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DISTRIBUTION OF CRIMEAN-CONGO HEMORRHAGIC FEVER VIRAL ANTIBODY IN SENEGAL: ENVIRONMENTAL AND VECTORIAL CORRELATES

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Abstract. The spatial pattern in Senegal of Crimean-Congo hemorrhagic fever (CCHF) virus IgG antibody prevalence in human and sheep was determined as was the relative abundance of potential tick vectors. A systematic, country-wide serological survey of sheep demonstrated that 10.4% of sheep exhibited IgG to CCHF virus. Sexes were infected equally. Antibody prevalence increased with age from 2.1% during the first year to 18.2% among sheep ≥3 years of age. IgG prevalence was highest in the northern, arid Sahelian zone, averaging 75.7% seropositivity, and decreased to zero in the southern, moister Sudano-Guinean and Guinean zones. Human IgG prevalence ranged from 21% to <1% among the 8 sites that were sampled throughout the country, being greatest in the arid north and least in the south. *Hyalomma* ssp. ticks predominated in those biotopes where antibody prevalence was highest. The abundance of *Hyalomma* ticks may be the proximal determinant of endemic transmission.

The worldwide distribution of Crimean-Congo hemorrhagic fever (CCHF) is astonishingly large for an arboviral zoonosis, including most of southern Eurasia, southern Europe, the Middle East, and Africa.[1] Active in the Paleartic, Oriental, and Ethiopian faunal regions, CCHF virus transmission occurs in ecologically diverse sites of ≥30 different countries.[1,2] Although apparently limited by extremely cold temperatures or high humidity, evidence of this virus is found in a variety of habitats and climatologic conditions. The physical and biological variables that prevent, limit or enhance transmission of CCHF virus remain poorly understood.

Factors that influence transmission of CCHF virus include the density of competent vector ticks, particularly of the genus *Hyalomma,* and the abundance of vertebrates that serve both as hosts to these ticks and as possible reservoirs of the virus.[1] At least 30 species of ticks[1,3] and >20 different vertebrate species[2] have been shown to be infected. Sustained transmission is found only where *Hyalomma* ticks are present, and epizootic or epidemic transmission is believed to occur during periods of increased abundance of these ticks.[2] However, the relationship between tick species diversity and the magnitude of CCHF virus transmission within a particular geographic region has not been studied systematically.

In sub-Saharan West Africa, circulation of CCHF virus has been demonstrated by the isolation of virus from ticks and the isolation of virus or the demonstration of antibodies from domestic and wild vertebrates or humans in Senegal,[4–10] Mauritania,[11–13] Burkina Faso,[14,15] Benin,[14] and Nigeria.[16–18] Initial observations in Senegal during the late 1960s demonstrated indirect evidence of domestic animal and tick infections.[4] During the 1970s and early 1980s, researchers at the Pasteur Institute in Dakar isolated numerous strains of CCHF virus from ticks feeding on cattle and sheep at slaughterhouses in Senegal.[5–9] Antibodies also were detected at various sites in the country, and a human case and antibodies in domestic animals were documented along the border in Mauritania.[12] More recently, we studied a fatal human illness due to CCHF virus infection in association with epizootic transmission during May 1988 near Rosso, Mauritania, on the Senegal River border.[19] Despite 2 decades of recognized CCHF virus activity in Senegal, the spatial pattern of transmission and the prevalence of human infection throughout the country have not been studied systematically. We report here on research designed to investigate the spatial and temporal aspects of CCHF virus transmission within Senegal by evaluating the seroprevalence among sheep and humans

compared with various bioclimatic variables and the relative abundance of ixodid ticks.

