Spatial distribution of commensal rodents in regions with high and low Lassa fever prevalence in Guinea

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ABSTRACT. Lassa fever is a hemorrhagic fever caused by an arenavirus, which affects approximately 150,000 persons per year in West Africa. It is principally transmitted by rodents of the genus *Mastomys*, which serve as both reservoir and vector of the virus. This study tested the hypothesis that human Lassa fever in Guinea is related to the occurrence rate of the multimammate rat, *Mastomys* spp, inside houses. The analysis was based both on Lassa virus antibody surveys in the human population and the commensal rodent distribution in the same prefectures. The analysis took into account several data sets compiled from the literature (Lukashevich et al., 1993; Demby et al., 2001) and data from our own ongoing rodent trapping activities in Guinea. The analysis revealed a probable regional gradient of introduced rodent species in houses, with the black rat, *Rattus rattus*, predominating on the coast and the house mouse, *Mus musculus*, predominating approximately 200 km southeast to the coast. The autochthonous species, *Mastomys* spp, were present deep inside the country, from High to Forest Guinea. The regression analysis of *Mastomys* occurrence on human Lassa virus antibody prevalence showed a positive correlation in six administrative regional districts (prefectures) between an increasing *Mastomys* occurrence and increasing seroprevalence. A seventh prefecture, where mainly *M. musculus* occurred, was discordant with this trend, and possible explanations for this divergence are discussed. The partial replacement of *Mastomys* by other species, especially *R. rattus* and *Myomys daltoni*, is discussed as a potential explanation for the low-prevalence of Lassa fever in certain areas.

KEY WORDS : Lassa fever, risk, prevalence, rodent-borne disease, *Mastomys*, occurrence.

INTRODUCTION

Lassa fever is a hemorrhagic fever caused by an arenavirus, which affects approximately 150,000 persons per year in West Africa. In the Republic of Guinea, the activity of Lassa fever varies according to different geographical zones, as determined by human seroprevalence studies. In the northern and coastal regions human antibody prevalences are generally low (3 – 5%), whereas they may be as high as 40% in southern Guinea, close to the borders with Sierra Leone and Liberia (Lukashevich et al., 1993; Ter Meulen et al., 1996; Bausch et al., 2001).

The disease is principally transmitted by rodents of the genus *Mastomys*, the multimammate rats, which serve both as reservoirs and vectors of the virus (Salazar-Bravo et al., 2002), and they might be infected by up to 30% in Lassa-endemic areas (Monath et al., 1974; Keenlyside et al., 1983; McCormick et al., 1987; Demby et al., 2001). Lassa antibodies have been detected in a small number of other rodent species; however, Lassa virus has rarely been isolated from other genera (Wulff et al., 1975; Demby et al., 2001) The primary human infections occur in villages, particularly in houses infested by many rodents belonging to this genus as noted by Keenlyside et al. (1983) and McCormick et al. (1987) in Sierra Leone. The principle modes of infection are thought to be exposure to highly infectious urine of chronically infected rodents (rev. in McCormick, 1999) and the direct handling of animals captured for human consumption (Ter Meulen et al., 1996).

Some species such as *M. erythroleucus*, *M. huberti* and *M. natalensis* are distributed in West Africa (Brambell & Davis, 1941; Duplantier et al., 1990; Britton-Davidian et al., 1995; Granjon et al., 1997). Their presence has also been confirmed in Senegal (Duplantier et al., 1990) and in Mali (Granjon, pers. com.). As their precise identification is difficult, the multimammate rats recently investigated in our study for Lassa virus and antibodies in Guinea were classed as *Mastomys* spp. according to Demby et al. (2001) in order to avoid false identifications.

We hypothesised that a high occurrence of *Mastomys* in houses is a possible risk factor of human Lassa fever. To this end, we performed a combined analysis of the literature data and our own data generated during ongoing ecological and genetic studies on commensal rodents to evaluate the eco-epidemiology of Lassa fever in Guinea.

MATERIAL AND METHODS

Background on Lassa virus activity in humans

From 1990 to 1992, Lukashevich and his collaborators conducted a large epidemiological survey of Lassa virus activity in human populations in the Republic of Guinea (LUKASHEVICH et al., 1993). They sampled 25 villages, distributed in different prefectures and established the Lassa virus antibody prevalences based on ELISA. Their results are shown in table 1, where the mean seroprevalences by prefecture were calculated.

