

Impact of the development of agricultural land on the transmission of sleeping sickness in Daloa, Côte d'Ivoire

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Although tools to control sleeping sickness do exist, their use is difficult; areas where intervention is most required often cannot be targeted for lack of appropriate risk indicators. The importance of human behaviour and habits in the manifestation of the disease is clear. In the development of effective new approaches to the control of the disease, information must be gathered about human populations, and their interaction with the environment, in rural as well as in urban and peri-urban areas. The results of a study carried out in Daloa show that use of some methods for the development of agricultural land leads to increased human-vector contact and, as a result, increased risk of sleeping sickness. Such land-management methods may therefore be useful as risk indicators for transmission. Transmission does not occur in the town of Daloa itself but in surrounding areas under cultivation. The use of the epidemiological risk index seems to be inappropriate in urban (and perhaps peri-urban) areas. The results emphasise not only the importance of environmental and demographic data in elucidating the epidemiology of human trypanosomiasis but also the need for further investigations in peri-urban areas.

Today, there is no accepted method of identifying risk areas for human African trypanosomiasis. It is partly because of the lack of appropriate risk indicators that nobody seems to know where, when or according to which strategy the tools available for control of this disease should be used. It is now clear that human behaviour and habits play a significant role in the occurrence and continued transmission of sleeping sickness (Laveissière and Hervouët, 1991). Land management creates new interactions between human populations, the environment and the vectors of the disease. The existence of the disease in an area may demonstrate the local community's

difficulty in managing its land in the most appropriate manner.

In Côte d'Ivoire, human trypanosomiasis is now associated with the cultivation of cash crops; production of these crops has led to forest degradation and large numbers of immigrants from the neighbouring countries of Burkina Faso, Ghana, Guinea and Mali. In the late 1970s, most cases of human trypanosomiasis were detected in the Centre West region (since divided into the Marahoué and Haut Sassandra regions), where about 2 million people (15% of the whole Ivorian population) now live. The results of population-based studies indicate that transmission of *Trypanosoma brucei* s.l. may be possible around some towns such as Daloa, Sinfra,

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Bonon, Aboisso and Ayamé (J.-P. Hervouët, unpubl. obs.). The records of the health facilities in Daloa show that the disease appeared in the town itself during the 1930s, and that cases are still being detected (unpubl. obs.). Daloa is the third largest town in Côte d'Ivoire and the urban centre of the region. It has about 160 000 inhabitants, almost 90% of whom are from outside the region. As around many African towns (Fleury and Moustier, 1999), the development of agricultural land around Daloa is important. Daloa is surrounded by coffee and cocoa plantations, whereas irrigated rice cultivation and market gardening are concentrated along the small river tributaries within the town boundaries. Agricultural activities trigger daily movements of the population between the town and its outskirts, favouring contact with tsetse flies (which may exist everywhere in the forest areas) and thus infection with trypanosomes. A variety of social conditions, *inter alia* increasing insecurity, induces planters and their families to settle in the town rather than close to their crops.

The main purpose of the present study was to identify where *T. brucei* s.l. is transmitted to human populations in and around Daloa, in order to determine whether development of agricultural land within the boundaries of the town and on its outskirts is conducive to the risk of human trypanosomiasis. Should this be so, those agricultural activities and land-management methods which lead to the greatest risk might be identified and used as indicators of areas that should be targeted for control. It was hoped that the study and examination of case reports dating back 40 years would reveal whether the town is a persistent focus of the disease and/or whether the presence of the disease is linked to interactions between the town and its periphery.

MATERIALS AND METHODS

Study Area

The study area was the town of Daloa and the surrounding, peri-urban area in which its in-

habitants carry out agricultural activities (called the 'area of mobility'). Eight peripheral villages, at the most 9.5 km from the centre of the town, and the leprosy hospital (*léproserie*) 5 km from the centre of Daloa were included in the peri-urban area (Fig. 1). Since 1956, >30 cases of sleeping sickness have been detected among the patients and their families at the leprosy hospital. [These cases have been attributed to the leprosy hospital's proximity to the region's trypanosomiasis hospital and the presence of tsetse flies between them (unpubl. obs.).]