MATERIALS AND METHODS

Animal serology

Blood samples from sheep throughout Senegal were obtained as part of a project initiated by l'Institut Senegalais de Recherches Agricoles (ISRA). The country was divided into 80 sample districts of approximately equal areas that corresponded to 1 or more governmental administrative districts. Of these sample districts, 26 were randomly chosen for study. The number of animals sampled in each district was predetermined at 1:3,000 of the estimated resident sheep density, which had been calculated previously from a government census undertaken by personnel of ISRA. Villages from the interior of each district were chosen and flocks were selected randomly. In large flocks, 10–20 sheep were bled; in small flocks, all sheep were bled until the predetermined sample size for that district was achieved. Between November 1986 and January 1987, sheep from 26 sample districts in 9 of Senegal's 10 governmental regions were bled. The sex and age for each animal were recorded. Sheep were categorized into 4 groups based on ages estimated by dental examination: <14 months, 14–28 months, 29–36 months, and >36 months. Blood samples were centrifuged and sera were stored at −20°C in the field and later tested at the Pasteur Institute in Dakar.

Sera were examined for evidence of IgG to CCHF virus using a direct ELISA[20] modified slightly by adding a saturating solution of PBS with 0.05% Tween 20 and 1% non-fat bovine milk. Ninety-six well plates (Immulon II, Dynatech Laboratories Inc., Alexandria, VA) were coated with 100 μl of diluted CCHF virus hyperimmune mouse ascitic fluid produced against CCHF virus strain IbAr 10200 from Sokoto, Nigeria. Sera were tested against 2 local CCHF virus strains: Dak H49199, isolated in 1988 from a human in Rosso, Mauritania[19] and ArD 43396, isolated from a pool of *Hyalomma marginatum rufipes* collected in 1985 in Yonofere, Senegal. The identity of these strains was confirmed by complement fixation at the WHO Collaborating Center for Arbovirus Reference and Research at the Pasteur Institute in Dakar. CCHF virus in crude suckling mouse brain was heat inactivated (1 hr, 60°C); 100 μl CCHF virus suspension was added followed by 100 μl of test sera, diluted 1:400 in ELISA buffer. Then 100 μl of test-species specific anti-gamma-chain immunoglobulin conjugated with horseradish peroxidase (Biosys, Compiegne, France) was added to detect the IgG. Finally, 100 μl of chromogenic substrate (orthotolidine, Sigma, LaVerpilliere, France) was added for colorimetry. All plates included a control of crude suckling mouse brain without CCHF virus antigen. Differences in optical density (OD) between the test and control wells were measured at 450 nm using an automatic reader (Titertek, Multiscan MCC/340, Flow Laboratories, Irvine, Scotland) coupled to a microcomputer. By iterations of the distribution of OD values, we determined the mean of the population of negatives. Sera were considered positive if the OD was >3 SD above the mean of negatives.

The specificity of this test was examined by using Dugbe, Bandia, and Bakel viruses as antigen, the 3 other major Nairoviruses that have been frequently isolated in Senegal and identified at the WHO Collaborating Center for Arbovirus Reference and Research. These viruses were tested against sera from a sheep inoculated with CCHF virus, a large sample of wild sheep that had tested positive against CCHF virus, and 3 human infections from which CCHF virus had been isolated.[21] Virtually no cross-reaction was observed and the few weak positives were eliminated by diluting sera to 1:400.

Human serology

Human blood samples were collected during 1986–1988 from 8 different sites in Senegal and southern Mauritania. In addition to samples from Yonofere, Dahra, Bandia, and Kedougou, we tested sera collected as part of other studies from Dagana and Ziguinchor by Alain Jouan, from Tambacounda by Jean-Francois Saluzzo, and from Rosso by Elizabeth Manus. Details of the sampling methods varied among the sites; however, all blood was obtained by venipuncture from apparently healthy people who were asked to donate for medical research. Blood was held from 1–4 days at ambient temperatures and sera was frozen at −20°C and later tested as above.

Distribution of ticks

The relative abundance and distribution of ixodid ticks was determined from our systematic samples of domestic ungulates[3] combined with similar data from Gueye and others[22–27] that were reanalyzed for this purpose. Ticks were detached from sheep, goats, or cattle monthly for ≥1 year in order to avoid bias due to seasonal variation in tick activity. We sampled 3 sites in northern Senegal: Yonofere, Dahra, and Bandia. In Yonofere, 5 flocks of sheep were chosen monthly by chance encounter from May 1987 through May 1989 and 10 randomly selected individuals from each herd were sampled. All ticks were removed with forceps and stored for later identification. The same methods were used in Dahra from May 1987 through August 1989. In Bandia, 12 sentinel goats and 2 cows were examined similarly 3 times each month from April 1987 through March 1989.

