Our cousins chimpanzees and baboons face global warming by digging wells to filtrate drinking water

G. Galat, A. Galat-Luong, G. Nizinski

IRD UR 60 CLIFA. BP 64501. 34394 Montpellier cedex. France.
Tel 33467636961. Fax 33467412138.
Gerard.Galat@ird.fr

Key words

Increasing dryness, Drinking water, Filtrated water, Wildlife, Chimpanzees, Baboons

Introduction.

Surface water is an essential source of life for mammals and higher vertebrates. Global warming and dryness restrict available water resources. In the African Sudanese climate, an annual rainfall deficit period, up to 350mm, began in the 1970' (Le Borgne, 1990; Michel, 1990; Lawson, 2005).

Objective.

How do Chimpanzees and other non human primates living in dry habitats face increasing dryness as water pools dry at the end of the dry season?

Methods.

Study site

The **study area** was the Tambacounda region, Eastern Senegal, including two main study sites, the Niokolo Koba National Park, with, outside of the Park, the Kédougou Department. It is the driest and the hottest long term chimpanzee study site.

The Niokolo Koba National Park is a protected area since 1954, now an UNESCO Mab Reserve. It covers 8,175 km^2 and is located by 12°40' at 13°20' N and by 12°30' at 13°20' W. The landscape includes three types of geomorphologic units: plateaus (which represent the dominant geomorphologic unit with 80 % of surface area), valleys and hills.

The **climate** of the region is dry tropical with mean annual rainfall of 1,076 mm $year^{-1}$ (Pi). The rainy season starts in May and ends in September; the mean annual potential evapotranspiration (Penman, 1948) is 2,114 mm $year^{-1}$ (E_p=5.2 mm day^{-1}), mean annual daily total radiation is 20.4 MJ day^{-1}, mean daily insulation is 7.9 hours, mean air temperature is 28.6 °C (T_{max}=35.2 °C, T_{min}=21.9 °C), air humidity is 56.3 % and wind speed is 122.3 km

day^{-1} (the long-term values estimated over the period of 1940-1998 and of 1989-1998 come from meteorological stations of Kédougou; 12°34' N; 12°13' W; and of Tambacounda, 13°46' N; 13°41' W) (www.fao.org/landwater/aglw/climat.stn). The highest place inside the Niokolo Koba National Park is Mount Assirick. Rainfall deficit over the recent years is increasing (Fig.1).