Epidemiology

A retrospective survey was carried out in order to identify the population at risk of trypanosomiasis in the study area. This was based on the medical records of the health facilities in the study area, for the period from 1956 to 1995. Only the records for patients who indicated Daloa, one of the eight peripheral villages in the study area or the leprosy hospital as their place of abode were included in the study. Whenever possible, these patients were followed-up and interviewed about their activities during the years before they developed trypanosomiasis. If they had been engaged in agriculture during this period, the exact locations of their fields were determined using a global positioning system (GPS), so that they could be mapped. The available maps, at scales of 1:10 000, 1:20 000 and 1:50 000, and aerial photographs taken in 1958, 1971, 1991, 1992 and 1996 were used to give better topographies of the town.

The results were analysed in comparison with data from the national census of 1988. The ethnic origin of the study patients was established in accordance with the Ivorian classification. The indigenous people of the Daloa region belong to the Krou group, and more specifically to the Bete subgroup. Although 'Dioula' tends to refer to religion and commercial activity rather than to ethnic origin, the Ivorian classification includes this subgroup within the Mande group. Investigations have shown that many of the Senoufo (Volta group) patients were incorrectly regis-

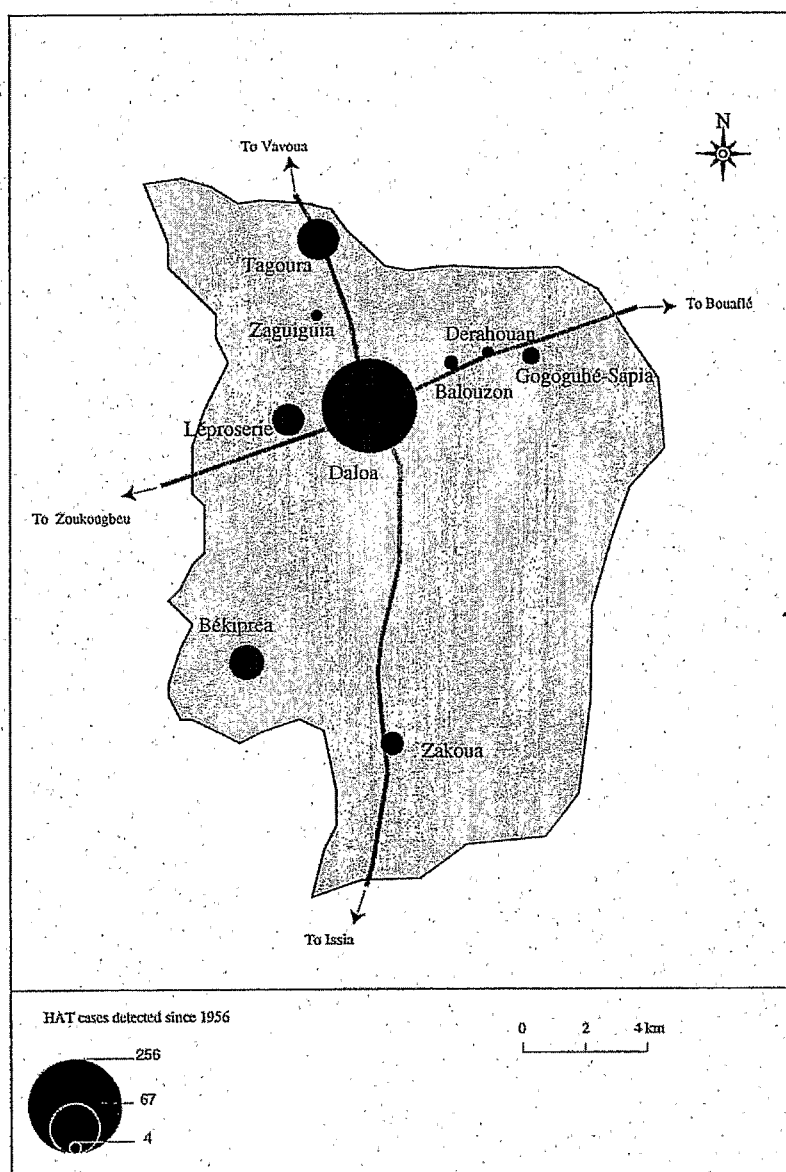


Fig. 1. Daloa and the peri-urban area, showing the peripheral villages, leprosy hospital (*léproserie*) and 'area of mobility' (■) investigated and the numbers of cases of human African trypanosomiasis (HAT). The villages of Gogoguhé and Sapia are too close to be shown separately on a map of this scale.

tered as Dioula and then included in the Mande group, either because of their own first declaration or because of an erroneous in-

terpretation by the health staff. Such errors undermine the accuracy of the estimates of the incidence of the disease in each ethnic group.