Published data from other sites in Senegal[22–27] were reanalyzed to make them consistent with our methods. We calculated the mean number of adult ticks per host from monthly samples of 40 cattle, sheep, or goats made for ≥12 consecutive months during 1985–1989. Because these ticks differ somewhat in their propensity for feeding on the 3 hosts, we transformed the data from all 7 sites to qualitative values that represent the relative abundances of each tick species among the sites. Each tick was categorized as either very abundant (average >2 ticks/host), moderately abundant (0.1–2/host), rare (<0.1/host), extremely rare (a few encounters), or absent.

Data analysis

Serological results for sheep were analyzed using χ^2 test with continuity correction, linear correlation analysis, and curve fitting from the Microstat version 4.1 statistical software.

RESULTS

Animal infection

A total of 10.4% of sheep were found positive for IgG to CCHF virus from the 942 sera tested from 66 flocks of 22 sample districts in 9 governmental regions (Table 1). The number of sheep tested in each village (mean = 14.3 ± 16.3), was independent of IgG prevalence ($r^2 = 0.013$, n = 66, $P = 0.36$), sex ratio ($r^2 = 0.008$, $P = 0.48$) and age ($r^2 = 0.03$, $P = 0.17$). Analyses were performed, therefore, on the combined sample. The overall IgG prevalence of 7.1% for rams (n = 156) was not statistically different from that of 11.3% for ewes (n = 773) ($\chi^2 = 2.006$, df = 1, $P = 0.16$). Furthermore, rams and ewes showed equal evidence of past infection among each of 4 age categories and within each governmental region (all P values >0.10).

TABLE 1

Prevalence of IgG antibodies against Crimean-Congo hemorrhagic fever virus among 942 sheep from 66 randomly selected villages from 9 regions in Senegal, November 1986–January 1987

Region	No. villages sampled	No. sheep tested	Ratio M:F	IgG prevalence (%)
St. Louis	2	37	1:8.3	75.7
	1	9	1:2	22.2
	1	16	1:1.7	28
	3	30	1:3.3	3.3
Louga	7	78	1:10.1	10.3
	8	192	1:11.8	13
	4	60	1:3.3	13.3
	4	60	1:2.2	1.7
Thies	3	48	1:2.4	0
Diourbel	3	44	1:3	9.1
Fatick	3	41	1:7.2	22
Kaolack	3	65	1:4.9	4.6
	3	33	1:7.3	12.1
Tambacounda	2	20	1:4	0
	2	21	1:20	0
	2	22	1:4.5	0
	1	12	1:3	0
	2	21	1:20	0
Kolda	4	43	1:6.5	0
	1	19	1:18	0
	4	34	1:5.8	0
Ziguinchor	3	37	1:2.1	0
Totals	66	942	1:4.7	10.4

Antibody prevalence increased with age. Only 2.1% of the youngest animals (aged <14 months) tested positive, whereas 18.2% of the oldest sheep (≥3 years) were seropositive. This age-related increase in seroprevalence was similar for rams and ewes (Fig. 1) in each region where infection was observed. Furthermore, a comparison of village rates using multiple stepwise regression of mean age, sex ratio, and number sampled regressed against IgG prevalence rates revealed a correlation solely with age ($r^2 = 0.10$, n = 66, $P < 0.001$). Prevalence was greater in older sheep than in younger sheep.

