DIVERSITY AND FUNCTIONS OF SOIL MACROFAUNA IN WEST AFRICA: CASE STUDY OF TERMITES AND ANTS IN CÔTE D'IVOIRE AND BURKINA FASO

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OUTLINE

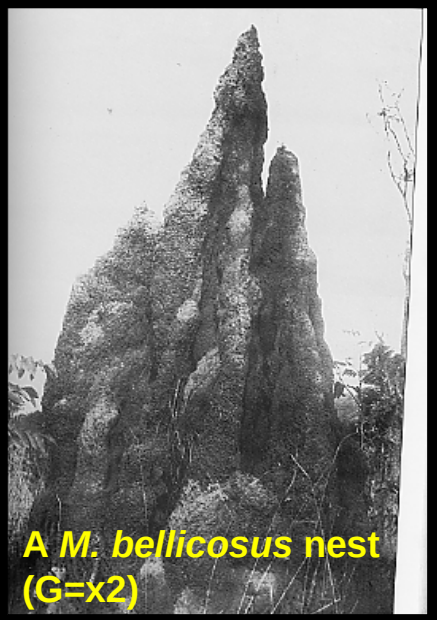
I. INTRODUCTION
II. DIVERSITY OF TERMITES AND ANTS ALONG CLIMATIC AND LAND USE GRADIENTS
III. ROLE OF TERMITES IN ECOSYTEM FUNCTIONING AND SOIL RESTORATION
IV. CONCLUSION

INTRODUCTION

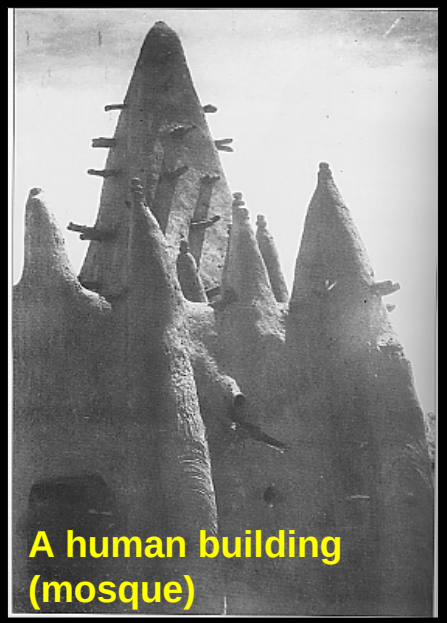
SOCIO ECONOMICAL IMPORTANCE OF TERMITES AND ANTS IN WEST AFRICA

- Ants as efficient control agents for some perennial crop pests
- Increase of soil fertility and water content by termites and ants
- Termites as food for human and animal

►Termite mounds as architectural models



A *M. bellicosus* nest (G=x2)



A human building (mosque)

►Soudanian house architecture in West Africa is inspired by the nest of the termite *Macrotermes bellicosus*.

►Nest material and architecture of *termites* are promising models for moderne building

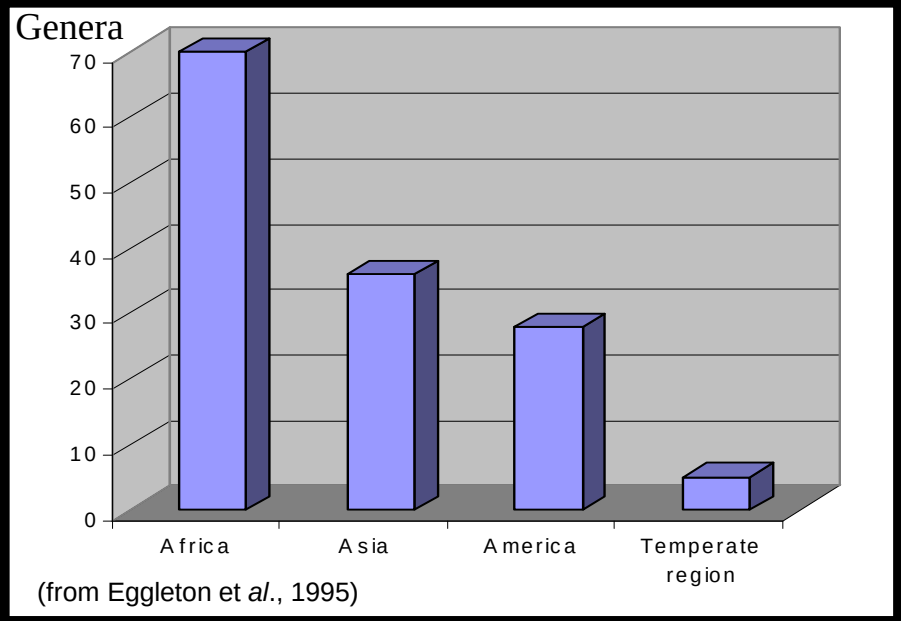
►Termites as a source for important non agricultural products

