Original article

An indigenous malaria transmission in the outskirts of Addis Ababa, Akaki Town and its environs

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Abstract

Background: In recent years malaria is becoming endemic in highland areas beyond its previously known upper limit of transmission. Assessment of the situation of the disease in such areas is necessary in order to institute appropriate control activities.

Objectives: The objectives of the study were to determine the prevalence of malaria, the parasite species involved and *Anopheles* species responsible in local malaria transmission.

Methods: A systematic sampling technique was used to select survey households. Blood films were collected monthly between October and December 1999 from all household members by a trained and experienced laboratory technician. Larval and adult mosquitoes were monthly collected using different methods from September 1999 to October 2000. **Results**: Among 2136 examined blood films, 78(3.7%) of them were malaria positive of which 54(69%) were due to *Plasmodium vivax* and 24 (31%) due to *P. falciparum*. *Anopheles gambiae* s. l. (presumably *An. arabiensis*) and *An. christyi* were the dominant man-biting species, with the former being the major vector in the area. Both these species were found to be more of exophagic and active in the early evening, unlike *An. pharoensis*, which showed an endophagic tendency.

Conclusion: This study indicated that indigenous transmission of malaria occurs in the study area. Transmission is reckoned to be maintained by low density of vector species for short period of time under favorable conditions. Therefore, the acquisition of communal immunity is interrupted by long duration of non-malaria season leading to the occurrence of recurrent malaria epidemics. [*Ethiop.J.Health Dev.* 2004;18(1):2-7]

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Introduction

Highland malaria has become very common in many African countries (1). Similarly, the rise of malaria cases at high altitude areas of Ethiopia has been indicated. This is considered to be partly as a result of human-induced climatic changes (2). In most parts of Africa in general and in Ethiopia in particular, the upper limit of malaria transmission was previously known to be below elevation of 2000 meter a. s. l., except during epidemics (1,3). However, recently, the encroachment of the disease to highland-fringe areas of the country was recorded (4). It is also known that many cities of Africa are becoming malarious (5). Likewise, about 31 urban centers of Ethiopia are known to be malaria endemic (6). For example, an outbreak of malaria was reported in Akaki Town involving adjacent areas including Kaliti and other suburbs of Addis Ababa in 1998/9 (Zone 6 Health Department, unpublished report, 1999).

Information is limited regarding the epidemiology of malaria in high altitudes of the country, including major urban centers. In order to elucidate the epidemiology of highland malaria in an urban area of Ethiopia, a survey was carried out in Akaki Town. The study included parasitological and entomological surveys to determine the prevalence and transmission of the disease.

Materials and Methods

Study area: Akaki (or Akaki Beseka) is an old residential and industrial town, 23km to the southeast of Addis Ababa. It is located at a relatively low-lying altitude, 2110 meter above sea level in the out skirt of the city. Population of the study area and the available health facilities are described elsewhere (7).

Sampling technique and sample size determination: The survey was conducted in a geographically restricted section of the study area rather than on a random sample of specified size from the total population. Two Kebeles (01 and 03) of the six urban sites with relatively high potential for malaria incidence, with representative sections in it were selected. Selection of the Kebeles was based on the prevailing focal characteristics of malaria as indicated elsewhere (8).

To determine the required sample size for the prevalence study, a malaria prevalence of 40 % is assumed. This is based on the result of unpublished report of Akaki Health Center and consideration of those cases that seek treatment elsewhere in the town. A sampling error (d) of 0.04 is considered to get a reasonable estimate. The calculation of sample size (n), was done by using the formula for estimating single proportion, where level of significance (α) is 0.05. Accordingly, the minimum sample size was determined to be 576. Since the study units are the individuals of the selected households, two-step sampling was performed to get the required sample size. First, 50% of the households of each of the two Kebeles were taken, next the actual requirement from each Kebele and Ketena of both Kebeles were determined by using proportional stratified sampling. A total of 116 households were selected systematically based on the calculated proportions for both Kebeles to sample 576 individuals. Based on the population census of 1994, for Addis Ababa Region, including Akaki, the average family size was reported to be 5.1 (9). Thus, from 116 households 712 individuals were sampled.

Parasitological Survey: After obtaining verbal consent from adult participants and attendants, blood samples were taken from all selected members of households by finger prick, and thick and thin smears were prepared. The slide films were labeled and examined under higher magnification (100X) for parasite identification. This survey was done monthly from October to December 1999. A trained and experienced laboratory technician handled the blood sample collection, processing and parsitological diagnosis.

Entomological survey: Larval mosquito collection: Longitudinal larval collections were performed from artificial ponds, canals, excavation ditches, stream margin, swamp and rain pools by using dipping ladles from September 1999 to October 2000. The specimens were preserved in 70% alcohol and slide mounted for species identification using a key (10).