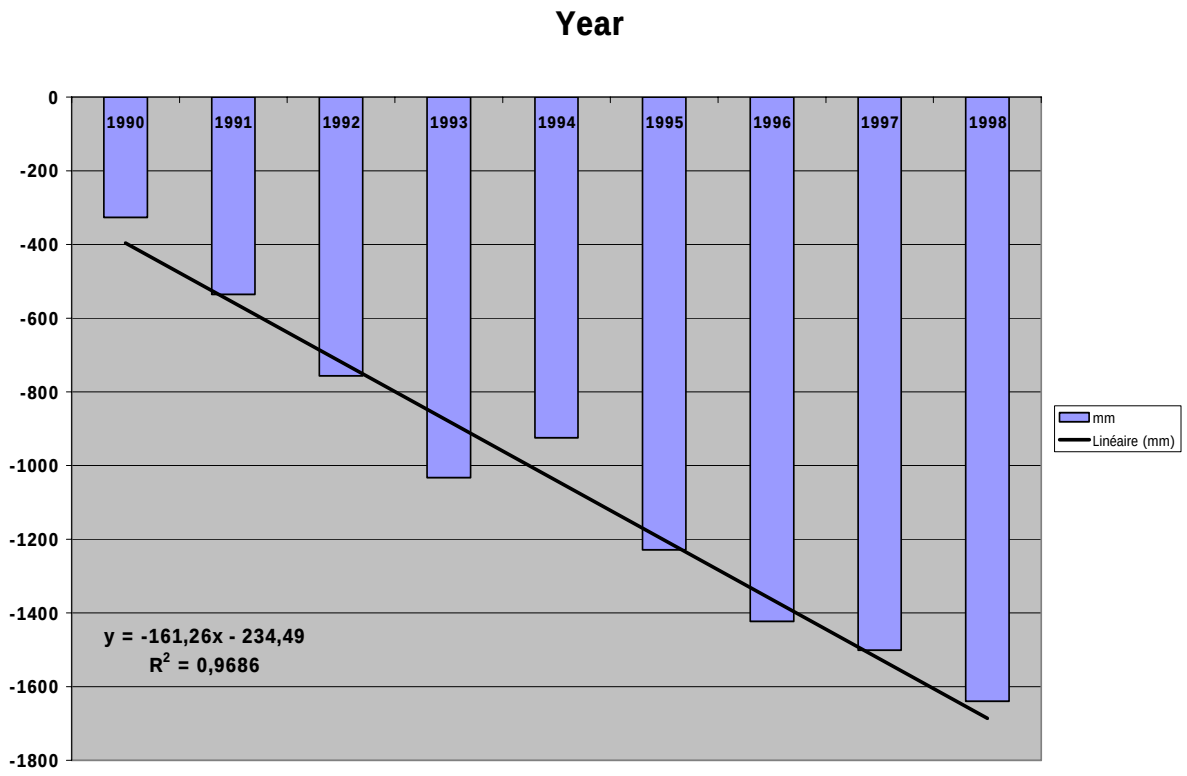

Figure 1. Cumulative rainfall deficit 1990-1998.
Data of the meteorological stations of Kédougou and Tambacounda.

The **vegetation** is the results of human (fires) and natural intervention (animal grazing). This action of man and animal grazing influenced more the aspect than the floristic composition of savannah (Schnell, 1977): from North to South, the tree canopy cover increases. The rivers are bordered by closed-canopy gallery forests and temporarily flooded savannah with a natural tendency to encroachment (an increase in density of woody plants often unpalatable to animals) becoming frequently visible.

The vegetation accounts for the transition between the bioclimatic zones distinguished by Trochain (1940) according to the annual rainfall (1931-1960) updates by Giffard (1974): Sudano-Sahelian (550-1000 mm of annual rainfall) in the North and Sudano-Guinean (950-1350 mm) in the South. A continuous herbaceous layer is strewn with trees and shrubs, with a vertical tree canopy projection onto the 1 ha soil surface ranging from 5 to 75 %. Le Houérou (1989) distinguished four types of savannah according to tree canopy cover: (1) « wooded savannah » with less than 5 percent of tree canopy cover; predominant woody species are *Combretum glutinosum* and *Combretum nigricans*; dominant herbaceous layer species are *Andopogon pseudapricinus, Hyperthelia dissoluta* and *Schizachyrium sanguineum*; (2) « wooded savannah » ranging from 5 to 25 percent of tree canopy cover; predominant woody species are *Afzelia africana* et *Pterocarpus erinaceus*; dominant herbaceous layer species are *Diheteropogon amplectens*, *Antropogon pseudapricus* and *Diheteropogon hagerupii;* (3)

« wooded savannah » ranging from 25 to 50 percent of tree canopy cover; predominant woody species are *Pterocarpus erinaceus, Terminalia macroptera, Erythrophleum africanum, Bombax costatum, Lanea acida, Combretum glutinosum* and *Hexalobus monopetalus*; dominant herbaceous layer species belong to *Antropogon* and *Pennisetum* gender; (4) « sparse woodland » with more than 75 percent of tree canopy cover; predominant woody species are *Pterocarpus erinaceus, Piliostigma thonningii* and *Anogeissus leiocarpus;* dominant herbaceous layer species belong to *Andropogon, Pennisetum* and *Hyparrhenia* gender.

Behavioural observations.

The chimpanzees *(Pan troglodytes verus)* of the Assirick site, the Niokolo Koba National Park and the Kedougou department have been studied since 1975:

- In 1975 and 1976 by G. Galat and A. Galat-Luong;

- From 1976 to 1979 by the Stirling African Primate Project, SAPP (McGrew, Baldwin, Tutin, 1981);
- From 1988 to 2002 again by A. Galat-Luong and G. Galat;
- and since 2000 by the Miami Assirik Pan Project, MAPP (Pruetz, Marchant, Arno *et al*., 2002).

Total duration of chimpanzee observation in South Eastern Senegal is now 39 years.

In 1975 and 1976, and from 1988 to 1999, we followed groups of chimpanzees and baboons living inside and outside the Niokolo Koba national Park in the Kedougou department, Senegal, and recorded water related behaviours and indices.

Biochemicals.

Additionally, comparative blind tests of water samples drink ability were made by an independent ratified laboratory.

Results.

The first time we saw non human primates digging holes and drink the filtrated water they get inside these wells was in 1988, while observing baboons resting and socializing on a sand beach of the Gambia River near the Kédougou cliffs. It is the only one record of this behaviour we made during the 1975-1994 surveys. As the river's water was gently flowing, unfiltered water was not putrid.

