

The prevalence of asthma and rhinitis in a Sudanese community seasonally exposed to a potent airborne allergen (the "green nimitti" midge, *Cladotanytarsus lewisi*)

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The period prevalence rates for asthma and rhinitis were studied in a Sudanese village close to the Nile (Kalakla), where the inhabitants are seasonally exposed to very large numbers of nonbiting midges (the "green nimitti" midge, Cladotanytarsus lewisi [Diptera: Chironomidae]). The results were compared with those in a control village some distance from the river, where this midge nuisance does not occur. Of the 5262 persons enumerated in Kalakla, 4.9% suffered from asthma compared with 3.2% of the 2634 in the control area. For allergic rhinitis the rates were 6.7% for Kalakla and 1.5% in the control town. The percentage of patients with the combination of asthma and allergic rhinitis was four times greater in the affected area. These differences were all highly statistically significant. Asthma and rhinitis appeared to affect all occupational classes in both locations with an unexplained high prevalence in civil servants. In both areas the majority with asthma developed their disease by young adulthood, with a predominance in males in almost all age groups. In Kalakla the rates for both asthma and rhinitis increased with age. In the control town there was a similar trend for rhinitis, but the prevalence rates for asthma did not vary appreciably with age. The patient's own subjective assessment of provoking agents and the higher incidence of symptoms during the winter months (the "green nimitti" season) indicated that seasonal exposure to chironomids was a major etiologic factor in asthma and rhinitis in Kalakla. These epidemiologic findings support previous immunologic data which indicated that the "green nimitti" midge is a potent seasonal allergen and that repeated exposure results in a very high incidence of allergic rhinitis as well as a significant increase in the indigenous asthmatic population. (J ALLERGY CLIN IMMUNOL 71:345, 1983.)

Hypersensitivity to Chironomidae (nonbiting midges) has been a problem in the Northern Sudan since about 1927.¹⁻³ In the affected areas, *Cladotanytarsus lewisi* Freeman accounts for about 80% to 90% of small midges, which have been termed "green nimitti" to distinguish them from an unrelated grey,

bloodsucking simuliid nimitti (*Simulium griseicollae* Becker), which are troublesome near fast-flowing stretches of the Nile, particularly in the Dongola area of Northern Sudan. The large numbers of *C. lewisi* are probably the result of increased breeding areas, made possible by dams that have produced lakelike conditions on parts of the White, Blue, and main Nile rivers. The periods of midge outbreaks, which in some years reach plague proportions, occur almost exclusively during the dry winter months when the discharge of the Nile is low.¹

The increase in Chironomidae has been associated with a high incidence of allergy symptoms, especially bronchial asthma and rhinitis. The disease has typical clinical features of immediate hypersensitivity to airborne allergens, with rhinitis and asthma being dominant.⁴ Affected individuals give a positive skin prick test to an extract of the midge, and their sera contain

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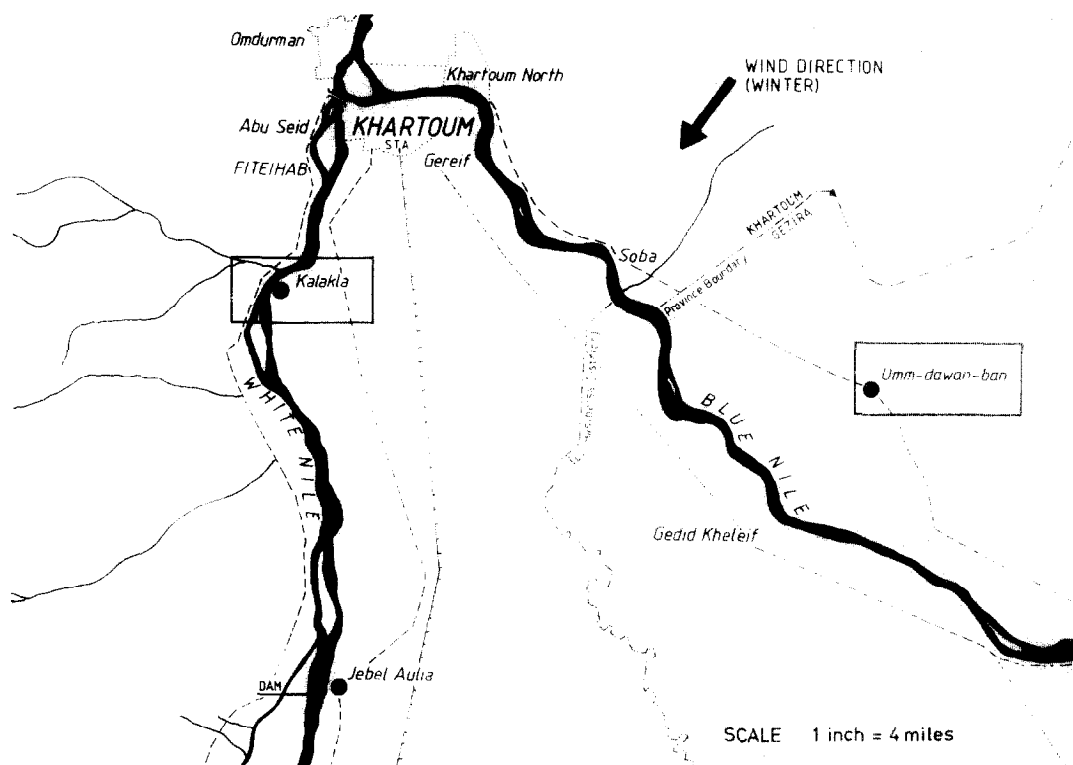


