home to more than 16,000 state-sponsored transmigrants, and the Paguyaman valley, where attempts to establish commercial sugar production in the 1930s reportedly had to be abandoned as a result of malaria infections among the plantation workers (Korn, 1934), to more than 20,000 (Buku data, 2000). Most dramatic of all has been the transformation of the Dumoga valley of Bolaang Mongondow, the malaria-ridden population of which in 1930 amounted to some 5,000 souls (Volkstelling, 1936); today more than 60,000 people live in the same area (Bolaang Mongondow dalam angka, 1995), and their prosperous wet rice-farming villages are regarded as rare models of successful transmigration.

If a marked decline in malaria prevalence had already occurred between 1930 and 1975, statistical evidence indicates a continuing or renewed decline in the course of the 1990s. For North Sulawesi as a whole, the incidence of clinical malaria (diagnosed on the basis of clinical symptoms only) from 1986 to 1999, according to provincial health service statistics, was as follows (Fig 2).

The apparent rise in malaria incidence from 1986 to 1988 may well be an illusion caused by progressively more complete disease reporting, since both the *puskesmas* (local

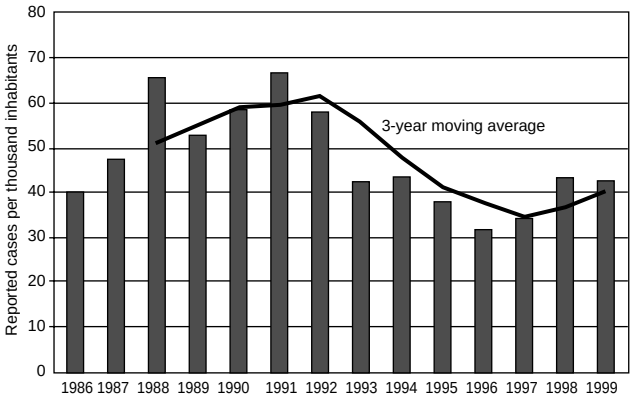

Fig 2–Reported malaria incidence, North Sulawesi, 1986-1999. Sources: Gunawan *et al*, 1999; Kanwil Kesehatan Sulut (primary data, 1999); Sulawesi Utara dalam angka 1998 (population totals). Much other illness, it should be noted, is misdiagnosed as malaria by *puskesmas* doctors (Sekar Tuti, 1995); conversely, however, by no means all persons suffering from malaria consult doctors (Datau *et al*, 1992).

health center) network, and public confidence in the state medical services, were still being consolidated at that stage. From 1991 to 1996, however, the figures show a marked downward trend which can only be interpreted as real, and from 1997 onward, as in many other parts of Indonesia (Suroso *et al*, 2000) a slight but distinct resurgence of the disease. The factors potentially responsible for the long- and short-term trends identified above can be divided into three categories: vector control activities, medical interventions, and environmental changes.

VECTOR CONTROL

As early as 1952 one part of North Sulawesi, the Dumoga valley (then already a target of local transmigration from neighboring Minahasa), was the site of experiments with residual DDT house spraying (Soeparmo and Stoker, 1952). To some extent, the province was also involved in the National Malaria Eradication Program of 1959-1968; a North Sulawesi branch of KOPEM (Komando Operasi Pembasmian Malaria, the Malaria Eradication Operation Command) was set up in 1962, ultimately including 20 full-time staff equipped with four vehicles. While some limited DDT spraying (and drug distribution) was carried out by KOPEM in coastal Minahasa, the main focus of its activity, especially following Balinese resettlement to Bolaang-Mongondow in the wake of the 1963 Gunung Agung eruption, was again on the transmigration areas in the Dumoga valley (AK Arbie, interview, 12/9/00). Like all other new inter-provincial transmigration sites since, these were subjected to preliminary house spraying before the settlers arrived, then sprayed again at six-month intervals for a standard period of five years. The quality of house spraying at transmigration sites, reportedly, has always been good thanks to the involvement of a second government department (that of Transmigration) which provides surveillance and control.

Malaria epidemics did initially occur among the Balinese transmigrants, whose homeland had been malaria-free and who therefore had no acquired immunity. According to one of the KOPEM personnel responsible, however, a "quite drastic" reduction in the infection rate was quickly achieved by the combination of regular insecticide spraying and chloroquine distribution (Soemarno, interview, 6/9/00). Three Dumoga valley villages, including the transmigration settlements of Werdhi Agung and Mopuya, were included in the 1975 US Navy parasitological survey; none of the blood samples obtained in these villages tested positive for malaria (Cross *et al*, 1977). Malaria has in fact remained a significant problem in Dumoga: a doctor who worked there from 1991 to 1996 estimates that 25% of his patients were malaria sufferers (Y Tedjo, interview, 4/9/00), and the three *puskesmas* serving the Dumoga area reported a clinical malaria incidence rate of 73 per thousand inhabitants in 1999 (data Kanwil Kesehatan Sulut). Infant and child malaria, however, is much less common in Dumoga than adult infection, indicating that the level of endemicity is low and/or that residual insecticide spraying has been effective in keeping mosquitos out of the houses. Many of the reported malaria cases, it should also be noted, occur among gold miners working in the forests

of the sparsely-populated western part of the *kecamatan*.