In contrast with the 1975-1994 surveys, those carried in the 1995-1999 period revealed that chimpanzees and baboons frequently dig wells in river basins during the dry season. We recorded Chimpanzee digged wells inside the Niokolo Koba National Park, near the Assirick river, and outside the Park, in the Fongolembi arrondissement of the Kédougou department. The distance of the most distant chimpanzee wells sites is c.a. 100 km. We found the wells digged by baboons only in the Mansa Fara – Assirick Area, inside the Niokolo Koba National Park. The distance of the most distant baboon wells sites is about 20 km.

The wells are hand dug holes localized in fine sand zones less than 2m far from stagnant water puddles (figure 2). The water in the wells is therefore filtrated by the surrounding sand (figure 3). Indices of animals access to water were only found around the wells dug in the sand, not near the stagnant water puddles. The water of the wells was clear and limpid, contrasting with the stagnant water of the natural puddles. Some wells dug by chimpanzees were dug with wood sticks used as "tools" (figure 4).

Figure 2. Wells hand digged in the sand near stagnant water.
Photos © Anh Galat-Luong IRD.

Figure 3. Filtrated water in wells hand digged in the sand.
Photos © Anh Galat-Luong IRD.

Figure 4. Wells digged in the sand using a wood stick tool.
Photos © Anh Galat-Luong IRD.

Results of comparative bacteriological analyses show that:

1) concentration of bacteria is **10 times less** in the wells filtrated water than in the natural puddle water;

2) pathogenic germs characteristic of stagnant putrid water (*Escherichia coli*, *Aeromonas hydrophila*) and frequently recognized as pathogenic for Primates (Daszak and Cunningham, Hyatt, 2001; Dobson and Foufopoulos, 2001; Chapman, Gillespie, and Goldberg, 2005; table I) were present in the natural puddle water and made water unsuitable for consumption. These germs were absent in the wells.

3) the water of the wells contained, at a much lower concentration, only pathogenic germs (*Klebsiella oxytoca*, *Enterobacter cloacae*) typical of mammal species which came to drink there, indicating that the chimpanzees did not wash their hands before digging and drinking, and therefore have contaminated the water with their own germs (Table I).

4) none among the following bacterial or water-mediated parasites: *Mycobacterium tuberculosis*, *Mycobacterium leprae*, *Shigella* sp., *Campylobacter* sp., and *Salmonella* sp., *Entamoeba histolytica*, *Balantidium coli*, *Iodamoeba butschlii*, *Dracunculiasis* and *Schistosomiasis* trichomonads, strongylates, ascaroids and threadworms known to be transmitted zoonotically in the wild (Michel and Huchzermeyer, 1998; Wolfe, Escalante, Karesh *et al*., 1998; Wallis, 2000; Rojas-Espinosa and Lovik, 2001; Nizeyi, Innocent, Erume *et al*., 2001; Lilly, Mehlman and Doran, 2002) have been found.

Thus, due to these wells dug in the sand near putrid water, chimpanzees and baboons are able to drink filtrated water. As this behaviour has not been seen during the 1975-1994 surveys, we think this is a recently appeared and (see figure 1) increased dryness adaptive behaviour.

Table I. Habitat and pathogenicity of the identified bacteria. After Euzéby (1998-2008), Herrick (2004), *LTSA Analyses, essais et inspections techniques*. 2008.

	Natural puddle water		**Filtrated wells water**	
Concentration	10^7/ml		10^6/ml	
Species	*Escherichia coli*	*Aeromonas hydrophila*	*Klebsiella oxytoca*	*Enterobacter cloacae*
Habitat	Intestinal bacterium of the mammals. Very common in Man (80 % of the natural intestinal flora of Man).	Omnipresent in the environment in all the fresh, muddy, and little saline water.	Ubiquist in surface water. Common commensal of the skin and the mucous membranes of mammals. Naturally present in the faecal flora of 30 % of the animals and man.	Soil and water. Can also be found in plants and in mammal faeces.
Pathogenicity	More than 5 % of pathogenic strains. Traveller's diarrhoea. Main germ of urinary and pulmonary infections. Determining indicator of the quality of drinking water on the bacteriological level.	Frogs red-leg disease. Pneumonias, septicaemias, abortions and wounds over infections. Horses' diarrhoea. Opportunist bacterium. For man, causes many and varied digestive and extra-digestive pathologies, cellulitis, diarrhoea, gastroenteritis, in particular in tropical countries, septicaemia, colitis and meningitis. Untreated water consumption increases the risk of infection.	In domestic animals, sometimes connected with urinary respiratory and reproductive infections Not seen as toxinfections agents and no more seen as cause of histaminic intoxications.	Common commensal of the digestive tract of animals and Man. As these bacteria have an important resistance to disinfecting and antibiotics, emergence of nosocomial infections in hospitals has been recently noted.
Risk for Man (European Parliament directive 2000/54/EC)	Low, but high for several strains.	Fixed maximum concentration with 20 ufc/100 ml in drinking water at the exit of the treatment system and with 200 ufc/100 ml in the water distribution network.	Low.	Low.
Risk for animals (Genetic engineering Commission)	Ea1.		None.	None.