Evidence of CCHF virus transmission varied among governmental regions and sample districts (Fig. 2). Average antibody prevalence among the 22 sample districts appeared highest in northern Senegal and decreased to nil in the

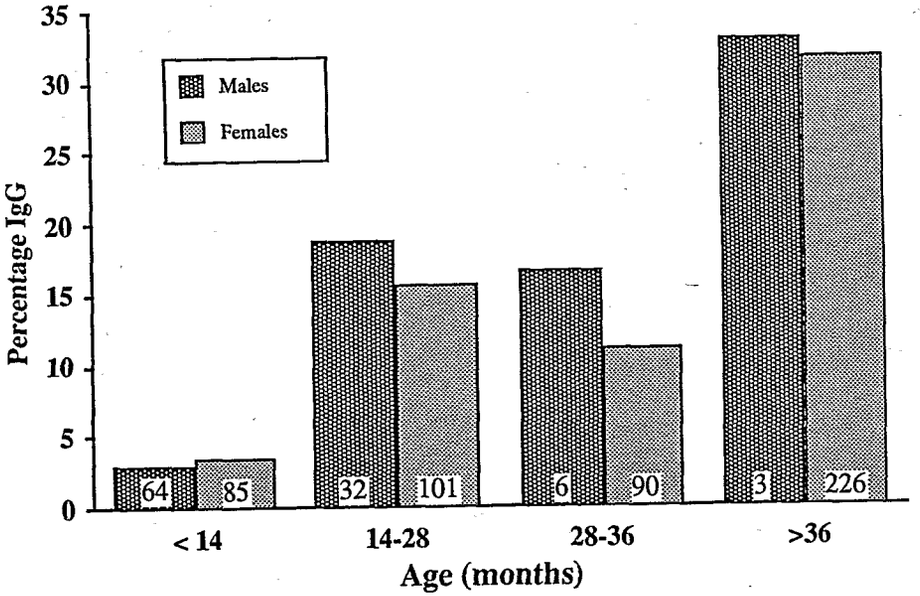

FIGURE 1. Prevalence of IgG antibodies to CCHF virus by age and sex of sheep from Senegal sampled between November 1986 and January 1987. Sheep from the 4 governmental regions where antibodies were found are included. Number of sheep in sample is shown at the base of each bar.

southern part of the country. Evidence of past infection was compared to vegetation and climatic characteristics by dividing the country into 5 bioclimatic zones.[28] Sheep from the northernmost Sahelian zone averaged 75.7% seropositivity, a proportion that decreased to 0% in the southernmost Sudano-Guinean and sub-Guinean zones (Table 2). Similar analyses of 6 geological formations, 4 altitude ranges, 6 soil types, and 3 levels of sub-surface water revealed no relationships. The sole physical characteristic that correlated with our measure of CCHF virus seroprevalence was that which defined bioclimatic zones.

Because rainfall alone constitutes a principal determinant of the bioclimatic zones of West

TABLE 2

Prevalence of IgG antibodies against Crimean-Congo hemorrhagic fever virus among 937 sheep and 1,017 humans grouped into 5 bioclimatic zones in Senegal, 1986–1988

		Sheep		Human		
Bioclimatic zone*	Average annual rainfall (mm)	(n)	IgG prevalence (%)	Village	(n)	IgG prevalence (%)
Sahelian	200–450	37	75.7	Rosso	150	11.3
				Dagana	91	5.5
Sahelo-Sudanian	450–700	484	11.4	Dahra	106	4.7
				Yonofere	128	21.1
Sudanian	700–1,200	279	4.9	Bandia	93	3.2
				Tambacounda	84	1.2
Sudano-Guinean	1,200–1,400	96	0	Kedougou	225	0.9
Sub-Guinean	1,400–1,800	38	0	Ziguinchor	140	0.7

* Zones based on the classification of Ndiaye.[28]