►Use of seasonal alates of *Macrotermes* spp. as protein source for the human population

►Consumption of seasonal carpophores (mushrooms) of several termite´s symbiotic fungi

ECOLOGICAL IMPORTANCE OF TERMITES AND ANTS

- ► **In the food web (transformer, predators)**
- ► **in ecosystem processes (E. engineering)**
- ► **Biomonitoring (bio-indicators)**
- ► **Ecosystem services (C. sequestration, seed dispersal…)**



(from Eggleton et *al*., 1995)

► Termite species richness decreases from the equator to the tropics.

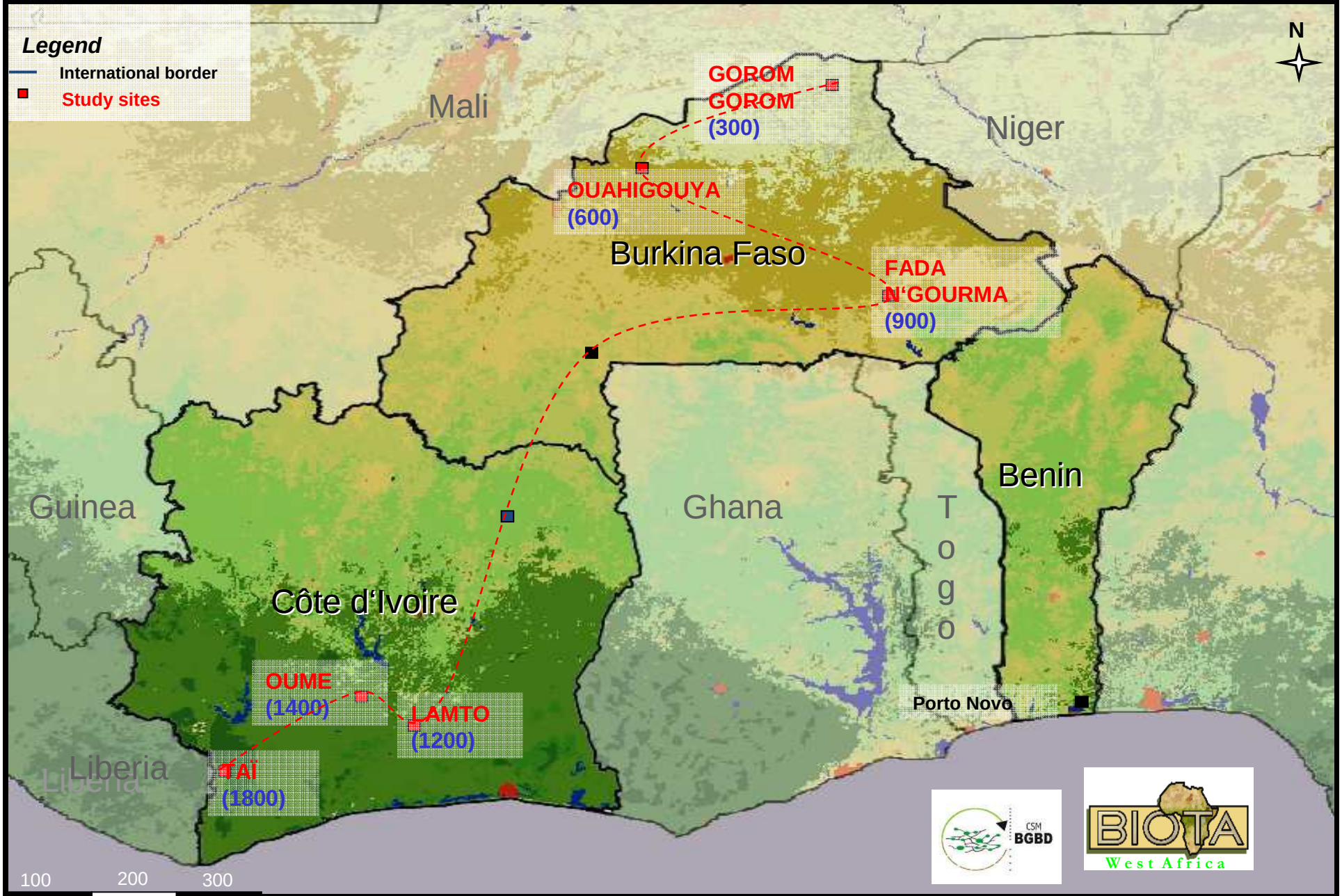
► Termite diversity is tremendous in Africa (1000 sp / 3106 sp)