TABLE 1

Prevalence of Lassa Virus-specific antibodies by prefecture in Guinea. Adapted from LUKASHEVICH et al., 1993.

Prefecture	Prevalence in % (N°positive/N°tested)
Kindia (Madina Oula)	34 (59/171)
Boffa	4 (6/160)
Boké	5 (5/102)
Pita	6 (10/165)
Labe	7 (8/111)
Mali	5 (9/176)
Faranah	35 (149/420)
Siguiri	11 (45/418)
Guékédou	37 (226/604)
Yomou	27 (119/441)
Lola	28 (102/358)

Background on rodent community

From 1996 to 1997, a team from the Centers for Disease Control (CDC), Atlanta, tested rodent populations in different regions of Guinea for the presence of Lassa virus and antibodies (DEMBY et al., 2001). They investigated 26 villages, distributed in different regions which partially overlap with those of Lukashevich. They captured rodents at 444 house sites and 7 bush sites. As the major part of the rodent collection was made in houses, we considered their results as mainly commensal rodents. Table 2 gives the occurrence rate of *Mastomys*, *Rattus* and *Mus* (percent of total captures) in their trapping. To be concordant with the human data, the rodent data are partitioned by prefecture. In the Kindia prefecture, DEMBY et al. (2001) sampled both the town (60,000 inhabitants) and three villages belonging to the Madina Oula district. To account for the bias of the high occurrence of *Mus musculus* in large towns (DUPLANTIER et al., 1991; DUPLANTIER et al., 1997), the correlation analysis was performed without the data from Kindia town.

TABLE 2

Occurrence of the three main commensal species in villages by prefecture in Guinea, adapted from DEMBY et al., 2001. * Data from Kindia prefecture showing the captures from the town itself were excluded, see text for explanation.

Prefecture	*Mastomys* spp.	*Rattus rattus*	*Mus musculus*
Kindia*	8 (24/295)	9 (26/295)	81 (240/295)
Faranah	94 (271/289)	0	0
Kissidougou	92 (71/77)	8 (6/77)	0
Guékédou	94 (505/536)	5 (25/536)	0
Yomou	94 (505/536)	5 (25/536)	0
Lola	94 (505/536)	5 (25/536)	0

An additional data set obtained from Kedougou in southeastern Senegal by BA (2002) was included in the map presentation. From July 1998 to April 2001, the captures in houses were mainly composed by *Mastomys* spp. (90%; 380/432) and *R. rattus* (9%; 38/432).

Own data on rodent community

Some rodents were collected in houses, distributed in 3 villages on the coastal region, Bamba (10°00'N, 13°53'W, 20 m a.s.l., ±650 inhabitants) and Yafraya (10°05'N, 13°40'W, 20 m a.s.l., ±1600 inhabitants) in October 2002, and Gayebombo (10°08'N, 13°35'W, 86 m a.s.l., ±80 inhabitants) in May 2003. The rodents were trapped with BTS and Ugglan traps in 3-days sessions during October 2002 and with Sherman traps during May 2003. Between four and six traps were set at 30 households. The location of traps was partly directed by the household and variation in building structures. Usually, two traps were set by room, e.g. bedroom, corridors, food storage, or an external kitchen and were baited with a mixture of peanuts, dried fish and wheat flower. Thirty houses were sampled with a total of 456 trap-nights.

In May 2003, an additional village in the Fouta Djallon, Gagal (11°05'N, 12°17'W, 1050 m a.s.l., ±760 inhabitants) was similarly sampled using Sherman traps, where 16 houses were sampled, giving 210 trap-nights.

Data analysis

The analysis proposed here is the combination of data compiled from 1) the human prevalence based on the paper of Lukashevich, 2) the commensal rodent community based on the paper of Demby and 3) our own data based on two recent rodent trapping sessions. To access to the correlation between human Lassa virus prevalence and *Mastomys* occurrence, a simple linear regression analysis was used with the dependent variable being the human prevalence and the independent variable being the *Mastomys* occurrence. Seven prefectures entered into the regression, which was performed with Statview 5, SAS Institute Inc. (1998).