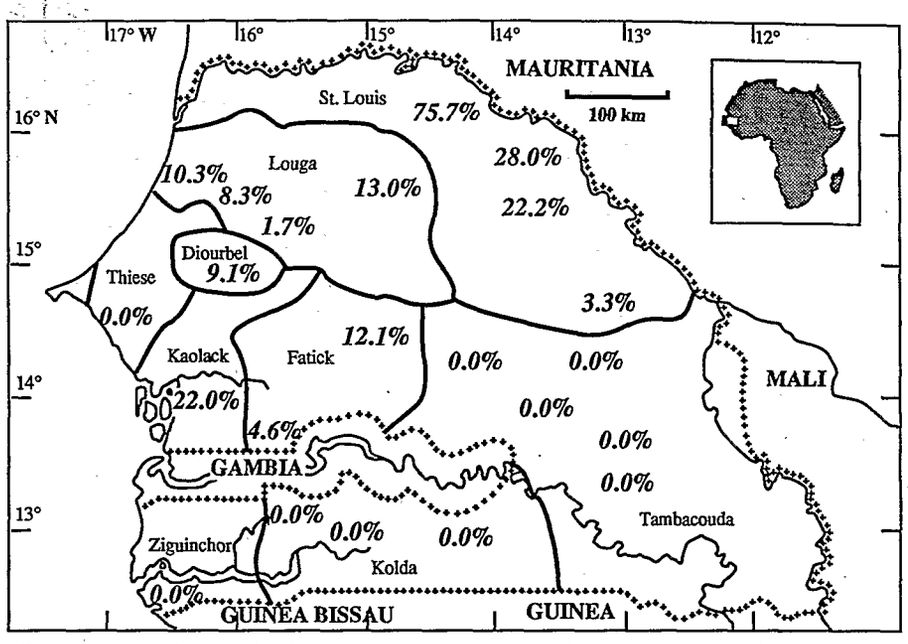

FIGURE 2. Map of Senegal showing the prevalence (in italics) of IgG antibodies to CCHF virus in sheep from 22 sample districts in 9 governmental regions.

Africa, we compared antibody prevalences with precipitation. Sheep were grouped according to the mean annual rainfall (100 mm ranges) of the village from which they were bled.[29] Antibody prevalence systematically increased as annual rainfall declined (Fig. 3). Within Senegal, increased precipitation correlated negatively with evidence of more active transmission of CCHF virus.

Human infection

Human IgG prevalence varied by as much as an order of magnitude among the villages sampled (Table 2). In northern sites along the Senegal River, 11.3% of people from Rosso and 5.5% of people from Dagana were seropositive. In the northcentral Sahel plains, 4.7% and 21.1% of residents from Dahra and Yonofere exhibited IgG, respectively. In Bandia, further south along the coast, 3.2% of adults tested showed evidence of previous infection. Low IgG prevalence was found in southern sites, including 1.2% in Tambacounda, 0.9% in Kedougou, and 0.7% in Ziguinchor. The prevalence of IgG was highest in the north and lowest in the south, a pattern that corresponded to that found in the sheep.

Spatial distribution of potential vectors

The predominant ticks sampled throughout the country were *Hyalomma* species, particularly in the north (Table 3). Indeed, *H. truncatum* was abundant throughout the northern sites, as was *H. m. rufipes* in north-central Senegal. In addition, *Rhipicephalus guilhoni*, considered synonymous with *R. sanguineus* before 1962,[30] was also abundant in the north. These ticks became progressively less abundant in the semi-arid Sudanian zone and the more humid habitats of the Guinean zone, being replaced by other *Rhipicephalus* species, *Boophilus* species, and *Amblyomma variegatum*. In general, each species of tick was relatively more abundant in only 1 or 2 bioclimatic zones.

DISCUSSION

The prevalence of IgG to CCHF virus in sheep varied among sites from high to none, indicating