► Highest diversity of ants in Africa (2500 sp / 12500 sp)

► **Data for West African termite diversity are scarce and the region remains poorly investigated**

DIVERSITY OF TERMITES AND ANTS

STUDY SITE



"Global Land Cover 2000 database. European Commission, Joint Research Centre, 2003. http://www-gem.jrc.it/glc2000."


GOROM GOROM (300 mm/yr)


FADA N'GOURMA (900 mm/yr)


TAÏ (1800 mm/yr)


LAMTO (1200 mm/yr)

COMBINED TERMITES-ANTS SAMPLING PROTOCOL

W

W

W

W

W

~ 10 m

10m

30cm

10 m

5 m

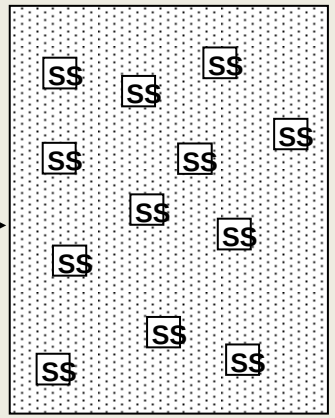
50 m

2m

Leaf litter Ants

Endogeic Ants

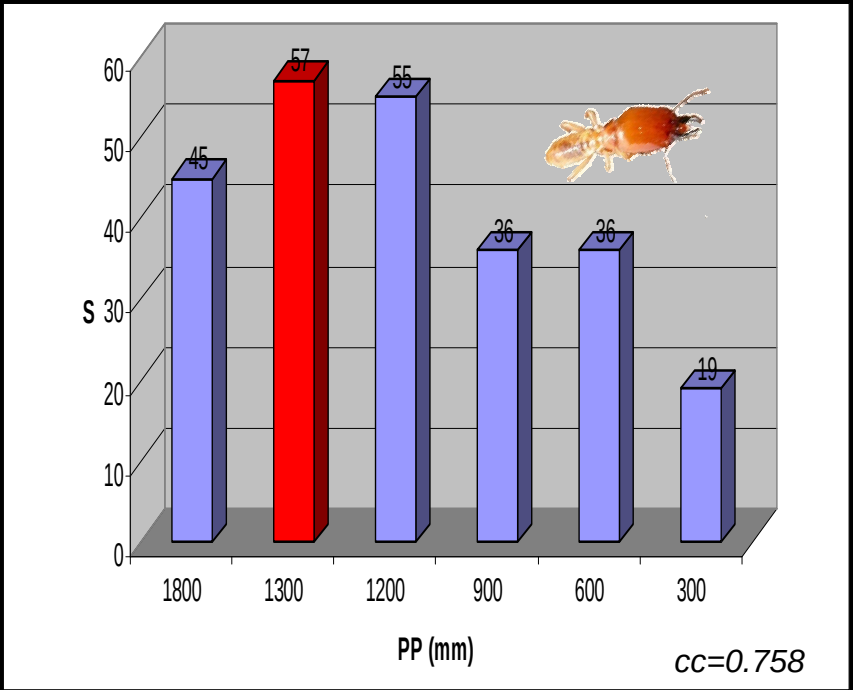
Termites

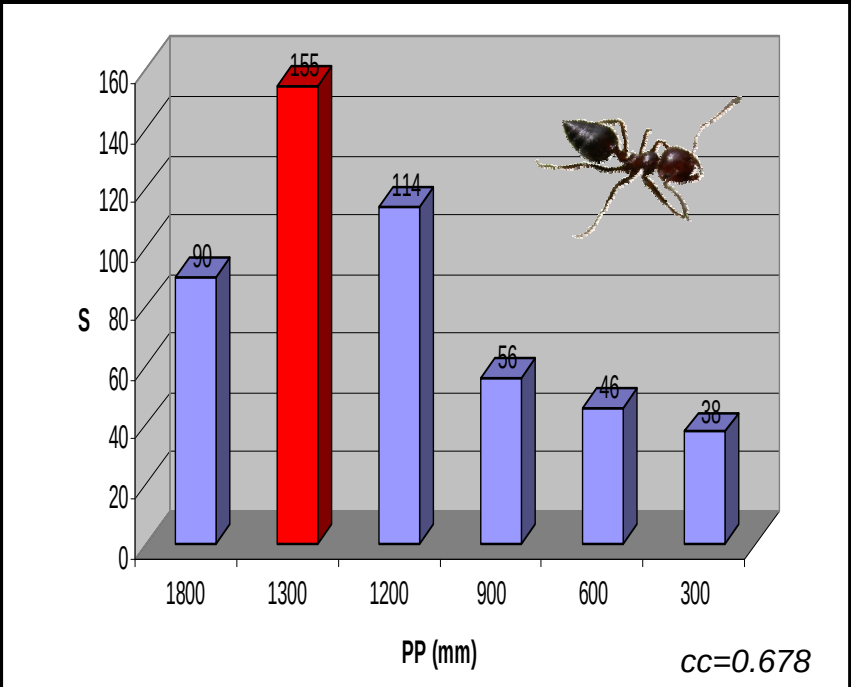


12 Soil Scrapes (12 x 12 x 10cm)