FIG. 1. Map of the Khartoum area, showing the location of Kalakla and the control town, Umm-dawan-ban. The scale is 1:250,000 and is taken from sheet 55B, scale map of the Sudan, published by the Sudan Government Survey (courtesy of the Royal Geographical Society, London).

specific IgE antibodies directed against green nimiti antigens.⁵ The exact number of individuals who are hypersensitive is uncertain, but our experience and that of others suggest that there are probably many thousands, especially at Wadi Halfa, certain parts of the Khartoum area (i.e., Kalakla, Shambat, and Jebel Auliya), Dongola, Wad Medani, those parts of the Gezira area close to the Nile, Sennar, Roseires, and to a lesser extent at Atbara and Shendi.^{6, 7} The problem probably extends to Upper Egypt near Lake Nasser. In contrast, people living in towns away from the Nile basin, such as Port Sudan and El Obeid, are not affected by allergy to these midges, nor are those in towns on the White Nile, such as Malakal and Juba, where the flow of the river is not affected by dams.

Since there is a lack of accurate data on both the prevalence of asthma and rhinitis in these areas and also the effects of seasonal exposure to chironomid allergens in these diseases, we have undertaken epidemiologic studies to determine the extent of the problem. This article describes the conduct and results of a field survey designed to compare the prevalence rates of asthma and allergic rhinitis in two contrasting settlements: Kalakla, on the bank of the

White Nile 20 km south of Khartoum, and Umm-dawan-ban, beyond the reach of the chironomid.

METHODS

Epidemiologic data were gathered by a questionnaire using a modified cluster sampling method.⁸ The questionnaire covered basic demographic data, age, sex, and occupation. Thereafter it proceeded to enquiries relating to the frequency and severity, first of asthmatic attacks and later of allergic rhinitis. Information was also sought on the age of onset of wheeze and/or rhinitis and whether the symptoms were seasonal. A range of possible provoking or exacerbating agents was posed, including exposure to green nimiti or pollens, various climatic conditions, emotion, and exercise.

The affected area chosen was a town called Kalakla, where previous immunologic studies had been undertaken.^{4, 5} The community consists of about 3000 houses, the total population being estimated at approximately 20,000 (Fig. 1). The flat-roofed, mud-built houses were all closely similar in size and type. The dwellings were dispersed over a stretch of 2 miles along the bank of the White Nile, at no point being further than 3 miles from the river. Green nimiti are not usually found more than 5 miles beyond their river breeding grounds. There were neither street names nor house numbers, but the village was divided into districts or

TABLE I. Prevalence of asthma and rhinitis in Kalakla and the control town*

	Kalakla	Control	χ^2	Significance
Population surveyed	5262	2634		
Asthma (with or without rhinitis)	257 (4.9%)†	84 (3.2%)	12.2047	p < 0.001
Rhinitis (with or without asthma)	353 (6.7%)	39 (1.5%)	101.6809	p < 0.001
Asthma (without rhinitis)	152 (2.9%)	71 (2.7%)	0.2385	ns
Rhinitis (without asthma)	248 (4.7%)	26 (1.0%)	87.8678	p < 0.001
Asthma + rhinitis	105 (2.0%)	13 (0.5%)	26.8968	p < 0.001

ns = not significant.