RESULTS

Commensal rodents on the coast and in the Fouta Djallon

The distribution of the commensal rodents according to each sampled village showed that on the coast, *Rattus rattus* was very abundant in large villages such as Bamba and Yafraya, whereas *Mastomys* spp remained the only species in small villages such as Gayebombo (Table 3). To include these data in the analysis, the *Mastomys* occurrence was calculated by combining the collection of the three coastal villages, indicating that *Mastomys* comprised 25% (15/61) of the rodent community. In Fouta Djallon, the *Mastomys* community in houses was 45% (4/9), with the majority of captures identified as *Myomys daltoni*.

TABLE 3

Trapping results from the coastal (Boffa and Dubreka) and the Fouta Djallon (Pita) regions in Guinea. Bamba and Yafraya were sampled in October 2002 whereas Gayebombo and Gagal were sampled in May 2003.

Prefecture	Village	*Mastomys*	*Rattus*	*Myomys*	*Praomys*	*Cricetomys*	*Mastomys* occurrence
Boffa	Bamba	3	20	0	1	0	25% (15/61)
Dubreka	Yafraya	0	24	0	0	1	
	Gayebombo	12	0	0	0	0	
Pita	Gagal	4	0	5	0	0	45% (4/9)

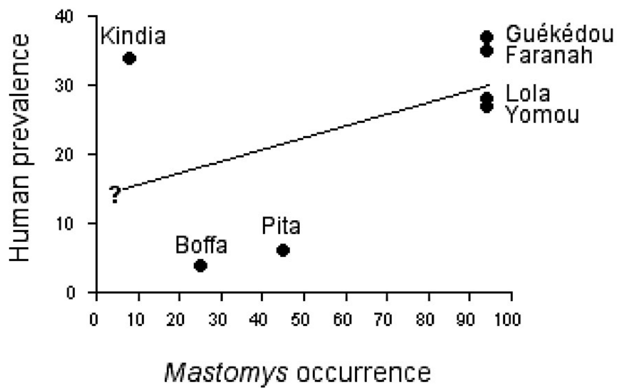

Fig. 1. – Linear regression of percent *Mastomys* occurrence and percent human Lassa seroprevalence in seven prefectures in Guinea. The question mark is related to the unknown epidemiological situation when the *Mastomys* occurrence is null.

Human seroprevalence related to Mastomys occurrence

The regression analysis showed a non-significant coefficient ($r^2 = 0.226$, $p = 0.280$) when the seven prefectures were included (Fig. 1). However, the regression was significant ($r^2 = 0.904$, $p = 0.004$) when Kindia was excluded from the analysis. These results were mapped, indicating missing data related to human seroprevalence or commensal rodents (Fig. 2).

DISCUSSION

Our study on commensal rodents in coastal Guinea and in the Fouta Djallon, combined with the data of Demby, showed that there could be a gradient of introduced species such as *Rattus rattus* and *Mus musculus*, from the coast to the highlands. It is, therefore, suggested to survey inside the country, from the Fouta Djallon to Forest Guinea, to observe autochthonous species such as *Mastomys* spp. and *Myomys daltoni* in households. A *Rattus rattus* gradient has been described by Duplantier et al. (1991, 1997) in Senegal, particularly on the axis between Casamance and the Southeastern region near Kedougou. It is suggested that *R. rattus* is moving further inland with humans and increasing its prevalence with increasing transportation activity and improved infrastructure.

The hypothesis that the Lassa fever risk is directly correlated to the magnitude of the occurrence of *Mastomys* spp. inside houses was partially verified in our analysis. This is also supported by the studies performed in the Tongo Field area in Sierra Leone where 26% (248/953) of humans were Lassa antibody positive and *Mastomys* spp. constituted approximately 80% (311/383) of the captures (Keenlyside et al., 1983). However, this correlation was not observed in the prefecture of Kindia, where three rural villages (Madina Oula, Kagbele and Dar es Salaam) had a high human prevalence of Lassa antibodies (34%) and a low occurrence of *Mastomys* spp. (8%). One explanation for this contradiction could be due to the fact that a Lassa fever outbreak occurred in this region in 1982-83, leading to 137 deaths (Boiro et al., 1987). The majority of these cases may have originated from human-to-human transmission from the potential introduction of a highly infectious Lassa virus variant. It is, therefore, possible that a high percentage of survivors could still be seropositive in the absence of Lassa virus infected *Mastomys* in the houses. Alternatively, *Mastomys* might have been replaced by *M. musculus*, between the occurrence of the epidemic in the 80s and the study performed by Demby more than 10 years later. This could be due to the intense population movements and traffic between the two countries, particularly during the civil war in Sierra Leone from 1991 to 2002. In such a situation, we can predict that the Lassa fever risk in the Madina Oula zone will decrease if *M. musculus* persists in colonizing the households. It is also possible that contact with infected rodents does not take place in houses but in the fields and bush during hunting of *Mastomys* and other rodents as a food source (Ter Meulen et al., 1996). It is expected that our ongoing investigations will help to understand the eco-epidemiology of Lassa fever in regions with a low prevalence of *Mastomys* spp.