DIVERSITY OF TERMITES AN ANTS ALONG A CLIMATIC GRADIENT IN WEST AFRICA

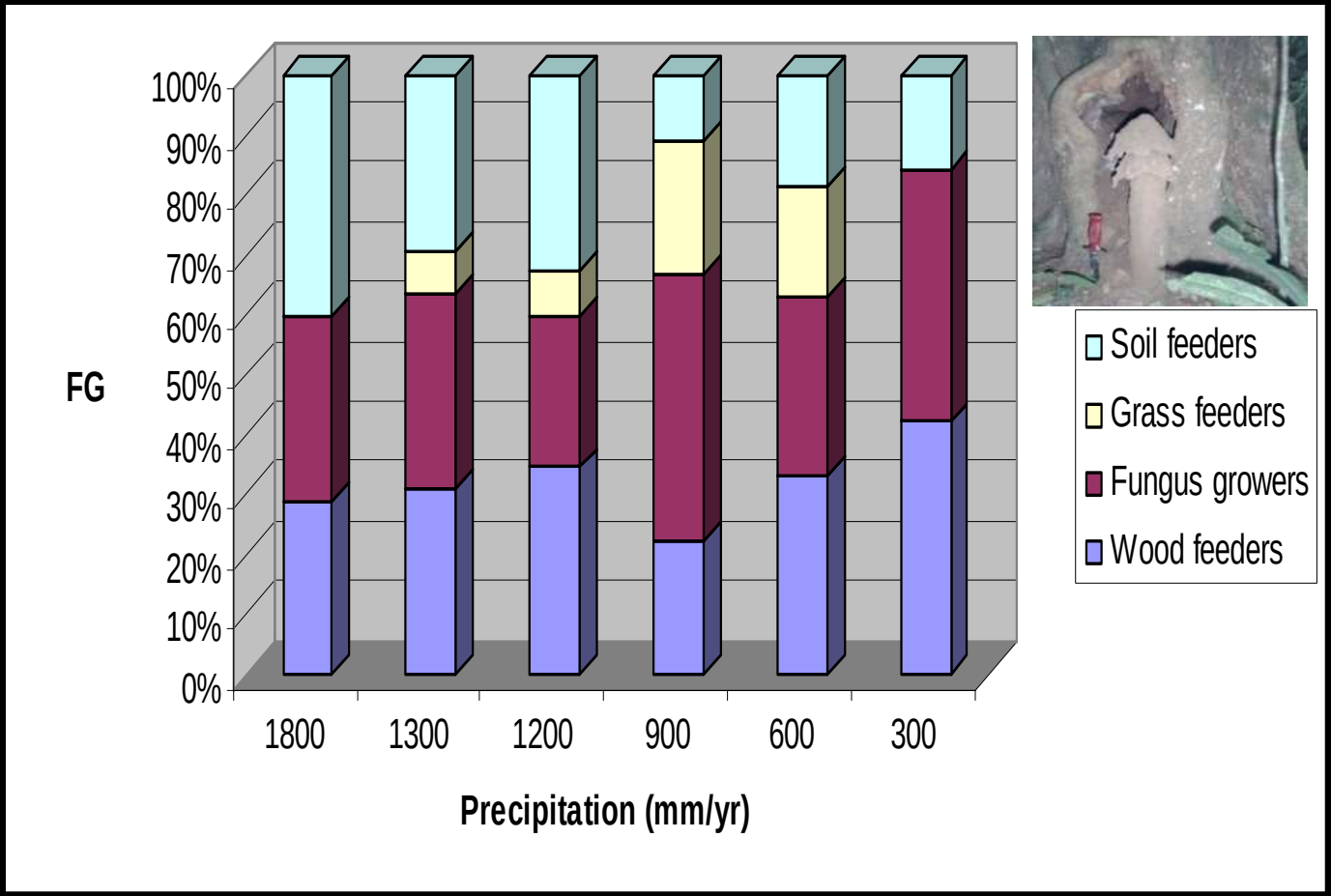
(426 sp. of ants and about 100 sp. termites, described)





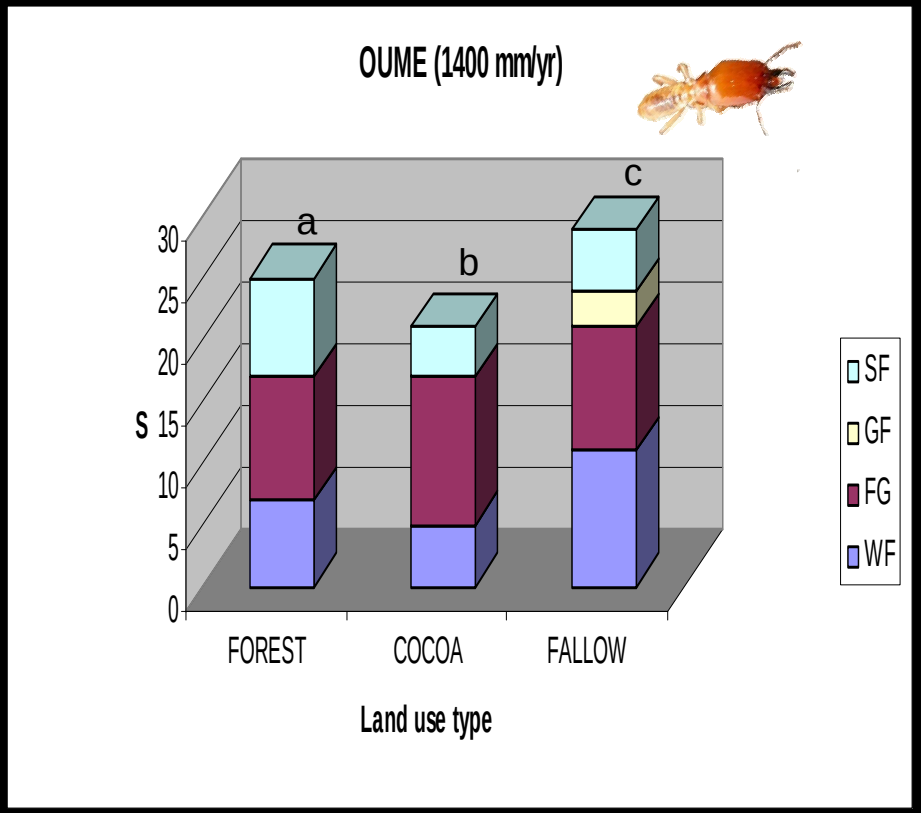
- **Termite and ant species richness broadly decrease with increasing aridity.**
- **The highest species richness is observed in semi-deciduous forest of Oumé**