After the dissolution of KOPEM in 1968 and the absorption of most of its staff into the provincial health services, residual house spraying was resumed in 1972. At first this still concentrated almost exclusively on transmigration areas, but later it was extended to other localities which were subjected to dramatic malaria exacerbations (KLB, *kejadian luar biasa* or "extraordinary events"), or where the background incidence was perceived as intolerably high. According to the official guidelines, any village where a malariometric survey revealed a parasite rate of more than 5% (later 3%) among children aged 0-9 was to be sprayed at intervals of six months until the rate had been reduced to 2% or less (Bona Sianturi, interview, 21/9/00). Budgetary limitations, however, meant that only a small proportion of the many localities meeting this loose criterion were either surveyed or sprayed in any given year (SA Tandayu, interview, 17/9/00). In practice the choice of locations often seems to have been somewhat arbitrary, influenced by political factors as well as by variations in the dedication and interests of local doctors and *kabupaten* health officials.

Especially during the early and mid-1990s, nevertheless, substantial numbers of people were certainly covered every year by insecticide spraying campaigns. In the peak year of 1995/1996 some 85,000 house sprayings were carried out in North Sulawesi, covering at least 42,000 separate dwellings (most houses were sprayed twice) containing between them perhaps 7% of the total population of the province. Thereafter spraying fell increasingly short of increasingly modest targets, but in 1997/1998 almost 30,000 house sprayings were still carried out; besides recent transmigration sites in Gorontalo, the target locations also included 41 villages in Sangir-Talaud and Minahasa which had experienced recent malaria exacerbations. Since 1998, by contrast, spraying has ceased altogether (Table 1) as the provincial health budget has fallen (in Rupiah terms) by approximately 30% (Sutjipto, interview, 12/9/00).

As at the national level, there are strong differences of opinion regarding the consequences of discontinuing spraying operations. The present head of Communicable Disease Control in North Sulawesi (Sutjipto, interview, 12/9/00) insists that this is "only very slightly" related to the recent rise in malaria cases, which he blames mainly on other changes: accelerated population movements (especially immigration from the troubled Moluccas) leading to an increase in imported cases; the suspension of many construction projects during

Table 1
Insecticide spraying activities, North Sulawesi, 1972-2000.

Period	Number of houses sprayed	Official target at beginning of year
1972-1974 (Pelita I)	Annual average 7,732	-
1974-1979 (Pelita II)	Annual average 23,494	-
1979-1984 (Pelita III)	Annual average 23,714	-
1984-1989 (Pelita IV)	Annual average 38,469	-
1989-1994 (Pelita V)	Annual average 57,991	-
Budget year 1994/1995	77,631	100,000
Budget year 1995/1996	85,278	78,940
Budget year 1996/1997	32,255	41,120
Budget year 1997/1998	29,310	43,000
Budget year 1998/1999	0	30,000
Budget year 1999/2000	0	10,950

Sources: Direktorat Jenderal PPM and PLP, 1995; Subdit Malaria, 1999; 2000, Kanwil Kesehatan Sulut (primary data 1997/1998).

the economic crisis, as a result of which mosquitos have bred in stagnant pools on building sites; and the unusual weather conditions associated with the 1997/1998 El Niño event, which have been convincingly linked with malaria epidemics in Irian Jaya (Bangs and Budi Subianto, 1999) and elsewhere (Patz *et al*, 2000). Other observers in North Sulawesi, however, do not hesitate to link both the recent resurgence, and the steady decline in malaria incidence from 1991 to 1996 (Fig 2), with the changes in the scope of spraying operations detailed in Table 1 (Sekar Tuti *et al*, 1999; J Sinaya, interview, 19/9/00). The progressive improvement of the early 1990s took place at a time when more houses were being treated with residual insecticides than ever before, while the turnaround of 1997 coincides closely with the collapse of the spraying program.