*Twenty-three questionnaires from Kalakla and 12 from the control town were omitted from this, and subsequent, analyses on the basis that the diagnosis of asthma or rhinitis seemed to be uncertain. Some of the questionnaires were inadequately completed or contained internal inconsistencies.

†The figures represent the absolute number, with the percentages in parentheses. The p values were calculated by the χ^2 test.

TABLE IIA. Occupations of the individuals surveyed in Kalakla and the control town

	Kalakla	Control
Child/student	2870 (546)*	1342 (509)
Housewife	1032 (196)	589 (224)
Laborer	375 (71)	180 (68)
Professional	284 (54)	133 (50)
Civil servant	183 (35)	32 (12)
Merchant	122 (23)	147 (56)
Other	210 (40)	102 (39)
Unknown	188 (36)	109 (41)
Total	5262	2634

*The figures represent the absolute numbers, with the rates per 1000 in parentheses.

areas, recognizable to the inhabitants. A mosque, store, and medical clinic were situated centrally.

We were informed by the inhabitants that during the winter, swarms of midges "made the sky dark," obliging the villagers to veil their faces with their wraps. The green nimitti were worst out of doors, at dusk, but were attracted by lights and could easily penetrate the houses.

The control town was named Umm-dawan-ban and contained approximately 10,000 inhabitants. It was approximately 20 miles to the southeast of the Nile at Khartoum and, since the prevailing wind in the green nimitti season was from the north, it was well out of range of the midges (Fig. 1). The entomologist in the team, Dr. Peter Cranston, was able to visit Umm-dawan-ban (during the time that *C. lewisi* were observed at Kalakla), set up a light trap at dusk, and establish that although chironomid midges were present around a pond, *C. lewisi* were absent.

A team of 50 interviewers was recruited from amongst final-year medical students at the University of Khartoum who were currently studying epidemiology and who were easily persuaded of the interest and importance of a field survey. After several briefing sessions and practicing the questionnaire on one another, they were taken into the field

TABLE IIB. Prevalence (per 1000) of asthma and rhinitis in Kalakla and the control town according to occupation

	Asthma		Rhinitis	
	Kalakla	Control	Kalakla	Control
Child/student	37	26	36	7
Housewife	54	34	115	24
Laborer	72	39	88	16
Professional	67	15	70	15
Civil servant	104	63	191	63
Merchant	90	54	98	7

to spend 2 working days in Kalakla and 1 day in Umm-dawan-ban. The interviewers were all competent English speakers, with an understanding of asthma and allergic rhinitis, and understood, for instance, the importance of distinguishing asthma from chronic bronchitis and rhinitis from the common cold. The interviews were conducted in Arabic. The survey took place in the last week of January 1980, at a time when other Sudanese seasonal allergens (particularly pollen from the neem tree, *Azadirachta indica*, which flowers in May) would not be expected to occur. Advance notice of the students' visits was given in each place, and local escorts were provided to introduce them and generally facilitate the exercise.

The modified cluster sampling method was as follows: Interviewers were first uniformly distributed throughout all the districts of the town. Starting with a particular dwelling as a center, they proceeded to call at adjacent houses surrounding the first one, until every student accumulated information on a cluster of households. All the individuals in each geographic cluster were included in the census data, but detailed disease information was gathered only in relation to persons with asthma or rhinitis.

The census investigated each household's composition in terms of age, sex, and occupation. Thereafter, enquiries as to members of the household who reportedly had asthma (wheezing attacks) or hay fever-like symptoms would de-

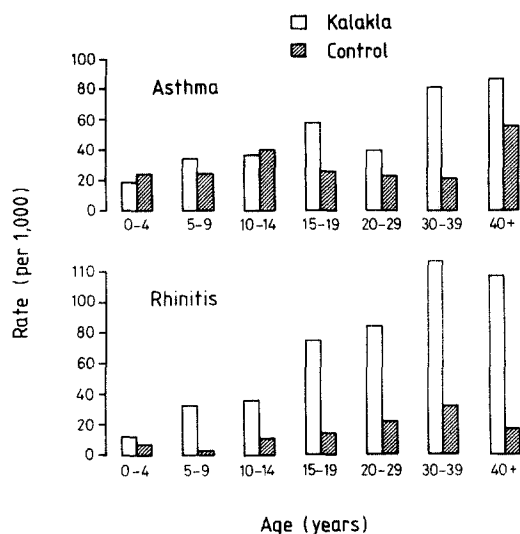


FIG. 2. Variation by age in the rates of asthma and allergic rhinitis in Kalakla and the control town.