Entomological Survey

An entomological survey was carried out between April 1997 and February 1998. Tsetse flies were caught using Vavoua traps (Laveissière and Grébaut, 1990). In each, 4-day, trapping session, 133 of these traps were distributed throughout the area: 33 in the town; 26 in the peripheral villages and leprosy hospital; and 74 elsewhere in the 'area of mobility'.

The exact locations of the traps were selected in accordance with environmental and human criteria, and were registered with a GPS in order to map the results. Traps were set on tracks, at water-supply points, in coffee and cocoa plantations, rice fields and market gardens or by fish ponds established along the urban watercourses. Trapped flies were collected daily between 14.30 and 17.30 hours, counted and sorted according to species and sex. Only the *Glossina palpalis palpalis* (Robineau-Desvoidy, 1830) were dissected. Apparent density by trap (ADT) was expressed as the number of flies caught per trap per day. Physiological age was determined using the technique of Challier (1965) and survival rates were calculated according to Challier and Turner (1985). Midguts of the dissected flies were examined for *Trypanosoma*, under a stereoscopic microscope.

Bloodmeals were collected on Whatman No. 1 paper and stored in a dry atmosphere until analysis by isoenzymatic electrophoresis (Diallo *et al.*, 1997); this method allowed human bloodmeals to be distinguished from those of other animals and the intensity of the human-vector contact to be evaluated. Separate epidemiological risk indices (ERI; Laveissière *et al.*, 1994) were calculated for the town, the villages/hospital and the area of mobility.

RESULTS

Population at Risk

Between 1956 and 1995, 417 cases of sleeping sickness were recorded by the health facilities among the residents of the study area. There were, in general, about 10 cases recorded annually, but an epidemic produced about 100 cases between 1967 and 1969 (Fig. 2). The numbers of cases seemed to decrease from 1985, particularly in the peripheral villages, where no cases have been detected since 1993.

Of 417 cases analysed, 60% lived in the town, 63.7% were aged < 30 years and 65.7% were male (Fig. 3). The risk of trypanosomiasis did not seem to vary according to ethnic origin. Only 20% of the cases occurred among the Bete (Krou group), 48% of the cases belonged to the Mande group (almost all

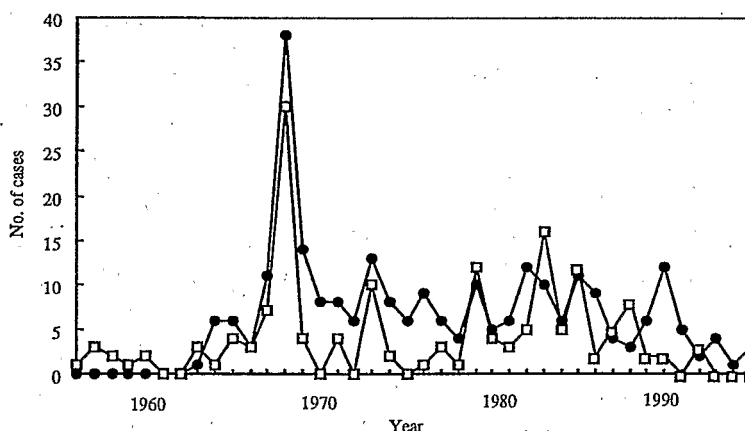


Fig. 2. The annual numbers of cases of human African trypanosomiasis recorded between 1956 and 1995 in Daloa (●) and its outskirts (□).