MEDICAL TREATMENT

An additional factor to consider when analyzing long-term changes in malaria prevalence is the use of antimalarial drugs. While one such drug, quinine, has been used in some parts of North Sulawesi since the middle of the nineteenth century, the availability of medical countermeasures has undoubtedly been greater in the 1990s than at any time in the past. The state health service distributed chloroquine free of charge, and although its supplies often become exhausted locally (SA Tandayu, interview, 17/9/00), chloroquine, Fansidar and quinine were also widely available on the free market. Besides 140 state *puskesmas*, in 1998 there were also 72 dispensing chemists and 99 licensed drug stores in the province (Sulawesi Utara dalam angka, 1999). Signs of chloroquine resistance were detected in *Plasmodium falciparum* parasites in all North Sulawesi *kapubaten* in the course of the 1980s, and some doctors believe that resistance to both chloroquine and Fansidar hampered medication efforts in the 1990s to a significantly greater extent than in the previous decade (J Sinaya, interview, 19/9/00). Other sources, however, indicate that most malaria patients treated with chloroquine still respond well (Gunawan *et al*, 1999).

The extent to which the common drugs actually reduce malaria transmission and infection as opposed to morbidity and mortality, on the other hand, is unclear, and drug treatment (especially with Fansidar) often actually promotes the transmission of the disease in the short term by stimulating the production of gametocytes, the sexual forms of the *Plasmodium* parasite (Marwoto *et al*, 1986). Some primaquine, which renders the gametocytes noninfective to vectors, is available for use in malaria outbreaks (KLB), but supplies are generally insufficient to provide this drug to every sufferer (Soemarno, interview, 13/9/00). It is also worth noting that quite a number of traditional (and probably ineffective) malaria remedies, mostly bitter-tasting leaves or plant extracts, are also still in common use (Moningka, 1995), and that as far as the severity of illness and mortality among malaria sufferers is concerned, a reduction in the prevalence of protein-calorie malnutrition has probably helped, alongside better medication, to reduce the impact of the disease since colonial times (Henley, in press; Kondrashin *et al*, 1991).

Whatever the relative effectiveness of the medical and vector control components of the strategy, most officials with field experience in North Sulawesi are convinced that the combination of repeated residual house spraying and mass drug administration has been effective as a means of suppressing local malaria epidemics. A case in point is the "extraordinary event" which affected four of the 20 villages in the Bolaang Mongondow district (*kecamatan*) of Passi at the beginning of the 1990s. In malariometric surveys carried out in June 1991 by *kabupaten* health officials following reports of heightened malaria incidence from local *puskesmas* doctors, 125 (45%) of the 277 children aged 0-9 examined in the four villages concerned tested positive for malaria parasites, mostly *Plasmodium falciparum* and mixed *falciparum*/*vivax* infections (data Kanwil Kesehatan Sulut). Within two weeks all sufferers and suspected sufferers in these villages had received a three-day course of chloroquine, and at the same time all houses were

sprayed with DDT (Soemarno, interview, 13/9/00); insecticide spraying, according to information from health personnel, was subsequently repeated three times at six-month intervals. Following these interventions, the number of (clinical) malaria cases reported by the local *puskesmas* (at Bilalang) declined dramatically (Fig 3).

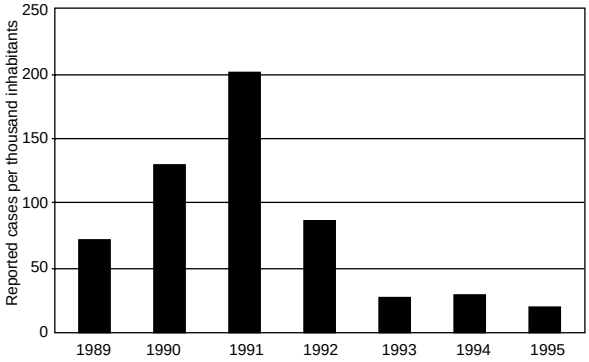

Fig 3–Reported malaria incidence, Passi (Bolaang-Mongondow), 1989-1995. Source: Kanwil Kesehatan Sulut (primary data).

ENVIRONMENTAL CHANGE

Besides deliberate control measures, incidental changes in environmental conditions brought about by other human activities can also have a major impact on malaria transmission (Soeroto Atmosoedjono *et al,* 1992; Van der Brug, 1994). Throughout Southeast Asia, a large proportion of endemic malaria has always been associated with forested rather than agricultural environments (Marwoto and Arbani, 1991). Studies from several countries of the region indicate that while the initial stages of agricultural expansion into forest areas are often accompanied by increases in malaria incidence, deforestation usually has the opposite effect in the long run (Kondrashin *et al,* 1991). In North Sulawesi, too, the progressive replacement of natural forests by man-made environments has probably been a positive development in medical terms. In 1850 the population of North Sulawesi was probably about 330,000 (Henley, 2001); by 1930 it had grown to 725,000 (Volkstelling, 1936), and the most recent estimates approach 2.8 million (Statistik Indonesia, 1998). While much of this growth has been sustained by agricultural intensification and food imports, it has also involved extensive conversion of both primary and secondary forest to permanent agricultural fields producing subsistence and commercial crops.