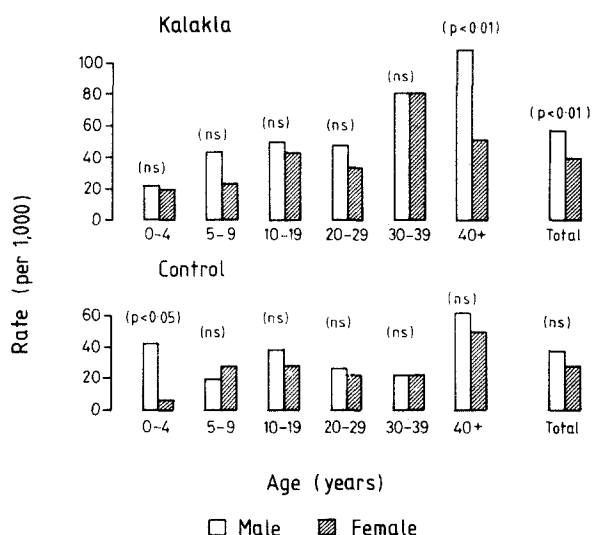


FIG. 3. Variation by age and gender in the rate of asthma in Kalakla and the control town. The p values were calculated by the χ^2 test. ns, Not significant.

termine whether or not the interviewer proceeded to a full set of questions about the relevant condition, addressed either to the sufferer or a proxy relative. In this way, the number of sufferers could be related to a defined population, in both the affected area and the control area, providing the basis for prevalence rates.

RESULTS

A total of 5262 persons were enumerated in Kalakla and 2634 in the control town (Table I). This represented approximately one quarter of the population in both communities. The overall prevalence of

asthma in the affected area was significantly higher ($p < 0.001$) than that in the control town (4.9% vs 3.2%). In Kalakla the incidence of rhinitis was almost five times as high ($p < 0.001$). The prevalence of asthma alone, i.e., without rhinitis, was virtually identical in the two communities (2.9% vs 2.7%), whereas that of rhinitis alone, i.e., without asthma, was five times higher in Kalakla (4.7% vs 1.0%) compared with control ($p < 0.001$). Similarly, there were four times as many people in Kalakla with the combination of asthma and rhinitis (2.0% vs 0.5%, $p < 0.001$).

The age-specific prevalence rates for asthma and rhinitis are shown in Fig. 2. The prevalence rates for both conditions were consistently higher in the affected area for each age group, with the exception that the rate for asthma was similar in both towns in the 0 to 4, 5 to 9, and 10 to 14 yr age groups. The overall tendency was for the prevalence of asthma and allergic rhinitis to increase with age in the area affected by green nimitti, whereas this pattern was not observed in the control area.

When the prevalence of asthma and rhinitis in male and female sufferers was compared it was found that in Kalakla, the rate of asthma in males was higher in virtually all age groups (Fig. 3). These differences between gender were statistically significant ($p < 0.01$) in individuals over the age of 40 yr and in the total population. A significant difference was also observed in the 0 to 4 yr age group in the control town ($p < 0.05$) but not in the other age groups. No significant differences were observed over the remainder of the age range in the control town.

The occupations of the individuals surveyed in Kalakla and the control towns are shown in Table IIA. The rates for each occupational class were similar in both locations, indicating that in this respect the two communities were comparable. When children and "students" (school and college attenders) were combined, they amounted to approximately half the total inhabitants of the towns in question. The prevalence of asthma and rhinitis in Kalakla and the control town according to occupation is shown in Table IIB. Asthma and rhinitis was very prevalent in civil servants, with almost one in five in Kalakla suffering from rhinitis and approximately one in 10 having asthma.

The age of onset of asthma according to gender is shown in Table III. In the affected and control areas the majority of individuals, both male and female, developed asthma before the age of 20 yr, and a large proportion before the age of 10 yr. Very few appeared to develop asthma over the age of 40 yr.