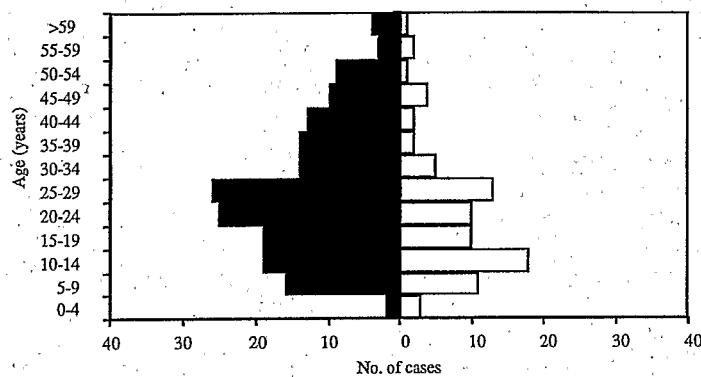


Fig. 3. Distribution of the male (■) and female (□) cases detected between 1956 and 1995, according to their age.

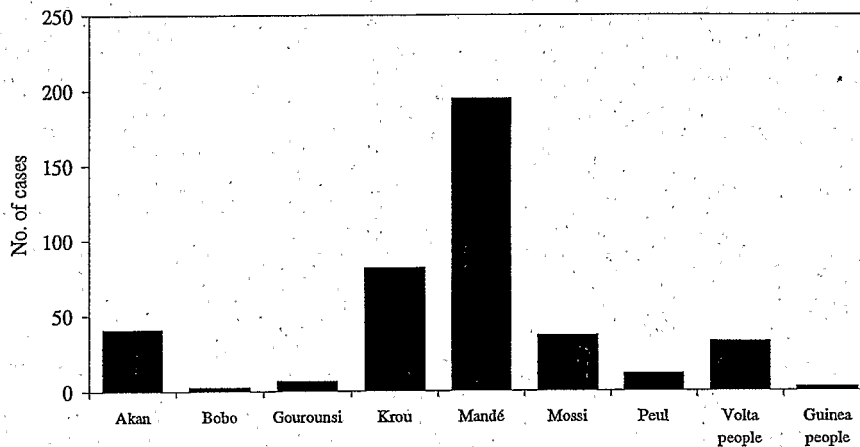


Fig. 4. Ethnic origins of the cases detected between 1956 and 1995.

Dioula), 7.4% to the Senoufo (Volta group) and 8.8% to the Mossi (Fig. 4). The non-Krou were immigrants from the north of the country and from neighbouring countries, mainly Burkina Faso and Mali. [According to the 1988 census, the population of Daloa was 13.1% Bete, 39.3% Dioula, 5.1% Senoufo and 7.1% Burkinabe (mostly Mossi).]

Investigation of the cases detected between 1982 and 1995 showed that 80% of them were engaged in an agricultural activity (57.6% in coffee and/or cocoa plantations and 23.7%

in irrigated rice fields) before the onset of disease. These activities took place near the peripheral villages and elsewhere in the area of mobility, but not inside the town.

Distribution and Dynamics of the Tsetse Population

Approximately 33 000 *G. p. palpalis*, the main vector of human trypanosomiasis in the forest area, were caught but only 3.1% were collected in the town. The mean ADT for this subspecies were 1.1, 10.1 and 11.9 in the

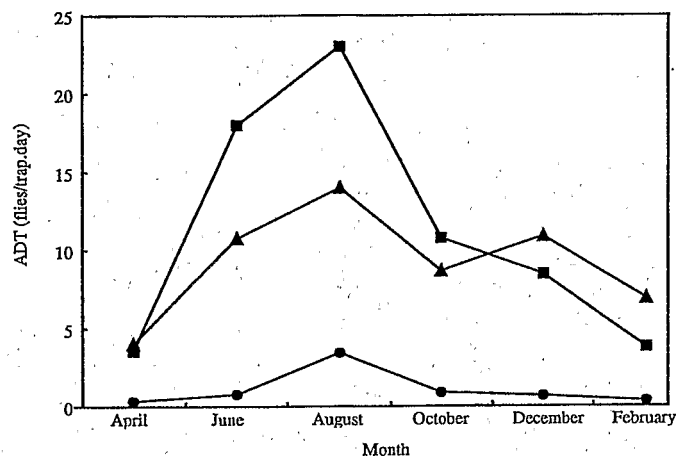


Fig. 5. Monthly variations in mean apparent densities by trap (ADT) of tsetse flies in the town (●), the peripheral villages/hospital (▲) and elsewhere in the 'area of mobility' (■).

town, peripheral villages/hospital and elsewhere in the area of mobility, respectively. The monthly variations in catch sizes were insignificant in the town but were more pronounced at the other collection sites (Fig. 5).