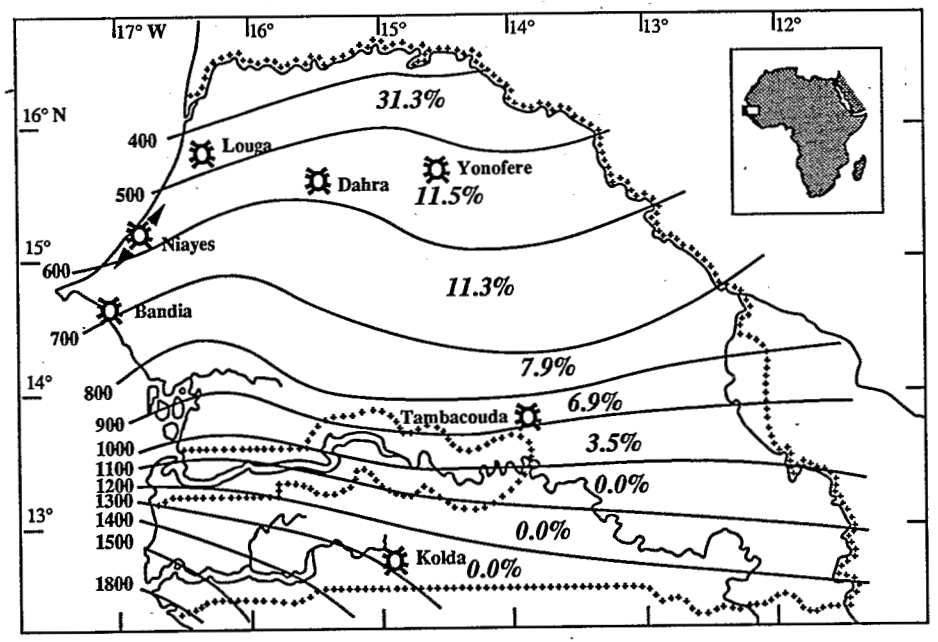

FIGURE 3. Average prevalence of IgG antibodies to CCHF virus in sheep from mean annual rainfall zones. Rainfall (in mm) is based on data from Leroux.[29] The 7 sites where abundance of ticks was estimated (results in Table 2) are indicated.

that transmission was either spatially focal or temporally sporadic. In some sites, IgG prevalence was such that half of all sheep could be infected during their lifetime. In other nearby villages, however, little evidence of recent virus activity was found despite apparent similarities in local ecology. We previously demonstrated a similar spatial heterogeneity in antibody prevalence to Rift Valley Fever virus.[31] Such variation among nearby villages may indicate that transmission was periodic or focal due to differences in vector abundance or infection rates. In general, antibody prevalence among sheep in our study was similar to average rates that have been reported from other sites in Africa.[2, 32]

Antibody prevalence increased with age and was similar for both rams and ewes in all regions. This suggests that transmission was enzootic. Our sample size was not large enough, however, to document epizootics retrospectively by analyzing the age distributions of antibody prevalence. That IgG was found in sheep of all ages in many governmental regions suggests endemic transmission throughout much of the country. Ewes were infected as frequently as were rams. CCHF virus appears to be enzootic, as each year the probability that sheep became infected increased.

Bioclimatic zones differed in the intensity with which CCHF virus was transmitted. Evidence of infection in sheep was greatest in the northern, arid, sparsely vegetated zone of Senegal and decreased consistently toward the southern, moister, forested zone. The negative correlation between prevalence of antibodies and average annual rainfall is consistent with that found in 1969 by Chunikhin and others.[4] That survey, which examined sera by the agar gel diffusion and precipitation test, reported seropositive rates for sheep of 5.8% (n = 512) in the Sahelian zone of Senegal, 1.4% (n = 70) in the northern Sudanian zone and 0% (n = 70) in the Guinean zone. A similar bioclimatic relationship has been observed elsewhere in Africa, Eurasia, and the Middle East: sites that experience the most intense CCHF virus activity tend to be relatively arid.[2] Transmission in Africa occurs primarily in savannah grasslands characterized by long dry

TABLE 3

Relative abundances of adult ixodid ticks on domestic sheep, cattle, and goats in selected sites and bioclimatic zones in Senegal

	Relative abundance in zones and villages†						
	Sahelian			Sahelo-Sudanian		Sudano-Guinean	
Tick species*	Dahra	Yonofere	Louga	Niayes	Bandia	Tambacounda	Kolda
H. truncatum	+++	+++		+++	+++	++	+
H. impeltatum	+++	+	+		+		
H. m. rufipes	+	+		++	++	+++	+
H. impressum				+	+		
H. dromedarii	•						
R. guilhoni	+++	+++	+++	+	+++		+
R. e. evertsi	•	+		+	+	+++	
R. sulcatus				+	+	•	+
R. senegalensis				+		•	
R. lunulatus						•	
R. muhsamae					+		
A. variegatum				+++	++	+	+++
B. decoloratus				+++	+	•	
B. geigyi							+++