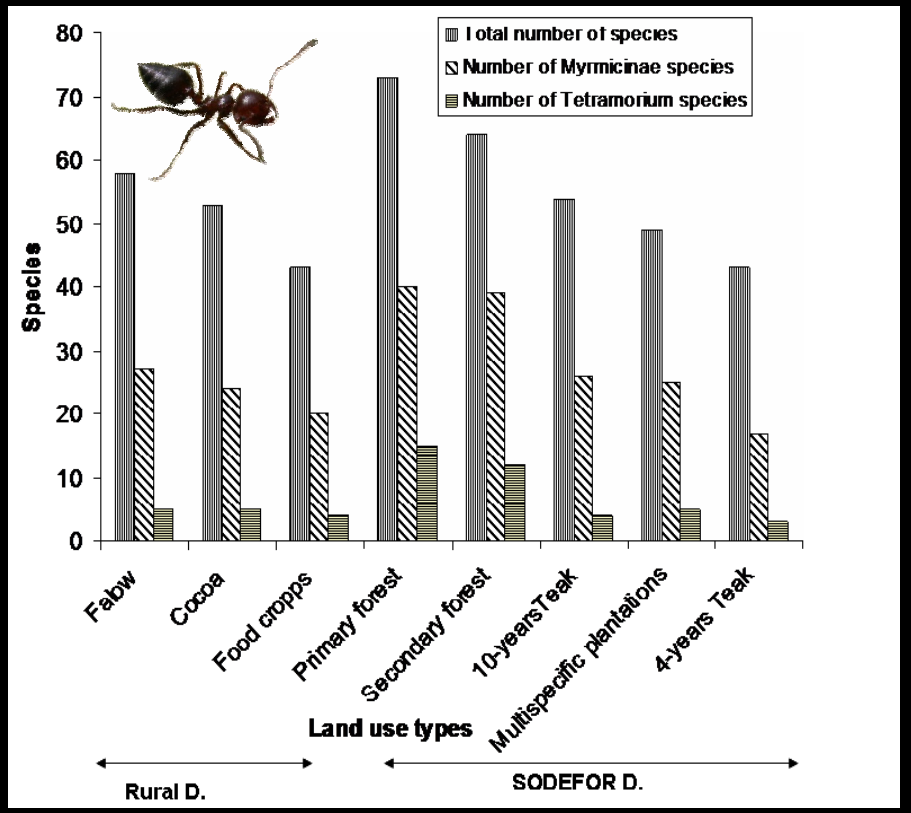
DIVERSITY OF TERMITES FEEDING GROUPS ALONG A CLIMATIC GRADIENT IN WEST AFRICA



Proportion of the soil feeders broadly decreases with increasing aridity.
The grass feeders are absent in the wettest and dryest regions.