Symptoms associated with the onset of asthma are

TABLE III. Age of onset of asthma in Kalakla and the control town according to gender

Age at onset (yr)	Kalakla		Control	
	Male	Female	Male	Female
0-4	37 (25.2%)*	18 (19.2%)	11 (23.9%)	6 (18.2%)
5-9	17 (11.6%)	12 (12.8%)	14 (30.5%)	8 (24.2%)
10-19	35 (23.8%)	32 (34.0%)	11 (23.9%)	6 (18.2%)
20-29	30 (20.4%)	21 (22.3%)	2 (4.3%)	4 (12.1%)
30-39	19 (12.9%)	5 (5.3%)	4 (8.7%)	6 (18.2%)
40+	9 (6.1%)	6 (6.4%)	4 (8.7%)	3 (9.1%)
Total	147 (100%)	94 (100%)	46 (100%)	33 (100%)

*The figures represent the absolute numbers in individuals, with the percentage of subjects enumerated in parentheses.

TABLE IV. Symptoms associated with the onset of asthma attack*

Symptoms	Kalakla	Control
Irritation of eyes	15 (6)*	4 (4.7)
Running nose	40 (16)	14 (16.6)
Irritation of eyes and nose	62 (24)	5 (5.9)
Wheezes spontaneously	87 (34)	51 (60.8)
Itching of skin of neck	5 (2)	2 (2.3)
Variable	41 (16)	6 (7.1)
Unknown	5 (2)	2 (2.3)
No. of asthmatics (= 100%)	257 (100)	84 (100)

*The figures represent the absolute numbers of individuals, with the percentage of subjects enumerated in parentheses.

shown in Table IV. In Kalakla irritation of the eyes and nose at the onset of attacks occurred four times more frequently than in the control town. In contrast, asthma attacks occurring spontaneously, i.e., without preceding rhinitis-type symptoms, were recorded in twice as many asthmatics in the control town compared with Kalakla.

With the exception of green nimitti there were no appreciable differences between Kalakla and the control area in the percentage of individuals who attributed their symptoms to the various agents posed in the questionnaire (Table V). The percentage of individuals who attributed their asthma or rhinitis to green nimitti in Kalakla was approximately 12 and six times higher, respectively, when compared with the control area.

As shown in Table VI, the majority of the asthma and rhinitis sufferers in Kalakla had symptoms only during the winter, whereas in the control village the numbers with symptoms in both the winter and summer were virtually the same.

By further questions (data not shown) we were able to ascertain that 21% of asthmatic individuals in

TABLE V. Agents that provoke or exacerbate asthma or rhinitis in Kalakla and the control town

	Asthma		Rhinitis	
	Kalakla	Control	Kalakla	Control
Green nimitti	70*	6	75	13
House dust	75	77	69	74
Sandstorms	62	76	70	74
Humidity	44	51	37	33
Emotion	44	48	28	23
Smoky atmosphere	44	58	42	44
Pollens	21	25	23	21
Nile fish	10	11	9	5
Exercise	68	76	N.A.	N.A.
Common cold	67	82	N.A.	N.A.
Coughing	65	74	N.A.	N.A.
Number (= 100%)	257	84	353	39

NA = not asked in the questionnaire.

*The figures are a percentage of the total numbers studied.

Kalakla, but only 6% in the control village, had changed the pattern of their disease from seasonal (i.e., winter only) to perennial. A substantial proportion of asthma sufferers both in Kalakla and the control village had severe symptoms. For instance, 52% of asthmatics in Kalakla and 37% in the control village had attacks that lasted 4 days or longer, and 27% of asthmatics in Kalakla and 40% in the control area required inpatient treatment some time during the previous 5 yr. Fifty-four percent of asthmatics in Kalakla and 60% in the control village had asthma severe enough to cease normal activities. Thirty percent of asthmatics in Kalakla and 40% in the control town had at some time consulted traditional healers for their asthmatic problem.

Of the 97 asthmatics in Kalakla whose asthma was confined to the winter, 80 (82.5%) had symptoms provoked or exacerbated by green nimitti (Table VII). In contrast, only three of 10 asthmatics in the control

TABLE VI. Seasonal variations in the severity of asthma and rhinitis in Kalakla and the control town

	Asthma		Rhinitis	
	Kalakla	Control	Kalakla	Control
Worse in winter	84 (75%)*	23 (44%)	223 (67%)	12 (34%)
Worse in summer	18 (16%)	24 (46%)	29 (9%)	11 (31%)
Same all year round or variable	10 (9%)	5 (10%)	81 (24%)	12 (34%)
Total	112 (100%)	52 (100%)	333 (100%)	35 (100%)

*The figures are absolute numbers, with the percentages in parentheses.