Discussion

Some mammal species like warthogs and antelopes dig for water in the bottom of dried pools as the water vanishes in the dry season. Large mammals and non human primates are able to exhibit outstanding behaviors in order to get drink water: during the hot dry season, we saw green monkeys prolong their siesta up to 6 hours in order to economize energy and water and we followed a green monkey striding at a round pace 11 km only to reach water and drink quickly and then returning the 11 km back. Among other water related behaviors, we observed:

- Lowe's guenon drinking from freshwater springs flowing into salt water lagoons below sea level (figure 5).

Figure 5. Lowe's guenon drinking from a freshwater spring flowing into a salt water lagoon below sea level. Photo © Anh Galat-Luong IRD.

- Lowe's guenons using the fur of their forelegs like sponges to dip in deep tree holes in order to get rain water (figure 6).

Figure 6. Lowe's guenon dipping its forelegs in a tree hole to get rain water. Photo © Anh Galat-Luong IRD.

- chimpanzees and baboons entering caves at the hottest hours of day, presumably in order to shelter in shadow. Caves are frequently spots where surface water is already available though it evaporated from the sunny places. We observed chimpanzees sheltering in caves in the Niokolo Koba and in the Comoe (Côte d'Ivoire) National Parks, but were not able to check if there was water in the caves. We observed baboons drinking water at the spring in caves in the Niokolo Koba National Park. We observed baboons and warthogs drinking rain water deep in caves in the Arli National Park, Burkina Faso (figure 7).


a


b

Figure 7. a, b, c: Baboons entering a cave in order to drink on underground water. d: The ground water, deep in the cave. Photos © Anh Galat-Luong IRD.

Chimpanzees use leaves (often chewed) as sponges or like spoons to bring the water to mouth (Whiten, A., Goodall, J., McGrew *et al*., 1999; Nishida *et al*., 1999a,b). The bonobos of Lilungu and Wamba dig for earthworms and mushrooms, but not for water (Bermejo *et al*., 1994; Kano, 1998).

Nishida *et al*. (1999a,b), observed Chimpanzees in at Mahale, Uganda, digging wet ground to reach the water. Chimpanzees have been recorded to use tool to dig with wet ground of a dry stream to obtain water. Only one juvenile female was seen to do this (Nishida, Kano, Goodall et al. 1999a,b).

All these behaviours are absolutely different from the behaviour we describe here, as, although water is still available, but as stagnant putrid water pools, chimpanzees and baboons dig wells in the sand nearby the stagnant water pools and get clear, limpid, filtrated water without excessive pathogenic germs, except, and at low tittle, for germs that probably come from the primates themselves.

We analyzed data from other long term (up to 48 years) chimpanzees field study sites, with a peculiar attention to sites where cultural behaviour has already been observed: - Guinea (Bossou), 33 years of observation; - Côte d'Ivoire (Taï), 33 years; - Tanzania (Gombe, Mahale), up to 48 years; - Uganda (Kibale, Budongo, Semliki-Toro) up to 21 years (Galat and Galat-Luong, 1985; Whiten, Goodall, McGrew *et al.*, 1999). Most of them are located in wet climate where surface water never fails. Thus, digging wells in order to get water is not a necessity and thus highly improbable.

Among the Chimpanzees populations studied on the long term in Africa, the main characteristic of the Senegalese Chimpanzees population we studied is that it is the northern most chimpanzee population (Galat, Galat-Luong, Ndiaye *et al*., 2000, 2002) and thus lives in a very hot and dry habitat (McGrew, 1980). It is also the first one we recorded, in Mai 1995, the hottest month of the year at the end of the dry season, to filtrate water.