In the 1930s, for example, the sparsely-populated Dumoga Valley was almost entirely forested (Verhoef, 1938), but by 1980 over 45% of its land area (Ulaen-Hoetagaol, 1985), including "nearly all" of the settled valley floor (Vermillion, 1986), had been cleared for agriculture. This transformation of the landscape, it appears, was accompanied by changes in the local mosquito fauna. In 1952 *Anopheles minimus* was the main suspected malaria vector in Dumoga (Soeparmo and Stoker, 1952), while prewar investigators had also reported the presence of *An. leucosphyrus* (Van Rhijn, 1941). In the early 1980s, by contrast, only *An. aconitus*, *An. bancrofti*, *An. barbumbrosus*, and *An. vagus* were detected there (*Peta Anopheles*, nd), and according to an extensive larval survey carried out throughout Bolaang Mongondow in 2000, the species found in Dumoga were *An. aconitus*, *An. balabacensis*, *An. barbirostris*, *An. barbumbrosus*, and *An. vagus* (unpublished data from Faculty of Agriculture, UNSRAT, Manado). Whereas both of the old species were essentially forest mosquitos, *An. aconitus* and *An. barbirostris* in particular are types which prefer to breed in sun-exposed wet ricefields and irrigation ditches; evidence from elsewhere, moreover, confirms that they are relatively less effective as malaria vectors (MJ Bangs, interview, 20/9/00).

On a larger scale and over a longer timespan, the same kind of process can be inferred in the case of Minahasa. Here the extent of natural forest has declined roughly from 65% to 15% of the land area since 1860, and the area under secondary woodland and grassland from 60% to 10% since 1920 (Table 2).

In late colonial times, two mosquitos were regarded as responsible for malaria transmis-

Table 2
Land use change (approximate figures), Minahasa, c.1860-2000.

Year	Area under natural forest cover (%)	Area under fallow vegetation and grass (%)	Area under irrigation and fishponds (%)
c.1860	65	30	1
c.1920	20	60	3
c.2000	15	10	5

The remaining area, at all dates, was under non-irrigated cultivation. Sources: Henley, in press (1860, 1920); Sulawesi Utara dalam angka, 1999.

sion in Minahasa: *An. subpictus* on the coasts, and *An. minimus* further inland (Henley, in press). The typical breeding sites of *An. subpictus* are brackish swamps, while *minimus* is "generally found in agricultural areas at margins of the foothill forests which have cool, clear-water streams" (Kondrashin *et al*, 1991). Recent studies, by comparison, show that while *An. subpictus* is probably still an important vector in lowland areas (Marwoto *et al*, 1996; Sekar Tuti, 1995), species like *An. aconitus*, *An. barbirostris*, and *An. vagus* now appear more common than *An. minimus* inland (Pendong, 1994; Salaki and Tarore, 1997; Sekar Tuti *et al*, 1999; Ulaen, 1987). Local entomological opinion currently favors *An. barbirostris* as the foremost malaria vector (Salaki and Tarore, 1997), and the only species positively incriminated by sporozoite tests on mosquitos captured in the village of Tara-Tara (near Tomohon) in 1995 were *An. barbirostris* and *An. kochi* (original data from NAMRU-2).

The progressive decline in the importance of *An. minimus* suggested here is consistent with reports that in the 1970s and 1980s there was a gradual upward movement of endemic malaria onto the central plateau (VM Memah and D Taroreh, interview, 11/9/00), an area formerly free from the disease (Henley, 2001) thanks to the fact that *minimus* does not normally breed at altitudes in excess of 600 meters (Bonne-Wepster and Swellengrebel, 1953). The replacement of secondary and primary forest by permanent farmland and plantations since the Second World War probably reduced the availability of the kind of breeding sites most favored by *An. minimus*. A further factor might have been an increase in the incidence of stream *banjir* (floods, runoff peaks) as a result of watershed deforestation (VM Memah and D Taroreh, interview, 11/9/00); in parts of upland Minahasa where clove trees are planted on steep slopes, soil erosion has certainly become a problem in recent times (Environmental Study Center, 2000).

Another influential theory regarding long-term changes in the prevalence of malaria in Indonesia and elsewhere (HJ van der Kaay, interview, 5/6/2000) is that these reflect the larvicidal effects of various kinds of water pollution. The Minahasan entomologist DT Sembel (interview, 8/9/00) is convinced that the use of insecticides in agriculture has had a major effect on mosquito populations in North Sulawesi. While few farmers in the province used any kind of pesticide before 1970, by the late 1980s many types were in wide use, and often in excessive quantities (Sembel *et al*, 1991). Although there has been no local investigation into the specific effects of water pollution by agricultural chemicals on *Anopheles* mosquito populations, recent research on the abundance and diversity of a wider range of aquatic fauna in Minahasan *sawah* confirms that the level of insecticide use is a significant factor (Kandowangko *et al*, 1993; Mogi *et al*, 1995). In this light it is tempting to speculate that the resurgence of malaria over the last three years, here and elsewhere, reflects reduced use of pesticides in connection with economic problems. This attractive hypothesis is immediately called into question, however,

by the fact that the recent malaria resurgence in Java has occurred more in areas where transmission is dominated by forest/hill mosquitos like *An. maculatus* and *An. balabacensis* than in the realm of *sawah*-breeding vectors like *An. aconitus* (MJ Bangs, interview, 11/8/00).