TABLE VII. Numbers of asthmatic subjects whose symptoms are confined only to the winter months and provoked or exacerbated by exposure to green nimitti

	Asthma	
	Kalakla	Control
Green nimitti		
Provokes/exacerbates	80 (82.5%)*	3 (30.0%)
No effect	17 (17.5%)	7 (70.0%)
Total	97	10

*The figures are absolute numbers, with the percentages in parentheses.

area incriminated green nimitti as the cause of their winter asthma.

DISCUSSION

There are well-known problems in estimating the prevalence of asthma. These include reliance on an operational definition, i.e., variable airflow obstruction, difficulties in distinguishing asthma from both recurrent wheezy bronchitis and chronic obstructive lung disease with a reversible component, as well as estimation of prevalence in a condition in which long periods of remission often occur. Although for practical reasons we were unable to undertake tests of ventilatory function, the interviewers all had clinical skills and were made aware in the detailed briefing sessions of the pitfalls of diagnosing asthma on the basis of a clinical history alone. Furthermore, our study was a comparative one between two communities with the primary aim of increasing knowledge of the effects of a potent airborne allergen in individuals seasonally exposed. This has enabled us, at the same time, to get more general information on the prevalence of asthma and rhinitis in communities in which, hitherto, this information had been lacking. However, it is difficult to compare our data on asthma prevalence with other studies, since we were measuring

period prevalence rates, i.e., symptoms occurring within the previous 3 mo, rather than point or cumulative prevalence.¹¹ In Great Britain and the United States the prevalence rate of childhood asthma is between 1.5% and 5.1%. In our study, the rates in Kalakla for the 0 to 4, 5 to 9, and 10 to 14 yr age groups were approximately 2%, 3%, and 4%, respectively (Fig. 2).

Although the methods for gathering the data were identical and the prevalence rates for asthma in the community affected by the midges were statistically higher than those in the control town, we cannot say with certainty that an environmental factor is causal rather than coincidental. Nevertheless, these data, taken together with (1) our previous findings of high concentrations of specific IgE to green nimitti in the serum of these asthmatic individuals,⁵ (2) positive bronchial provocation tests using nondialyzable extracts of the midges (Gad el Rab and Kay, unpublished observations), and (3) the fact that symptoms are considerably higher in the winter months when the midges emerge in large numbers (Tables V and VI), make it most likely that *C. lewisi* is a major etiologic factor in these patients' disease. This does not mean that exposure to the midges is the sole factor in the inception of the disease, its tendency to persist, or the provocation of all acute attacks, since in the control area, where this environmental agent was not present, the "indigenous" asthma population was as high as 3.2%.

Ideally, we would have wished to have combined the present epidemiologic study with immunologic measurements such as skin tests and specific IgE concentrations. For a number of reasons, particularly the danger of losing community cooperation if the methods were too invasive, we decided to restrict ourselves on this occasion to the data provided by the questionnaire. Nevertheless it should be emphasized that Kalakla and Jebel Auliya (30 km further south on the White Nile) were the sites of previous extensive immunologic surveys in which we established, by means of the radioallergosorbent test, that the asthma

sufferers, compared with normal Sudanese and British controls, had high concentrations of IgE antibodies to an extract of green nimitti.^{4, 5}

In Great Britain, the United States, and Australasia, about 50% of patients experience the onset of asthma before the age of 10 yr, whereas in Scandinavia, India, and Nigeria onset of asthma by this age has been found to occur in only 10% to 30% of patients.⁹ In the present study, 35% in Kalakla and 50% in the control area had developed their disease by 10 yr of age, and in this respect our findings are similar to these previous results.

Rhinitis presents similar difficulties of diagnosis, although, except for the common cold, it is not usually mistaken for other conditions. There was almost a fivefold increase in the prevalence of rhinitis in Kalakla compared with the control area (Table I). In this respect it would appear that the green nimitti midge is acting in a similar fashion to other airborne allergens such as grass, mold, and tree pollens, the house dust mite, and animal danders in that it is causing rhinitis predominantly and contributing, to a lesser extent, to attacks of asthma.

It was of particular interest that the prevalence of asthma alone, i.e., without rhinitis, was similar in the two areas (2.8% vs 2.7%, Table I). This suggests that there is an indigenous population of asthma sufferers whose disease is unassociated with exposure to the midge.