The highest ADT were observed along an east-north-east-west-south-west axis, which corresponds to the highest human population densities (Fig. 6). Presence of flies was associated with that of coffee and cocoa plantations, tracks and water-supply points. Few or no flies were caught in the vicinity of the urban watercourses.

The mean ERI were 0.00015 in the town, 0.02355 in the villages/hospital and 0.10824 in the area of mobility. The highest ERI observed (0.48887) was in June in the area of mobility (Fig. 7). In the villages/hospital and in the town, the maxima were reached in August, with values of 0.06443 and 0.00206, respectively. In the villages/hospital and the area of mobility, the risk appeared to be associated with high levels of human-vector contact. In the town, however, the risk was associated with high numbers of teneral female tsetse (data not shown).

Trypanosomes (presumably *T. brucei* s.l. or *T. congolense*) were observed in 11.4% of the dissected midguts.

DISCUSSION

Although sleeping sickness tends to be considered a rural disease, it has been described in towns such as Bamako and Brazzaville (A. Challier, unpubl. obs.; Gouteux *et al.*, 1986). In Daloa, however, there appears to be no urban focus of transmission. The present ERI indicate that the risk of transmission exists on the periphery of the town, where the development of agricultural land is important and there are large numbers of agricultural workers. Since most of the cases were urban residents who travelled to the area of mobility and back each day, the ERI, an index initially developed for forest areas, may be an inappropriate indicator of disease risk in urban settings. The ERI does take some account of human mobility, in terms of human-vector contact. The high level of human mobility in Daloa, however, follows a totally different pattern from that observed in rural areas.

In most years there were only small numbers of cases recorded annually, although it is unclear what proportion of actual cases is recorded by the health services; there has been no active case detection in the study area since 1985. The predominance of males among the