FUTURE AVENUES

At both local and central government levels, the more optimistic health officials suggest that the current reduction in insecticide spraying can be compensated by more emphasis on other types of vector control, and by greater speed and precision in case diagnosis and medical treatment. They also claim that effective use of insecticides is in any case highly dependant on correct seasonal timing, and on accurate research regarding biting habits (indoor or outdoor) and insecticide resistance (on which subject virtually no information is yet available from North Sulawesi) among the local *Anopheles* populations (Sutjipto, interview, 12/9/00). Others, however, argue that both drug treatment and individual/community prophylaxis involve closer supervision and control than insecticide spraying. Left to their own devices, for instance, many sufferers cease taking an antimalarial medication before completing the full course of treatment, a practice which favors both disease transmission and the development of drug resistance (Datau *et al*, 1992). In some areas where mosquitos are numerous enough to be a physical nuisance at night, such as Belang in Minahasa and Marisa in Gorontalo, the use of bed nets was already common long before the recent government campaigns (AK Arbie, interview, 12/9/00; S Mustafa, interview, 7/9/00); attempts to disseminate this practice more widely during the 1990s, however, have met with very little success (J Sinaya, interview, 17/9/00).

One point of wide agreement is that greater coordination will be needed in the future between health officials, entomologists, community leaders, and members of other government departments (particularly Agriculture and Public Works). Steps have already been taken to involve the entomological research group led by Prof Sembel (of the Sam Ratulangi University Agricultural Faculty) in malaria control policy-making. Up to now, however, this kind of cooperation has been conspicuous mainly by its absence. In so far as they are interested in entomological details, for instance, provincial malaria control officials refer to a distribution map of (suspected) vector species compiled by an unidentified foreign researcher in the first half of the 1980s (*Peta Anopheles*, nd). The Agricultural Faculty entomologists, conversely, are unaware of this older research, while none of their own more recent and extensive data are available at the Health Department.

Historical experience suggests that in North Sulawesi, the prospects for effective malaria control by means of deliberate environmental management are poor. Attempts to drain "unhealthy" coastal swamps in Minahasa and Sangir date from before the end of the nineteenth century, but seldom had the desired effect (Van Kol, 1903; Wattendorf, 1883), while strong wave erosion and deposition made it impractical to keep brackish lagoons open to the tides as a means of controlling *An. subpictus* (Weg, 1938). At local transmigration settlements established in the south of Minahasa during the 1920s, the draining of fishponds identified as *An. minimus* breeding sites resulted only in stronger concentrations of the same species in nearby natural streams (Van Aken, 1932). Even where colonial species sanitation programs were successful, as in Jakarta during the 1920s and 1930s, it is important to note that they depended not only on a relatively simple transmission situation involving a single very localized vector species (*An. sundaicus*), but also on the availability of good information, generous funding, administrative efficiency, and sufficient coercive power to force the local population (as well as civil servants themselves) to implement the necessary countermeasures on a consistent basis (Soeparmo and Stoker, 1952; Snellen, 1990; Zon, 1939).

If comparable skills and resources are not forthcoming in the future, then it can only be

hoped that incidental environmental changes like those which have helped to mitigate the malaria problem in the past will continue to come to the rescue. The unfortunate irony here is that judging by the evidence summarized above, the expensive broad-spectrum malaria control strategy pursued in the New Order period, however imperfect, did produce real benefits.

ACKNOWLEDGEMENTS

This research was carried out under the auspices of the EDEN (Ecology, Demography and Economy in Nusantara) project of the Dutch Royal Institute of Linguistics and Anthropology (KITLV). Fieldwork was supported by financial assistance from the Netherlands Foundation for the Advancement of Tropical Research (WOTRO), made possible by the Indonesian Institute of Sciences (LIPI), and sponsored by Harijani Ardi Marwoto of the Communicable Disease Research Center, National Institute of Health Research and Development, Jakarta; for her help, both technical and bureaucratic, I am very grateful.