After Assirick, Semliki-Toro is the second driest chimpanzee long term field study site. Rainfall averages 1200 (FAO Aquastat, 2008) but years with less than 1000 mm occur (Hunt, 2000). The rainy season is from August to December, with short rains in March, April and May. Semliki is hot and humid. The mean daily maximum was 34 ^{o}C. Only Mount Assirik is hotter.

There, Hunt *et al*. (1999) observed in 1997 a female chimpanzee digging a hole in the sandy riverbank near the Mugiri. This behaviour has then also been observed in other sites in Uganda (Marchant, McGrew, and Hunt, 2007; Hunt and McGrew, 2002). Unlike Mahale (Nishida *et al*., 1999), many of these wells were dug near identifiable water sources, often quite close, suggesting that these wells may function to filter water (Hunt and McGrew, 2002).

Conclusion.

Digging wells in order to get filtrated water is a new Chimpanzee cultural behaviour[1]. It appeared recently and independently in different Chimpanzees populations, first in Senegal 1n 1995 during an increasing rainfall deficit, then in the second driest chimpanzee long term field study site in Uganda in 1997, as an adaptation to face a long increase of dryness period.

[1] For Chimpanzee cultural behaviour, see Whiten, Goodall, McGrew *et al.* 1999.

Acknowledgements.

Thanks to National Parks and Forestry Departments of Senegal, Côte d'Ivoire and Burkina Faso, and the related Administrations in charge of Nature protection and Wildlife research, to our field assistants and to the local people we met.

Grants ORSTOM, now IRD, the French public science and technology research institute in charge of research and overseas development, and DDR, the Senegalese Administration for rural development.

Bibliography.

Bermejo M., Illera G. and Sabater Pi J. 1994. Animals and mushrooms consumed by bonobos (*Pan paniscus*): New records from Lilungu (Ikela), Zaire. *International Journal of Primatology*, 15: 879-898.

Chapman C. A., Gillespie T. R., and Goldberg T. L. 2005. Primates and the Ecology of Their Infectious Diseases: How will Anthropogenic Change Affect Host-Parasite Interactions? *Evolutionary Anthropology* 14: 134–144.

Daszak P, Cunningham AA, and Hyatt AD. 2001. Anthropogenic environmental change and the emergence of infectious diseases in wildlife. *Acta Trop* 78:103–116.

Dobson A, and Foufopoulos J. 2001. Emerging infectious pathogens of wildlife. *Philos Trans R Soc Lond B Biol Sci* 356: 1001–1012.

Euzéby, J.P. 1998-2008. *Dictionnaire de Bactériologie Vétérinaire.* http://www.bacterio.cict.fr/bacdico/index.html, http://www.bacdico.net

FAO Aquastat. 2008. http://www.fao.org/nr/water/aquastat/main/indexfra.stm.

Galat, G. and Galat-Luong, A. 1985. La communauté de Primates diurnes de la forêt de Taï, Côte d'Ivoire. *Revue d'Ecologie (Terre et Vie)*, 40, 3-32.

Galat, G., Galat-Luong, A., Ndiaye, I. and Keita, Y. 2000. Geographical distribution of chimpanzees and baboons in Senegal. *Folia Primatologica*, 257.

Galat, G., Galat-Luong, A., Ndiaye, I. and Keita, Y. 2002. Fragmentation de la distribution et statut actuel du Chimpanzé, *Pan troglodytes verus*, en limite d'aire de répartition au Sénégal. *African Primates* **4** (1&2) : 71-72.

Giffard, P.L. 1974. *L'arbre dans le paysage sénégalais. Sylviculture en zone tropicale sèche*. Centre Technique Forestier Tropical, Nogent-sur-Marne, France.

Herrick, J. 2004. *Les bactéries sont-elles nos ennemies ?* Le Pommier, Paris 62 p.

Hunt KD. 2000. Initiation of a New Chimpanzee Study Site at Semliki-Toro Wildlife Reserve, Uganda. *Pan Africa News* 7 (2): 14-16.

Hunt KD, Cleminson AJM, Latham J, Weiss RI, and Grimmond S 1999. A partly habituated community of dry-habitat chimpanzees in the Semliki Valley Wildlife Reserve, Uganda. *Am. J. Phys. Anthropol*. Suppl. 28: 157.