The prevalence of asthma in the older age groups in Kalakla was higher than in childhood with rates of greater than 8% in the 30 to 39 and 40+ yr age groups. Again, because of differences in methods, these figures are difficult to compare with previous studies. The rates in adults from worldwide studies range from 1.1% to 9.9%, with particularly high figures from isolated communities such as the islanders of Tristan da Cunha.¹⁰ Most of these studies seem to have measured cumulative rather than point prevalence, where higher rates were to be expected.

The differences between Kalakla and control according to occupation were very marked for rhinitis. For instance, with merchants there was a 14-fold difference. The potentially high prevalence of asthma and rhinitis amongst civil servants, however, is difficult to explain without having more details of the life style of these individuals (Table IIa).

From the data presented in Table III, there is no evidence that asthma developing late in life is an appreciable problem in these Sudanese communities.

Asthma provoked by airborne allergens such as pollens and animal dander are frequently preceded by, or associated with, rhinitis-type symptoms. Thus it was of interest that four times as many asthmatics in

Kalakla had irritations of the eyes and nose at the onset of asthma attacks, thus indicating that allergy was probably an important factor in the etiology of their disease (Table IV). Conversely, twice as many asthmatics in the control area wheezed spontaneously, a finding in keeping with the general pattern of "indigenous asthma" common to most populations studied.⁹

Most studies of childhood asthma have revealed a higher prevalence of asthma in males, with rates varying between 1.5 and 33:1.⁹ These differences do not appear to apply for adult asthma, and it was therefore of interest that in the present study the male-to-female ratio in the asthmatics at Kalakla over 40 yr of age was 1.43:1 (Fig. 3). It is possible that males are more susceptible to allergen provocation than females, with, in general, allergy being the more important etiologic factor in childhood than adult asthma. Thus in the control area, where the male-to-female ratio was 1.23:1, the pattern was more like adult asthma found elsewhere, whereas in Kalakla the unusually severe seasonal exposure to the potent allergens was associated in a persistence of the increased male-to-female ratio.

There was no significant difference in the percentage of asthma or rhinitis sufferers attributing their symptoms to provocation by the various agents listed in Table V, except green nimitti. If exposure to green nimitti is indeed a major etiologic factor in asthma and rhinitis in the inhabitants of Kalakla, symptoms should be greater during the winter months, when the midges appear. On the other hand, the seasonal differences should not be expected in a community where this problem does not exist. Thus the results in Tables VI and VII give further support to the view that green nimitti is a major allergen in the affected area.

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REFERENCES

1. Lewis DJ: Chironomidae as a pest in the Northern Sudan. *Acta Trop* 13:142, 1956.
2. Lewis DJ, Henry AJ, Grindley DN: Daily changes in the number of chironomid midges at Khartoum. *Proc R Soc Lond [A]* 29:124, 1954.
3. Freeman P: A species of chironomid (Diptera) from the Sudan suspected of causing asthma. *Proc R Soc Lond [B]* 19:58, 1950.

4. Kay AB, Gad El Rab MO, Stewart J, Erwa HH: Widespread IgE-mediated hypersensitivity in Northern Sudan to the chironomid *Cladotanytarsus lewisi* ("green nimitti"). Clin Exp Immunol **34**:106, 1978.
5. Gad El Rab MO, Kay AB: Widespread IgE-mediated hypersensitivity in the Sudan to the "green nimitti" midge *Cladotanytarsus lewisi* (Diptera: Chironomidae). I. Diagnosis by radioallergosorbent test (RAST). J ALLERGY CLIN IMMUNOL **66**:190, 1980.
6. Satti MH, Abdel Nur OM: Chironomidae as a cause of nuisance and allergic manifestation. Sudan Med J **12**:77, 1974.
7. Cranston PS, Tee RD, Gad El Rab MO, Kay AB: Immediate-type skin reactivity to extracts of the "green nimitti" midge (*Cladotanytarsus lewisi*) and other chironomids in asthmatic subjects in the Sudan and Egypt. Ann Trop Med (in press).
8. Barker DJP, Bennett RJ: Medicine in the tropics: practical epidemiology. Edinburgh, 1973, Churchill Livingstone.
9. Gregg I: Epidemiology, in Clark TJH, Godfrey S, editors: Asthma. London, 1977, Chapman and Hall, pp. 215-240.
10. Mantle J, Pepys J: Asthma amongst Tristan da Cunha islanders. Clin Allergy **4**:161, 1974.