I would also like to thank the following people for their cooperation and support: Abdul Kadir Arbie (KOPEM, North Sulawesi, 1964-1968); Nur Azif (Settlement Preparation, Department of Transmigration, North Sulawesi Province); Dr Michael J Bangs (Department of Medical Entomology, NAMRU-2, Jakarta); Dr Suriadi Gunawan (Chief, Communicable Disease Research Center, National Institute of Health Research and Development, Jakarta); Dr Paul N Harijanto (Bethesda Hospital, Tomohon); Prof HJ van der Kaay (Leids Universitair Medisch Centrum); John SH Kojongian (Communicable Disease Control, Department of Health, North Sulawesi Province); Dr Ferdinand J Laihad (Chief, Malaria Sub-Directorate, Directorate-General of Communicable Disease Control and Environmental Health, Ministry of Health, Jakarta); Ir Ventje M Memah (Faculty of Agriculture, Sam Ratulangi University, Manado); Said Mustafa (Communicable Disease Control, Department of Health, *kabupaten* Gorontalo, North Sulawesi); Dr Georg Petersen (World Health Organization representative, Jakarta); Eddy Rumayar (Faculty of Law, Sam Ratulangi University, Manado); Prof Dantje T Sembel (Head, Faculty of Agriculture, Sam Ratulangi University, Manado); Ferdy Sialagan (Communicable Disease Control, Department of Health, North Sulawesi Province); Bona Sianturi (Malaria Sub-Directorate, Directorate-General of Communicable Disease Control and Environmental Health, Ministry of Health, Jakarta); Dr James Sinaya (Head of Communicable Disease Control, Department of Health, North Sulawesi Province, 1989-1997); Soemarno (malaria control official, KOPEM and Department of Health, North Sulawesi, 1963-1996); Soeroto Atmosoedjono (NAMRU-2, Jakarta);

GLOSSARY

kabupaten	administrative division ("regency") immediately below province level
Kanwil Kesehatan Sulut	North Sulawesi Provincial Health Office
kecamatan	administrative division ("district") below *kabupaten* level
KLB	malaria outbreak ("extraordinary event")
KOPEM	"Malaria Eradication Operation Command" (1959-1968)
NAMRU-2	US Naval Medical Reseach Unit No.2 (Jakarta)
Pelita	Five Year Development Plan
puskesmas	local health center
Subdit Malaria	Malaria Sub-Directorate, Directorate-General of Communicable Disease Control, Republic of Indonesia Department of Health (Jakarta)
UNSRAT	Sam Ratulangi University (Manado)

Dr Sutjipto (Head of Communicable Disease Control, Department of Health, North Sulawesi Province); Dr SA Tandayu (Head, Department of Health, North Sulawesi Province, 1988-1997); Ir Dantje Tarore (Faculty of Agriculture, Sam Ratulangi University, Manado); Dr Yusuf Tedjo (Malalayang Public Hospital, Manado); Fred Watung (Communicable Disease Control, Department of Health, North Sulawesi Province).

REFERENCES

Baird JK. Resurgent malaria at the millenium; control strategies in crisis. *Drugs* 2000; 59: 719-43.

Bangs, MJ, Budi Subianto D. El Niño and associated outbreaks of severe malaria in highland populations in Irian Jaya, Indonesia: a review and epidemiological perspective. *Southeast Asian J Trop Med Public Health* 1999; 30: 608-19.

Bolaang Mongondow dalam angka. Kotamobagu: Kantor Statistik Kabupaten Bolaang Mongondow, 1995: 15.

Bonne-Wepster J, Swellengrebel NH. The anopheline mosquitoes of the Indo-Australian region. Amsterdam: De Bussy, 1953: 375.

Boomgaard P. Morbidity and mortality in Java, 1820-1880: changing patterns of disease and death. In: Owen NG, ed. Death and disease in Southeast Asia. Singapore: Oxford UP, 1987: 48-90.

Buku data tahun anggaran 1999/2000. Manado: Kantor Wilayah Departemen Transmigrasi dan Pemukiman Perambah Hutan, 1999: 16-7.

Cross JH, Wheeling CH, Stafford EE, *et al*. Biomedical survey on the Minahasa peninsula of North Sulawesi, Indonesia. *Southeast Asian J Trop Med Public Health* 1977; 8: 390-99.

Datau EA, Lao SK, Waworuntu HGM, Sembel D. Malaria prevalence, entomological survey of *Anopheles*, breeding places, and ecologic factors affecting malaria in peripheral regions to Manado City. Manado: Eastern Indonesia Universities Development Project, 1992: 1, 9.

Direktorat Jenderal PPM and PLP. Malaria; Situasi dan hasil kegiatan. Jakarta: Departemen Kesehatan, Direktorat Jenderal Pencegahan dan Pemberantasan Penyakit Menular dan Lingkungan Pemukiman, 1995: 68-72.

Dutrieux, FB. Aanvullende memorie van overgave onderafdeling Boalemo (document MvO KIT 1189 in Dutch State Archives, The Hague). 1930: 24.