DIVERSITY OF TERMITES AND ANTS ALONG A LAND USE GRADIENT IN A SEMI DECIDIOUS FOREST ZONE





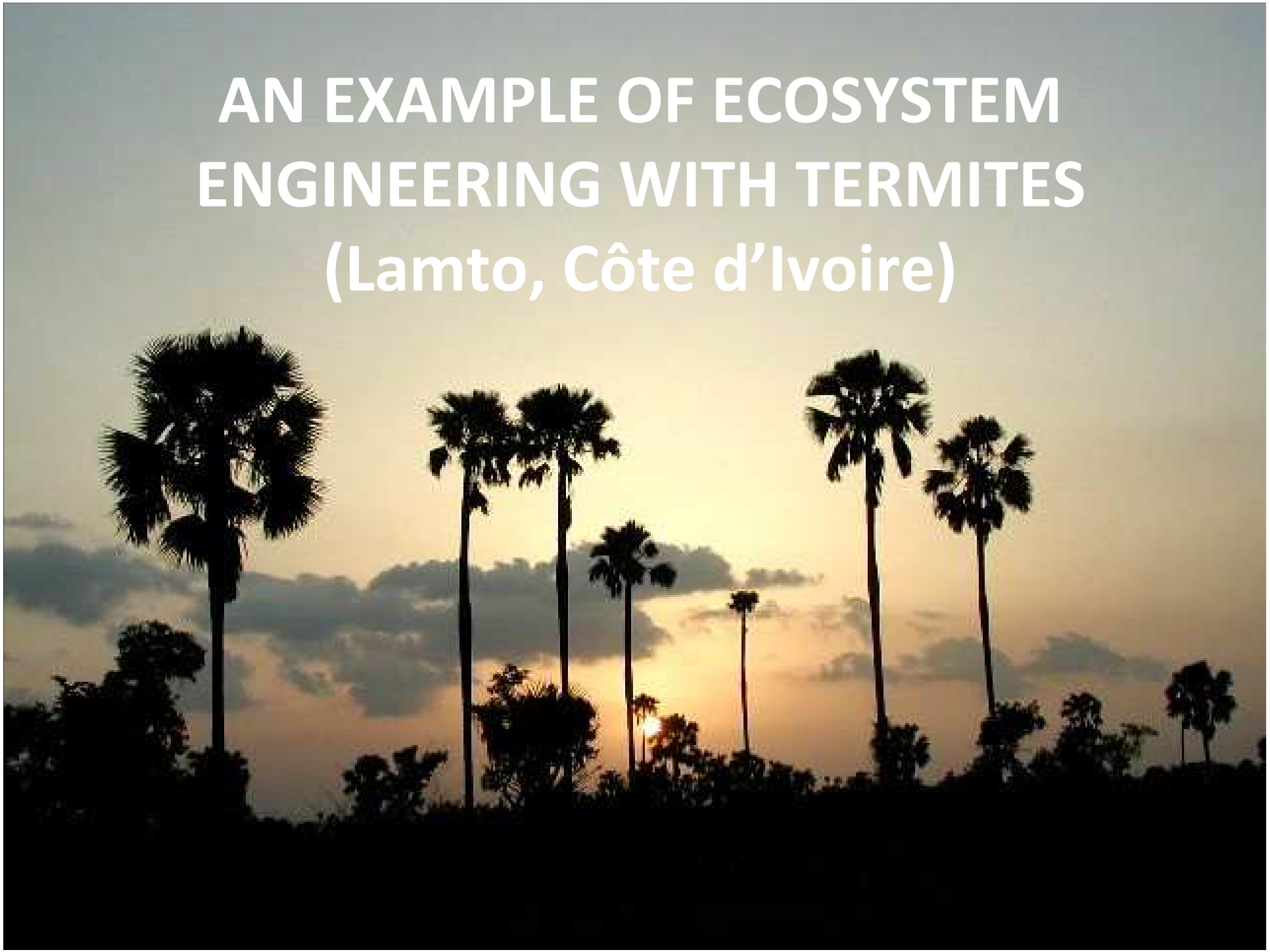
► Species richness is higher in near natural areas (forest and savanna) compared to perennial crop plantations (cocoa and coton)

► Soil feeders are well represented in near natural areas, fungus growers are abondant in all of land use type

► Diversity of ants from sub-familly Myrmicinae and the genus Tetramorium decrease with land use intensification.

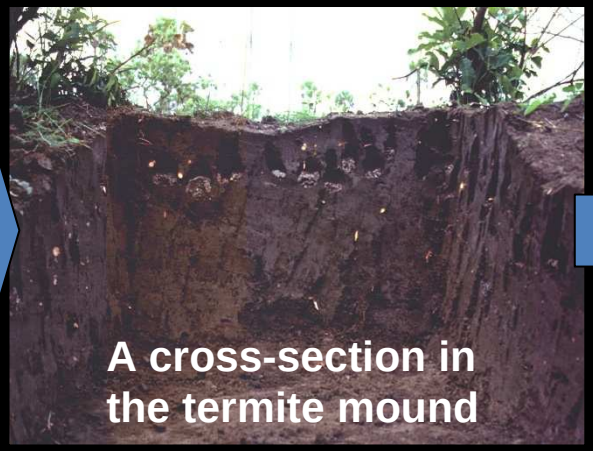
FUNCTIONS OF TERMITES

AN EXAMPLE OF ECOSYSTEM ENGINEERING WITH TERMITES (Lamto, Côte d'Ivoire)