* Genera are *Hyalomma, Amblyomma, Boophilus,* and *Rhipicephalus.*
† Very abundant, +++; moderately abundant, ++; rare, +; extremely rare, •; and absent (no mark). Based on our observations in Dahra, Yonofere, and Bandia and reanalyzed previously published data from studies by Gueye and collaborators for Louga,[23] Niayes,[27] Tambacounda,[24] and Kolda.[25]

seasons, where *Hyalomma* ticks abound. In Eurasia, areas dominated by deserts, semi-deserts, and steppes also support circulation of this virus. Climate influences the distribution and abundance of potential vectors[2, 3] which, in turn, affects the spatial pattern of CCHF virus transmission. However, bioclimatic zones also differ in other factors such as the presence and abundance of potential vertebrate reservoirs that may alter horizontal transmission. Similarly, the periodic, long-distance migration of domestic animals that occurs in drier parts of Africa might increase exposure to questing ticks, thereby elevating the prevalence of infection. To understand whether evidence of greater transmission in semi-arid zones is due to differences in the species diversity of vector ticks, suitable reservoirs, amplifying vertebrate hosts, or other variables will require further study.

Human seroprevalence varied considerably. In 4 northern Senegal villages, 5–21% of people showed evidence of previous CCHF virus infection. An antibody prevalence of ~3% was found in the central coastal site of Bandia. Only ~1% of people sampled from 3 southern sites were seropositive. Indeed, the 3 human cases of CCHF thus far recognized from this area of West Africa all occurred in either the Sahelian[19] or Sudanian[11, 15] bioclimatic zones. Human seroprevalence was generally lower than that of sheep, even though the average age for sheep was ~2 years. However, the spatial pattern of human seroprevalence varied in a manner similar to that of sheep. Presuming that human IgG remains detectable for many years, risk of infection among sheep appears to be greater than that for people. Because of their relatively short life-span as compared with that of humans, sheep may serve both as an index of recent transmission and of the spatial distribution of human risk.

Nomadic migration may have affected some of our results. Principally undertaken by certain young men in northern Senegal who herd their animals in search of food, such activity is irregular and occurs during only part of the year. Such movement by a small subgroup of the population, however, would not be likely to have a major influence on the observed spatial relations. Indeed, such migration, when it occurs, also involves sheep, whose risk of infection would be altered as well. The distribution of ticks, virus, or seroprevalence over the scale of tens of kilometers could be influenced by local migration. However, the size of the area that we studied as well as the robust trends observed are unlikely to have been affected by such movement.

No evidence of infection in sheep was found in southern Senegal where human seroprevalence was low. In regions where CCHF virus transmission is periodic and/or weak, human IgG prevalence may exceed that of these shorter-lived animals. Despite the absence of antibodies among

sheep in southern Senegal, low-level transmission was suggested by the presence of human antibodies, and by the previous results of Chuñikhin and others[4] showing 8.6% of cattle (n = 93) from that area with antibodies. Indeed, cattle may represent a more sensitive indicator of low level CCHF virus circulation, as they can be 10-fold more heavily infested by *Hyalomma* ticks than are sheep,[32] and, on average, they are longer-lived.

The tick vectors that maintain CCHF virus transmission in Senegal are unknown, although our results indicate that ≥1 *Hyalomma* species are important.[32] Results from other studies have suggested a correlation between *Hyalomma* tick abundance and virus transmission,[1] even though numerous species from 6 other genera have been shown to be infected.[3] Our study demonstrated a positive correlation between the spatial patterns of *H. truncatum, H. impeltatum,* and *H. m. rufipes* abundance, and that of IgG prevalence in humans and sheep. A similar relationship with *R. guilhoni* was also apparent. Although *A. variegatum* and other *Rhipicephalus* species were present where evidence of CCHF virus transmission was found, these ticks were most abundant in the central and southern sites where virus circulation appears less active. *Hyalomma* ticks predominated in areas where transmission to humans and sheep was most intense, and CCHF virus has been isolated in Senegal from those 3 species that were most abundant.[3] Thus, certain *Hyalomma* ticks are circumstantially implicated in the enzootic cycle. In addition, 4 species of 3 other genera have been shown to be infected in Senegal,[3] notably *R. guilhoni* and *A. variegatum.* Epidemic transmission may include some of these ticks. Controlled studies of horizontal and vertical transmission using native vertebrate hosts are needed to examine the actual role of each potential vector.