Environmental Study Center. Rangkuman Hasil Penelitian Tahap 1; Analisis perubahan tata guna lahan daerah aliran sungai Tondano. Manado: Environmental Study Center, Sam Ratulangi University, 2000: 9.

Gunawan CA, Harijanto PN, Sutjipto. Malaria di Sulawesi Utara. In: Harijanto PN, ed. Malaria; Epidemiologi, patogenesis, manifestasi klinis and penanganan. Jakarta: EGC, 1999: 26-37.

Henley D. Goudkoorts; mijnbouw, gezondheid en milieu op Sulawesi (1670-1995). *Spiegel Historiael* 1997; 32: 424-30.

Henley D. Population, economy and environment in North and Central Sulawesi, c1600-1930. Leiden: KITLV Press, 2001 (in press).

Kandowangko DS, Sembel DT, Rimbing J. Pengaruh penggunaan beberapa jenis insektisida pada tanaman padi terhadap jenis dan populasi organisme air di Minahasa. *J Fakultas Perikanan UNSRAT* 1993; 2: 33-43.

Kondrashin, AV, Jung RK, Akiyama J. Ecological aspects of forest malaria in Southeast Asia. In: VP Sharma, AV Kondrashin, eds. Forest malaria in Southeast Asia. New Delhi, 1991: 1-28.

Korn B. Nota onderafdelingen Gorontalo en Boalemo (document MvO KIT 1195 in Dutch State Archives, The Hague). 1934: 4.

Marwoto HA, Arbani PR. Forest malaria in Indonesia. In: Sharma VP, Kondrashin AV, eds. Forest malaria in Southeast Asia. New Delhi, 1991: 115-31.

Marwoto HA, Ritchie TL, Soeroto Atmosoedjono *et al.* Transmisi lokal malaria di Kodya Manado. Bul Penelit Kesehat 1996; 24: 60-8.

Marwoto HA, Susetyono, Sekartuti E. Sulaksono, *et al*. Gametocyte production in patients of falciparum malaria treated with Fansidar. *Bul Penelit Kesehat* 1986; 14: 5-7.

Mogi M, Memah V, Miyagi I, *et al*. Mosquito (Diptera: Culicidae) and predator abundance in irrigated and rain-fed rice fields in North Sulawesi, Indonesia. *J Med Entomol* 1995; 32: 361-7.

Moningka BH. Beberapa bahan obat dan ritus dalam pengobatan tradisional di Tonsea-Minahasa.

Antropologi Indonesia 1995; 18: 75-107.

Netherlands Indies Medical and Sanitary Service. Control of endemic diseases in the Netherlands Indies. Weltevreden: Landsdrukkerij, 1929: 19-20.

Patz JA, Graczyk TK, Geller N, Vittor AY. Effects of environmental change on emerging parasitic diseases. *Int J Parasitol* 2000; 30: 1395-405.

Pendong HD. Fluktuasi populasi nyamuk *Anopheles* spp di kabupaten Minahasa, kotamadya Manado dan Bitung (undergrad diss, Faculty of Agriculture, Sam Ratulangi University, Manado, 1994): 44, 55, 59.

Peta Anopheles suspect vector malaria. Manado: Sub Dinas P2M, Dinas Kesehatan Propinsi Sulawesi Utara (no date).

Profil kesehatan Bolaang Mongondow 2000. Kotamobagu: Dinas Kesehatan Kabupaten Bolaang Mongondow, 2000: 8.

Riedel, JGF. De Minahasa in 1825. Bijdrage tot de kennis van Noord-Selebes. *Tijdschrift voor Indische Taal-, Land- en Volkenkunde* 1872; 18: 458-568.

Roberts DR, Laughlin LL, Hsheih P, Letgers LJ. DDT, global strategies, and a malaria control crisis in South America. *Emerg Infect Dis* 1997; 3: 295-302.

Roep B. Hygiëne op de Talaudeilanden. *Tijdschrift voor het Binnenlandsch Bestuur* 1917; 53: 414-33.

Salaki CL, Tarore D. Laporan penelitian jenis dan kepadatan nyamuk *Anopheles* sp dan *Aedes* sp di propinsi Sulawesi Utara. Manado: Agricultural Faculty, Sam Ratulangi University, 1997: 12, 13, 17.

Sekar Tuti. Penelitian transmisi malaria di daerah Sulawesi Utara. Jakarta: Pusat Penelitian Penyakit Menular, Badan Penelitian dan Pengembangan Kesehatan, Departemen Kesehatan RI, 1995.

Sekar Tuti Es, Marwoto HA, Tumewu M, *et al*. Situasi malaria di daerah Sulawesi Utara. *Maj Kesehat Masyarakat Indonesia* 1999; 27: 435-39.

Sembel DT, Kaseger F, Pongoh J, Kandowangko D. Pengkajian terhadap penggunaan pestisida oleh petani di kabupaten Minahasa dan Bolaang Mongondow. *Jurn Fakultas Perikanan UNSRAT* 1991; 1: 6-13.