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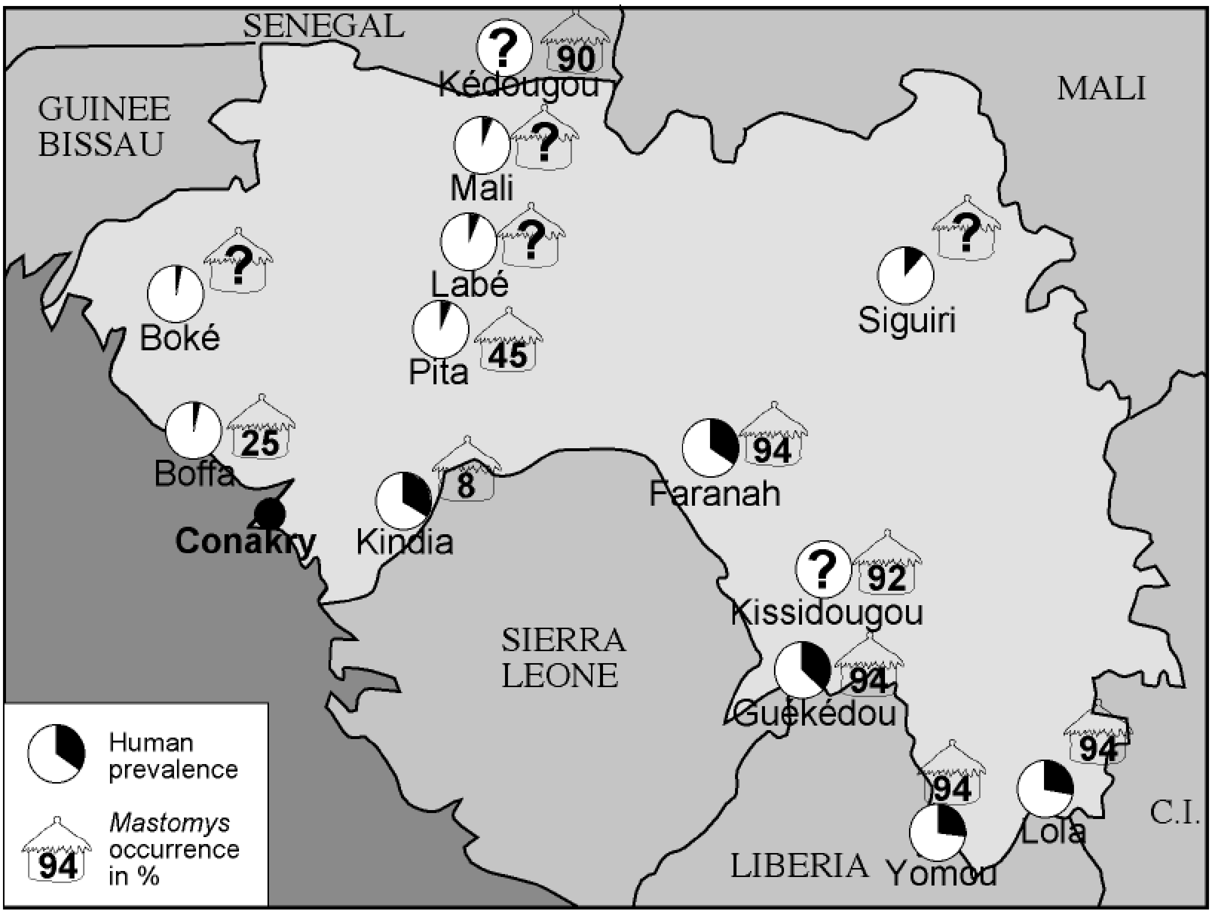

Fig. 2. – Distribution of Lassa virus human prevalence and *Mastomys* occurrence by prefecture in Guinea.

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