Hunt, K.D. and McGrew, W.C. 2002. Chimpanzees in the dry habitats at Assirik, Senegal, and at Semliki Wildlife Reserve, Uganda. In: *Behavioural Diversity in Chimpanzees and Bonobos*, Boesch, C., Hohmann, G. & Marchant, L.F. (eds.) Cambridge: Cambridge University Press, pp. 35-51.

Kano T. 1998. A preliminary glossary of bonobo behaviors at Wamba. In Nishida T. ed. *Comparative study of the behavior of the genus* Pan *by compiling video ethogram*. Nissho Printer, Kyoto, pp. 39-81.

Lawson, G. 2005. Impacts of global change on natural vegetation in southern Africa, and possible adaptation strategies: 183-197.

Le Borgne, J. 1990. La dégradation actuelle du climat en Afrique, entre Sahara et Equateur. In: *La dégradation des paysages en Afrique de l'Ouest. Séminaires de Dakar,* Presses Universitaires de Dakar, Dakar : 17-36.

Le Houérou, H.N. (1989) *The grazing land ecosystems of the African Sahel*. Ecological studies, 75, Springer-Verlag, Berlin, Germany.

Lilly A.A., Mehlman P.T., and Doran D. 2002. Intestinal Parasites in Gorillas, Chimpanzees, and Humans at Mondika Research Site, Dzanga-Ndoki National Park, Central African Republic. *International Journal of Primatology*, 23, (3): 555-573.

LTSA Analyses, essais et inspections techniques. 2008. http://www.ltsa.fr/sante.html.

Marchant LF ; McGrew WC ; and Hunt KD. 2007. Ethoarchaeology of manual laterality: well-digging by wild chimpanzees. *American Journal of Physical Anthropology.* (Suppl 44): 163.

McGrew, W.C., Baldwin, P.J. and Tutin, C.E.G. 1981. Chimpanzees in a hot, dry and open habitat: Mt. Assirik, Senegal, West Africa. *J. Hum. Evol.* 10 : 227–244.

Michel, P. (1990). La dégradation des paysages au Sénégal. In: *La dégradation des paysages en Afrique de l'Ouest. Séminaires de Dakar,* Presses Universitaires de Dakar, Dakar : 37-53.

Michel AL, and Huchzermeyer HF. 1998. The zoonotic importance of *Mycobacterium tuberculosis:* transmission from human to monkey. *J S Afr Vet Assoc* 69: 64–65.

Nishida, T., Kano, T., Goodall, J., McGrew, W.C. and Nakamura, M., 1999. Ethogram and ethnography of Mahale chimpanzees. *Anthropol. Sci.* 107: 141-188.

Nishida, T., Kano, T., Goodall, J., McGrew, W.C. and Nakamura, M., 1999. Ethogram and ethnography of Mahale chimpanzees. http://biologybk.st-and.ac.uk/cultures3/articles/download/Ethogram.doc downloaded 5/3/2008

Nizeyi JB, Innocent RB, Erume J, Kalema GR, Cranfield MR, and Graczyk TK. 2001. Campylobacteriosis, salmonellosis, and shigellosis in free-ranging human-habituated mountain gorillas of Uganda. *J. Wildlife Dis*. 37: 239–244.

Pruetz, J.D., Marchant, L.F., Arno, J. and McGrew, W.C. 2002. Survey of savanna chimpanzees (*Pan troglodytes verus*) in southeastern Senegal. *Amer. J. Primatol.* 58 : 35–43.

Rojas-Espinosa O, and Lovik M. 2001. *Mycobacterium leprae* and *Mycobacterium lepraemurium* infections in domestic and wild animals. *Rev. Sci. Technol.* 20: 219–251.

Schnell, R. 1977. *Phytogéographie des pays tropicaux*. I-IV, Gauthier-Villars, Paris, France.

Trochain, J.L. 1940. *Contribution à l'étude de la végétation du Sénégal*. Librairie Larose, Paris, France.

Wallis J. 2000. Prevention of disease transmission in primate conservation. *Ann. NY Acad. Sci.* 916: 691–693.

Whiten, A., Goodall, J., McGrew, W. C., Nishida, T., Reynolds, V., Sugiyama, Y., Tutin, C. E. G., Wrangham, R. W. and Boesch, C. 1999. Cultures in chimpanzees. *Nature,* 399 (6737): 682-685.

Wolfe ND, Escalante AA, Karesh WB, Kilbourn A, Spielman A, and Lal AA. 1998. Wild primate populations in emerging infectious disease research: the missing link. *Emerg. Infect. Dis*. 4: 149–158.