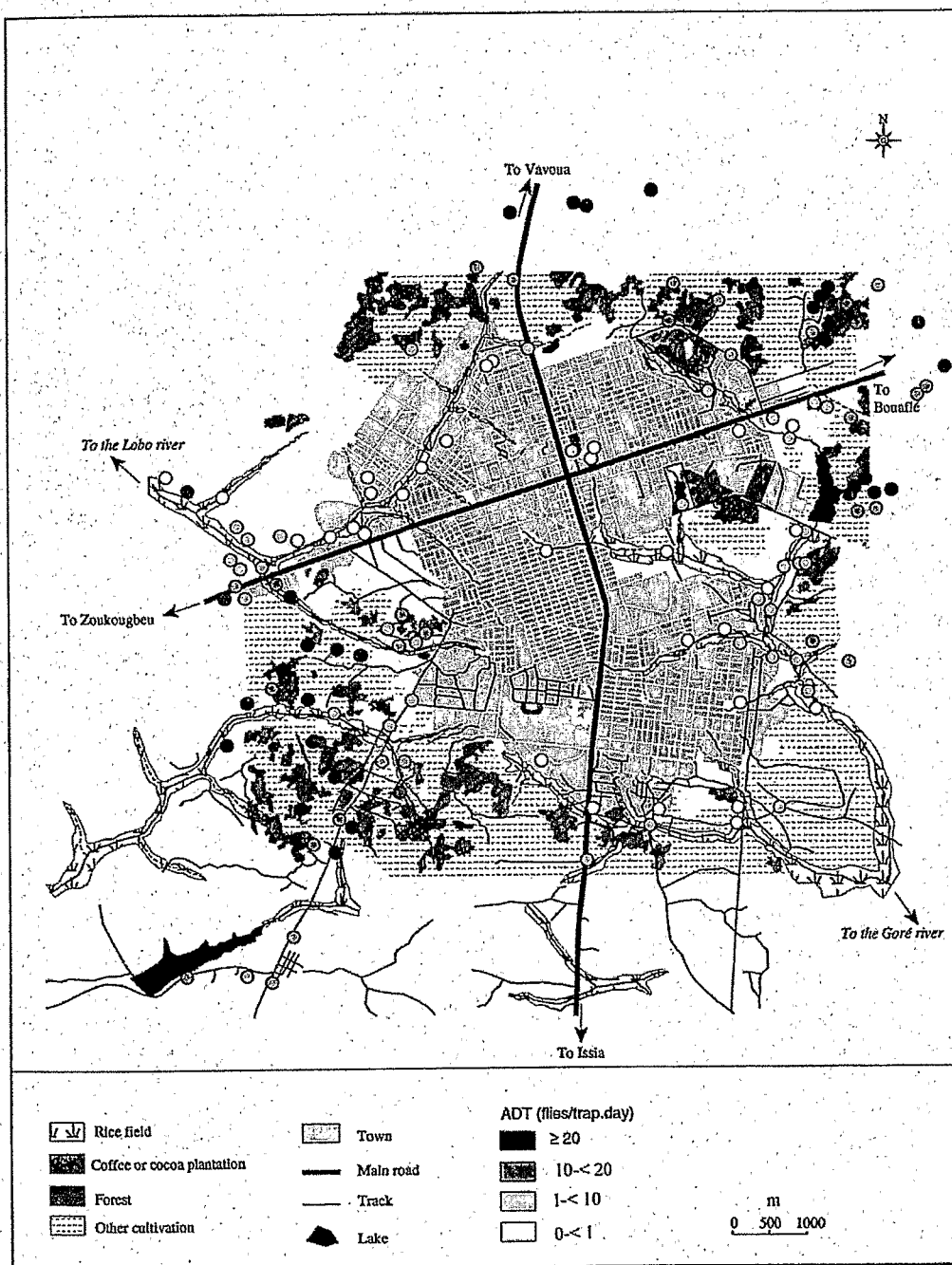


Fig. 6. Apparent densities by trap (ADT) of tsetse flies in Daloa and its outskirts.

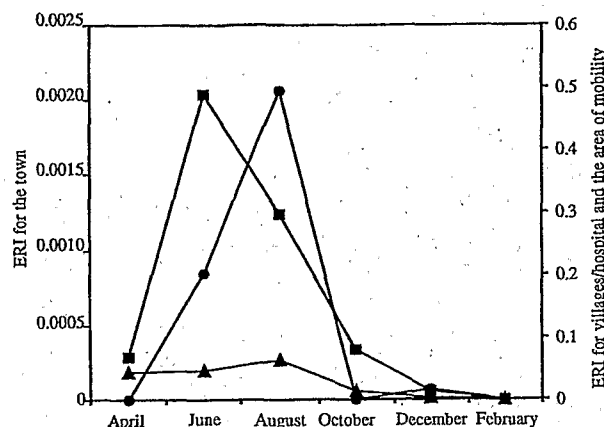


Fig. 7: Monthly variations in epidemiological risk indices (ERI) for Daloa town (●), the peripheral villages/hospital (▲) and elsewhere in the 'area of mobility' (■).

cases is probably a reflection of the largely male, agricultural workforce.

Human trypanosomiasis in Daloa and its environs seems to be associated with agricultural-land development. The risk of transmission was the highest during the harvest periods (June and December). Coffee and cocoa plantations, which presumably offer forest-like habitats for the tsetse, are associated with a greater risk than rice fields. Those infected in the rice fields were presumably bitten by infected tsetse living in the remnants of forest that border the urban watercourses. The fact that very few tsetse flies were caught along these watercourses indicates that current management of the banks is good. In other towns, such as Sinfra, where the banks of urban watercourses are not totally cleared, tsetse flies may be found in the residual vegetation (unpubl. obs.). The overall infection rate with trypanosomes in the *G. p. palpalis* dissected in the present study is lower than those generally observed in forest areas (McNamara *et al.*, 1995).

Comparison between the last 40 years' observations on trypanosomiasis in the study area and the current environment allows some observations. Forty years ago in the town, watercourses were not managed and vegetation was more abundant. The environment

within the town might then have been more favourable to the flies and thus to trypanosome transmission. However, there is no evidence of this in the present results: few cases were detected within the town before 1962, and since 1962 the annual numbers of urban cases have not shown the downward trend seen in the area of mobility. Urbanization has pushed the tsetse flies back to the town periphery but has not eliminated them. Their distribution correlates with that of the densest human populations on which they must feed, although, presumably, increasing urbanization will eventually drive them even further from the town centre.

Daloa is not a persistent focus of sleeping sickness. The presence of the disease is linked to interactions between the town and its periphery. Most of the cases identified in the present study have changed residence since their diagnosis. This made it impossible to identify a non-diseased, control population with a similar exposure history. However, since 80% of the cases were involved in agriculture, particularly in cash-crop plantations, it seems clear that some methods of land development constitute a health risk.