Human cases of CCHF are seen rarely in West Africa, enigmatic in that seroprevalences are at levels equal to or greater than that found in other regions of the world.[1, 2, 33–43] At least 23 primary human cases (10 fatal) have been documented in southern Africa since 1981,[42] while seroprevalence among people there was only 1.5%.[42] Hundreds of human cases have been diagnosed in the Soviet Union, yet antibody prevalence is similarly low.[2] The paucity of health care and of epidemiological surveillance throughout much of West Africa would suggest that many clinical cases of CCHF occur without diagnosis. Deaths in remote villages may go unreported or may be reported without etiology. Thus, underestimation of severe disease and fatalities could be considerable. Because CCHF virus appears to be weakly- or non-pathogenic to domestic ungulates, and is rarely diagnosed in humans, only large-scale epidemiological studies will expose the true intensity of virus circulation. More systematic, prospective serological studies and increased attention to the etiologic agent in hemorrhagic fever cases may reveal widespread transmission of CCHF virus and its true frequency as a cause of human morbidity and mortality.

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BOOKS REVIEWED

M.D.: One Doctor's Adventures Among the Famous and Infamous from the Jungles of Panama to a Park Avenue Practice, by B. H. KEAN with TRACY DAHLBY. XII + 402 pages. Ballantine Books, New York. 1990. $19.95.

I hate to tell people that I am a parasitologist because I always get the same responses. Most often the person I'm talking to changes the subject, since he probably has no idea of the functions of a parasitologist. The second most common response is, "It must be really fascinating to study ESP." Sometimes, the person has had a stool examination at one time, and thinks that parasitologists spend all their time looking at feces. These people usually ask me what made me decide to choose such an "interesting" career. I used to have trouble answering this question. Well, not anymore. Now I simply tell them to read Ben Kean's book.

I count myself among the 5,000 or so Cornell Medical School students who have heard Kean lecture on parasitology. Some teachers of parasitology give dense, detailed lectures about life cycles, epidemiology, symptomatology, and control. Not Ben Kean. He tells stories. Out of a 50 minute lecture period, he may tell anecdotes for 40 minutes and then show a life cycle and a few pathology sections just before the bell rings. But, he always makes his listeners so interested in the diseases that they then go home and learn the details from the textbook. As a student, I was enthralled by the picture he painted of a strange and primitive, yet critically important, field. It was during one of his lectures that I decided to become a parasitologist.

This book contains Kean's best parasite stories. He recounts in detail, for example, his experiences with an elderly uranium baron and his entourage (including a voluptuous blond mistress named "Baby") as the boss is purged of a tapeworm. And how he was caught by a female physician while watching a movie starlet gyrate nude in an attempt to make her ascaris dizzy. There are also fascinating medical detective stories, such as how he discovered the cause of an epidemic of trichinosis among telephone company employees and the cause of an epidemic of toxoplasmosis among medical students.

Kean's non-tropical adventures are equally amusing and interesting. There are wonderful sections about post-war Germany and about the Shah of Iran (his patient), which give a doctor's perspective on important historical events. He tells about his meeting with FDR to discuss whether sharks really ate downed airmen and his debilitating attack of turista just prior to his meeting with the Pope. And his stories about his famous patients, such as Salvador Dali, Oscar Hammerstein, Martina Navratilova, and Frank Loesser, are funny and touching (this chapter could have been entitled "Feces of the Rich and Famous").

Kean was born in Indiana and grew up in Greenwich Village. After finishing his medical training, he spent the war years as a pathologist at the Gorgas Memorial Laboratory in Panama and several years after the war in the U.S. military as a health officer in Germany. He returned to New York and began a double life as a physician on Park Avenue and a professor in academia. In both worlds, Kean has had a knack for adventure, and he has collected some truly fascinating and funny anecdotes in this book.

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