Adult mosquito collection

Human-bait catches: Night-biting catches of adult mosquitoes were conducted monthly in four sites for 4 to 8 consecutive nights between October 1999 and October 2000. At each site, a pair of baits/collectors under recommended chemoprophylaxis caught mosquitoes landing on their legs from 18:00 to 06:00 hrs, with a change of teams at mid-night. A total of eight 12th grade complete data collectors who were trained for 5 days on catching landing mosquitoes were assigned to collect mosquitoes.

An investigator of the study (PI) and a senior entomology technician from the Institute of Pathobiology conducted continuous supervision throughout the collection nights. Bites per man per night were computed for the commonest anophelines collected.

CDC light-trap collection: Two dry cell battery-operated CDC light-traps were hung on a pole 2m long and far apart from each other from 18:00 to 06:00 hrs to collect adult mosquitoes.

Space spray: A space spray was performed in a single house once a month from 8:00 to 9:00 hours using a household aerosol insecticide (Mobil spray) and the adult anophelines knocked down were collected. No house is sampled more than once during the survey.

Mosquito identification and dissection: Identification of all the anophelines collected was undertaken using a key (11). Dissection of the identified female anophelines for determination of sporozoite rates was then conducted (10).

Ethical Considerations: Individual verbal consent was obtained for taking blood film in sampled households and appropriate anti-malarial treatment was given to positive cases. Similarly, household heads or other designated individuals gave verbal consent to conduct indoor nightbiting catches and space spray at the selected houses.

Data Analysis: Data analyzed using standard descriptive techniques.

Results

Parasitological study: Of total 2136 blood films examined in three surveys, 78(3.7%), 32 males and 46 females, were found infected (Table 1). *Plasmodium vivax* and *P. falciparum* were the infecting species. Infection was only detected in the first two surveys (October and November 1999) with none in the last survey (December, 1999). *Plasmodium falciparum* was dominant in the first survey, while *P. vivax* replaced it in the second.

Table 1: **Prevalence of parasite species in relation to the survey period in all age groups in Akaki Town from October to December 1999**

	No.	No.	Infection by sex		Infecting species	
Months	Examined	Positive	Male	Female	*P. falciparum*	*P.vivax*
October	712	30 (4.2)	12 (40.0)	18 (60.0)	21 (70.0)	9 (30.0)
November	712	48 (6.7)	20 (41.7)	28 (58.3)	3 (6.3)	45 (93.7)
December	712	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	2136	78 (3.7)	32 (41.0)	46 (59.0)	24 (30.8)	54 (69.2)

Of the total positives (n = 78) of the study population (n=712), 5 were under the age of five years (11 months to 4 years) (Table 2).

Table 2: **Cumulative modified age-specific malaria infection prevalence in the study population, Dec. 1999**

Age group (years)	No. examined	No. (%) positive
<5	73	5 (0.7)
5 – 9	106	12 (1.7)
10 – 14	115	12 (1.7)
15 and above	418	49 (6.9)
Total	712	78 (110)

Malaria infection was detected in the peripherally located ‘Ketenas’ (subunits in ‘Kebeles’), while absent in the three centrally located ones. A slight variation was also observed among the peripheral localities (Table 3).

Table 3: C**umulative malaria prevalence by Kebele in relationship to geographical location in Akaki Town from October to December 1999**

Mosquito collection: Of the total 1156 collected mosquito larvae, *An. christyi* was the most abundant (91.7%); *An. arabiensis* (6.7%) and *An. cinereus* (1.6%) were scarce (Table 4). Qualitatively, about half of the *An. christyi* larvae were collected from stream margin followed by rain pools, swamps and excavation ditches. However, *An. arabiensis* was abundant in excavation ditches, rain pools as well as

Kebele-Ketena	Geographical location	No. examined	No. (%) Positive
01-1	Central	47	0 (0.0)
01-2	Central	96	0 (0.0)
01-3	Central	65	0 (0.0)
01-4	Peripheral	132	38 (28.8)
03-1	Peripheral	166	20 (12.0)
03-3	Peripheral	206	20 (9.7)
	Total	712	78 (11.0)

along canals.

Table 4: **Species of *Anopheles* larvae collected from various breeding sites in Akaki Town from September 1999 to October 2000.**

Breeding sites	An. arabiensis	An. christyi	An. cinereus	Total
Artificial pond	0	27	0	27 (2.3)
Canals	14	70	0	0 (0.0)
Excavation ditch	36	111	0	0 (0.0)
Stream margin	0	492	0	492 (42.6)
Swamp	0	161	0	0 (0.0)
Rain pool	27	199	19	245 (21.2)
Total	77 (6.7)	1060 (91.7)	19 (1.6)	1156 (100.0)

Regarding the collection of adult anophelines, *An. christyi* and *An. arabiensis* were the commonest species, while the other two species: *An. pharoensis* and *An. coustani* were rare (Table 5). Human-bait collection was the most successful method for all species.