Snellen WB. Success and failure of malaria control through species sanitation – some practical examples. In: Takken W, Snellen WB, Verhave JP, *et al*, eds. Environmental measures for malaria control in Indonesia – an historical review on species sanitation. Wageningen: Wageningen Agricultural University, 1990: 81-127.

Soemarlan, Gandahusada S. The fight against malaria in Indonesia: a historical review and future outlook. Jakarta: National Institute of Health Research and Development, Ministry of Health, 1990: 26.

Soeparmo HT, Stoker WJ. Malaria control in Indonesia. *Maj Kedokteran Indonesia* 1952; 2-7: 253-60.

Soeroto Atmosoedjono, Arbani PR, Bangs MJ. The use of species sanitation and insecticides for malaria control in coastal areas of Java. *Bul Penelit Kesehat* 1992; 20: 1-15.

Stafford EE, Masri S, Sorensen K. Parasitological survey in Gorontalo, North Sulawesi, Indonesia. *Southeast Asian J Trop Med and Public Health* 1976; 7: 405-10.

Statistik Indonesia 1998. Jakarta: Badan Pusat Statistik, 1999: 55.

Subdit Malaria, Hasil pelaksanaan program pemberantasan malaria dalam Pelita VI (1994/95-1998/99). Jakarta: Sub Direktorat P2 Malaria, Direktorat Pemberantasan Penyakit Bersumber Binatang, Departemen Kesehatan RI, 1999.

Subdit Malaria, Laporan tahunan program P2 malaria tahun 1999/2000. Jakarta: Sub Direktorat P2 Malaria, Direktorat Pemberantasan Penyakit Bersumber Binatang, Departemen Kesehatan RI, 2000.

Sulawesi Utara dalam angka 1998. Manado: Badan Pusat Statistik Propinsi Sulawesi Utara, 1999: 85, 43, 88, 119, 146.

Suroso T. Bona Sianturi, Budi Pramono. Vector control policy in malaria control programme in Indonesia. Jakarta: Sub Direktorat P2 Malaria, Direktorat Pemberantasan Penyakit Bersumber Binatang, Departemen Kesehatan RI, 2000: 1.

Tammes PML. De biologische achtergrond van het bevolkingsvraagstuk op Noord-Celebes en de Sangihe- en Talaud-archipel. *Tijdschrift voor Econom Geogr* 1940; 31: 177-98.

Ulaen HA. Identifikasi serangga nyamuk yang terbesar pada beberapa kecamatan di kabupaten Minahasa dan kota madya Manado (undergrad

diss), Faculty of Agriculture, Sam Ratulangi University, Manado, 1987: 23-4.

Ulaen-Hoetagaol S. Manalun dan mamarut jurame: kajian tentang aktivitas perladangan di sekitar kawasan taman nasional Dumoga Bone, Bolaang-Mongondow, Sulawesi Utara, University of Indonesia, Jakarta, 1985: 50, 75 (PhD thesis).

Van Aken AP. Memorie van overgave residentie Menado, (document MvO MMK 306 in Dutch State Archives, The Hague). 1932: 213.

Van der Brug PH. Malaria en malaise: de VOC in Batavia in de achttiende eeuw. Amsterdam: De Bataafsche Leeuw, 1994.

Van Kol H. Uit onze koloniën. Uitvoerig reisverhaal. Leiden: Sijthoff, 1903: 300.

Van Rhijn M. Memorie van overgave residentie Menado (document H 1179 in Western Manuscripts Collection, KITLV, Leiden). 1941: 136.

Verhoef L. Bijdragen tot de kennis der bosschen van Noord- en Midden-Celebes V. Het boschgebied Ongkak Doemoga (Bolaang Mongondow). *Tectona* 1938; 31: 7-29.

Vermillion, DL. Rules and processes: dividing water and negotiating order in two new irrigation systems in North Sulawesi, Indonesia. Cornell University, Ithaca, New York, 1986: 59 (PhD thesis).

Volkstelling 1930, Deel V: inheemsche bevolking van Borneo, Celebes, de Kleine Soenda Eilanden en de Molukken. Batavia: Departement van Economische Zaken / Landsdrukkerij, 1936: 122, 135.

Wattendorf FL. Memorie van overgave residentie Menado, 1883 (document MvO MMK 301 in Dutch State Archives, The Hague).

Weg UJ. Memorie van overgave afdeling Menado, (document MvO KIT 1178 in Dutch State Archives, The Hague). 1938: 213.

World Health Organization. A global strategy for malaria control. Geneva: WHO, 1993.

Zon BK. Zoutwatervischvijvers en malaria. *Geneesk Tijd Ned Ind* 1939; 79: 529-40.