An understanding of the ecological relationship between human populations and their environment is essential in elucidating the epi-

demology of communicable diseases. Natural-resource development can have unexpected impacts, positive as well as negative, particularly in peri-urban regions, which can be considered as transitional areas (Mouchet and Carnevale, 1997; Birley and Lock, 1999). Use of geographical information systems (GIS) in the field of public health may improve our comprehension of the health status of populations (Mott *et al.*, 1995). The combination of GIS with remotely sensed data permits a change in scale and perspective and, in terms of sleeping sickness, perhaps a better and more useful assessment of the risk of trans-

mission. However, although Rogers *et al.* (1996) succeeded in predicting the distribution of tsetse flies using climatic and vegetation variables, the present results indicate that such analyses may not fully explain the epidemiology of sleeping sickness in urban areas.

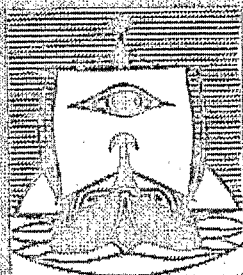
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REFERENCES

- BIRLEY, M. H. & LOCK, K. (1999). *The Health Impacts of Peri-urban Natural Resource Development*. Liverpool, U.K.: Liverpool School of Tropical Medicine.
- CHALLIER, A. (1965). Amélioration de la méthode de détermination de l'âge physiologique des glossines. Etudes faites sur *G. palpalis gambiensis* Vanderplank, 1949. *Bulletin de la Société de Pathologie Exotique*, 58, 250-259.
- CHALLIER, A. & TURNER, D. A. (1985). Methods to calculate survival rate in tsetse fly (*Glossina*) populations. *Annales de la Société Belge de Médecine Tropicale*, 65, 191-197.
- DIALLO, P. B., TRUC, P. & LAVEISSIÈRE, C. (1997). A new method for identifying blood meals of human origin in tsetse flies. *Acta Tropica*, 63, 61-64.
- FLEURY, A. & MOUSTIER, P. (1999). L'agriculture périurbaine, infrastructure de la ville durable. *Cahiers Agriculture*, 8, 281-287.
- GOUTEUX, J. P., NKOÛKA, E., NOIREAU, F., FRÉZIL, J. L. & SINDA, D. (1986). Les glossines de l'agglomération brazzavilloise. I. Répartition et importance des gîtes. *Revue d'Élevage et de Médecine Vétérinaire dans les Pays Tropicaux*, 39, 355-362.
- LAVEISSIÈRE, C. & GRÉBAUT, P. (1990). Recherches sur les pièges à glossines (Diptera: Glossinidae). Mise au point d'un modèle économique: le piège 'Vavoua'. *Tropical Medicine and Parasitology*, 41, 185-192.
- LAVEISSIÈRE, C. & HERVOUËT, J. P. (1991). *La Trypanosomiase Humaine en Afrique de l'Ouest. Épidémiologie et Contrôle*. Paris: Institut de Recherche pour le Développement (ORSTOM).
- LAVEISSIÈRE, C., SANÉ, B. & MÉDA, A. H. (1994). Measurement of risk in endemic areas of human African trypanosomiasis in Côte d'Ivoire. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 88, 645-648.
- MCMANARA, J. J., LAVEISSIÈRE, C. & MASIGA, D. K. (1995). Multiple trypanosome infections in wild tsetse in Côte d'Ivoire detected by PCR analysis and DNA probes. *Acta Tropica*, 59, 85-92.
- MOTT, K. E., NUTTALL, I., DESJEUX, P. & CATTAND, P. (1995). New geographical approaches to control some parasitic zoonoses. *Bulletin of the World Health Organization*, 73, 247-257.
- MOUCHET, J. & CARNEVALE, P. (1997). Impact des transformations de l'environnement sur les maladies à transmission vectorielle. *Cahiers Santé*, 7, 263-269.
- ROGERS, D. J., HAY, S. I. & PACKER, M. J. (1996). Predicting the distribution of tsetse in West Africa using temporal Fourier processed meteorological satellite data. *Annals of Tropical Medicine and Parasitology*, 90, 225-241.

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