Table 5: **Adult *Anopheles* mosquitoes collected by different methods in Akaki Town between October 1999 and October 2000.**

Species	Human-bait	Space spray	Light trap	Total (%)
An. arabiensis	36	12	7	55 (50.0)
An. pharoensis	5	0	0	5 (4.5)
An. coustani	1	0	0	1 (1.0)
An. christyi	23	7	19	49 (44.5)
Total (%)	65 (59.1)	19 (17.3)	26 (23.6)	110 (100.0)

Biting rates of the commonest species showed seasonal variation that peaked in July and September (Table 6). Both *An. arabiensis* and *An. christyi* manifested exophagic tendencies. The outdoor density reached its peak in September for *An. arabiensis*. On the other hand, *An. christyi* showed an immediate rise in August that slowly declined thereafter. The small number of *An. pharoensis* collected showed an erratic distribution throughout the survey period.

Table 6: **Biting rates of *Anopheles* species caught on human-baits indoors (in) and Outdoors (out) in Akaki Town between October 1999 and October 2000.**

Survey	No. of	*An. arabiensis*		*An. christyi*		*An. pharoensis*		*An. coustani*	
Period	Man-nights	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Oct. 1999	10	0	0	0	0	1 (0.1)	1 (0.1)	0	0
Nov. 1999	10	0	0	0	1 (0.1)	1 (0.1)	0	0	0
Dec. 1999	8	0	0	0	0	0	0	0	0
Jan. 2000	8	0	0	0	0	0	0	0	0
Feb. 2000	8	0	0	0	0	0	0	0	0
Mar. 2000	8	0	0	0	0	0	0	0	0
Jun. 2000	8	0	3 (0.38)	0	0	1 (0.13)	0	0	0
Jul. 2000	16	2 (0.13)	4 (0.25)	0	2 (0.13)	0	0	0	1 (0.13)
Aug. 2000	16	2 (0.13)	5 (0.31)	1 (0.10)	9 (0.56)	0	0	0	0
Sep. 2000	16	1 (0.10)	16 (1.0)	3 (0.38)	3 (0.38)	0	0	0	0
Oct. 2000	16	0	3 (0.38)	0	4 (0.25	1 (0.1)	0	0	0

Total	124	5 (0.36)	31 (2.32)	4 (0.48)	19 (1.42)	4 (0.48)	1 (0.3)	0	1 (0.1)

Of the total 110 anophelines collected by various means; 43 *An. arabiensis*, 49 *An. christyi*, 2 *An. pharoensis* and 1 *An. coustani* were dissected for detection of sporozoites. None were, however, positive.

Discussion

From the present parasitological survey, 3.7% of the study population was found infected. The proportion of positive cases was more in the first survey (October 1999) followed by the second (November 1999), while no case was detected in the last survey (December 1999). More interestingly, the prevalence of *Plasmodium* species showed variation between the first two surveys, with *P. falciparum* predominating in the first survey, while *P. vivax* took over during the second survey. The variation between these two species might be due to the seasonality in characteristics of the two important parasites. It is generally known that *P. falciparum* is the dominant species during the peak malaria transmission season in September and October, while *P. vivax* tends to dominate during the dry season in Ethiopia (6). The absence of any case during the third survey in December (dry season) might be attributed to interventions through treatment and personal protection during the preceding peak transmission months. It could also be due to reduced availability of favorable conditions for the breeding of the vectors.

In the present study, the highest prevalence of malaria was detected in one of the Zones (peripheral area), the southern most of the town. The risk of contracting malaria for the inhabitants residing in peripheral areas is higher than the central ones. The localized abundance of man-made breeding sites is partly considered to have created favorable conditions to vector breeding. Moreover, the fact that houses are relatively scattered in the periphery, appears to allow accumulation of surface water. In contrast to this, houses are overcrowded and compact with intensive human activities prohibiting water collection in the old (central) parts of the town. In harmony with this, other studies confirmed the predominance of malaria at peripheral parts of urban setups elsewhere (8). This is obviously as a result of proximity of residence to breeding sites (12).

On the other hand, no gametocyte carriers were observed, and this could also be related to the lower infectivity rate and sporozoite circulation in the community. In general, high consumption of anti-malarial drugs in such urban centers is expected to minimize the possibility of obtaining gametocyte from the prevailing infection. The previous intensive epidemic control measures such as mass drug administration, treatment of confirmed cases and vector control activities during the 1998 outbreaks are reckoned to have contributed similarly to the low infection rate. In contrast, the presence of asymptomatic cases in areas like Akaki, presumably hypoendemic, is an implication of concomitant immunity, which develops only on repeated infection.

Qualitative observations on collected and identified larvae in the study area showed preference to different breeding sites. *Anopheles arabiensis* was sampled from temporary breeding sites such as canals, excavation ditch and sun lit rain pool with emergent vegetation. This is in agreement with previous findings for this species (6). Moreover, *An. christyi* larvae were abundant and collected from almost all kinds of breeding habitats. Unlike *An. arabiensis*, it occurred throughout the survey period. The highest larval density of this species was collected from excavation ditch and rain pool during the wet season. Nevertheless, *An. cinereus* larvae were the least available during this survey. This species was commonly reported as a highland anopheline occurring in rain pools, for instance, in Addis Ababa, around Filwoha 2457 meter; Entoto, 3000 meter, (13). Generally, larval densities of the anopheline species were closely associated with the availability of temporary breeding places, except *An. christyi* that breed in permanent water bodies.

In addition, the present study confirmed that *An. christyi* tolerates pollution of breeding sites with organic substances. Since Akaki is an industrial town, industrial liquid waste and toxic substances are being dumped into Akaki River from these industries for the last three decades (14). Earlier studies in Ethiopia have also indicated that the larvae of *An. christyi* unusually tolerate relatively high levels of pollution (15). On the contrary, pollution of the surrounding area, including Akaki River that over run parts of the town, could perhaps suppress the distribution of the main malaria vector.

Man-biting densities of *An. pharoensis* and *An. coustani* did not show a clear-cut seasonality, because of scarcity of these species in the area. *An. pharoensis* is known to prefer permanent water bodies at lower altitudes (6, 15).

The build up of the man-biting densities of *An. arabiensis* and *An. christyi* was noted between June and October. This rise was partly due to the appearance of suitable breeding sites as already observed in larval collections.

Even though *An. christyi* was found to breed in almost all the water collections investigated, it appears to show low biting density. This may be related to its poor anthropophilic behavior, but it is known to be predominantly zoophilic. For example, in Kenya and Rwanda only 12% and 5% were positive for human blood, respectively, while samples from Addis Ababa were negative (15).

It is to be noted that *An. arabiensis, An. chriysti* and *An. pharoensis* were the three important anthropophilic species in Akaki. In the present study, *An. arabiensis* is found to be predominantly exophagic in its behavior. *Anopheles arabiensis*, however, fed predominantly indoors than outdoors in Gambella (16). In Ziway, however, the same

species fed predominantly outdoors than indoors (17). In Gergedi, Upper Awash, the biting behavior of *An. arabiensis* was indicated to depend on availability of host whether outdoors or indoors and time of the evening (18).

From the present finding, the most important species that might be involved in the transmission of malaria in Akaki is *An. arabiensis* although it occurred in very small numbers compared to other endemic areas elsewhere. The absence of sporozoite infection in the species could also be due to the very small number dissected. Very low numbers of *An. pharoensis* were caught biting man, and thus may play no significant role in the transmission of malaria in Akaki. In spite of its lower density, *An. christyi* was the second manbiting species in Akaki area. Studies show that the epidemiological importance of this species in malaria transmission is unknown in Ethiopia (15). The later researchers indicated that this species is widely distributed in east African highlands, at altitudes ranging from 1400 to 2500m. However, the role of this species in malaria transmission is not yet understood throughout its range of occurrence.

Of the four anthropophilic species observed in this survey, *An. coustani* was found to be the least in abundance. It was previously reported to be common in Akaki and Addis Ababa (19). A study elsewhere in Ethiopia has shown that the species is less anthropophilic with no epidemiological importance in malaria transmission (20). Detailed studies are thus required on habits and habitats of *An. arabiensis, An. chriysti* and *An. pharoensis* to ascertain their exact role in malaria transmission in Akaki and the surrounding areas.

Generally, malaria transmission is negatively associated with urbanization as was shown in Kinshasa (5). This is mainly due to overcrowding, elimination of breeding sites due to construction or pollution of the breeding places resulting in lower vector densities in urban centers. These mechanisms are believed to have played an important role to suppress mosquito density in Akaki area. However, autochthonous malaria transmission could also be maintained for short period of time as speculated earlier (21) during the wet season as a result of the appearance of temporary breeding sites, mainly at the peripheral parts of the study locality. Given the vulnerability of the population for malaria due to short duration of transmission with interruption of acquired communal immunity, the occurrence of recurrent malaria epidemics is a common encounter in such areas. Thus, sustainable and integrated vector control measures including drainage of breeding sites and appropriate case management are envisaged to play a crucial role in preventing the occurrence of further malaria epidemics.

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