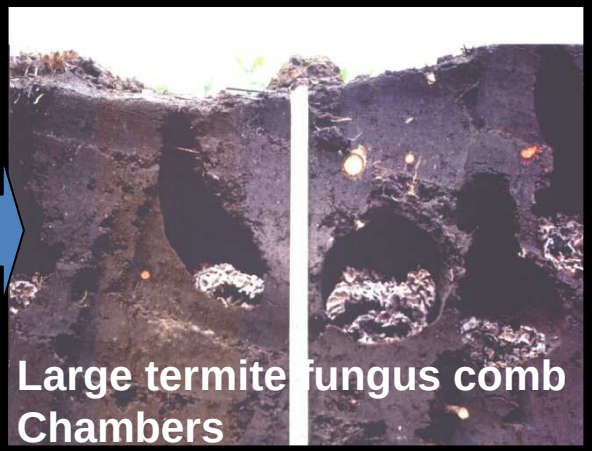


THE FUNGUS GROWING TERMITES AS ECOSYSTEM ENGINEERS IN LAMTO

The large termitaria of *Odontotermes*

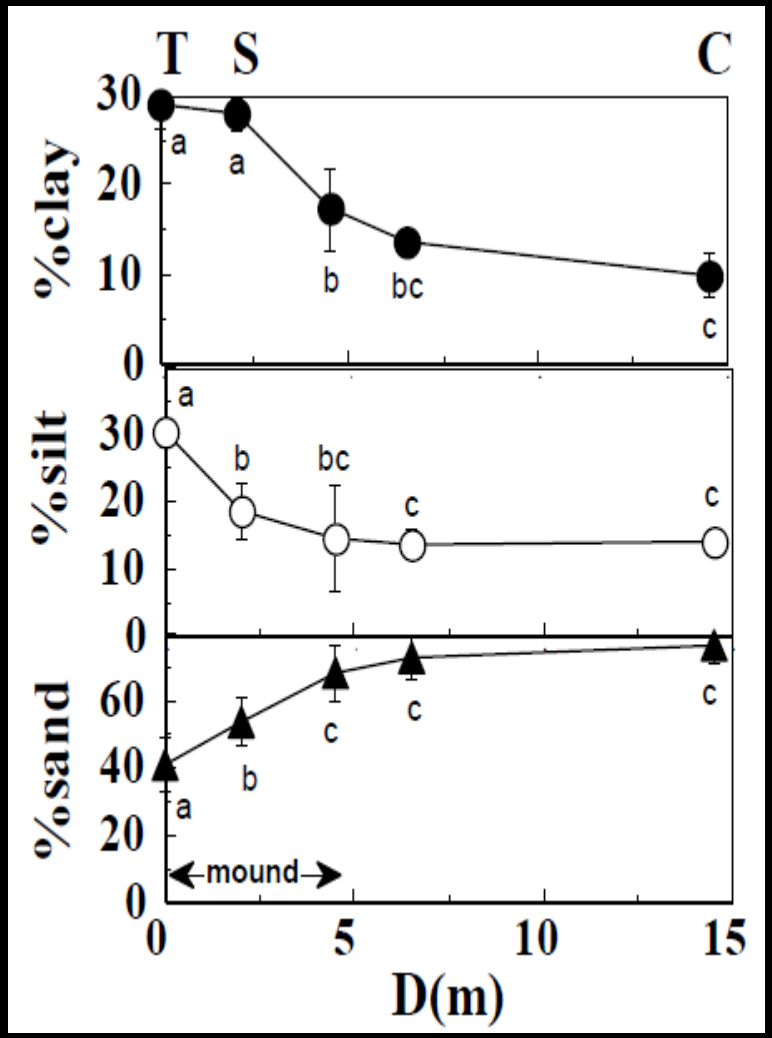


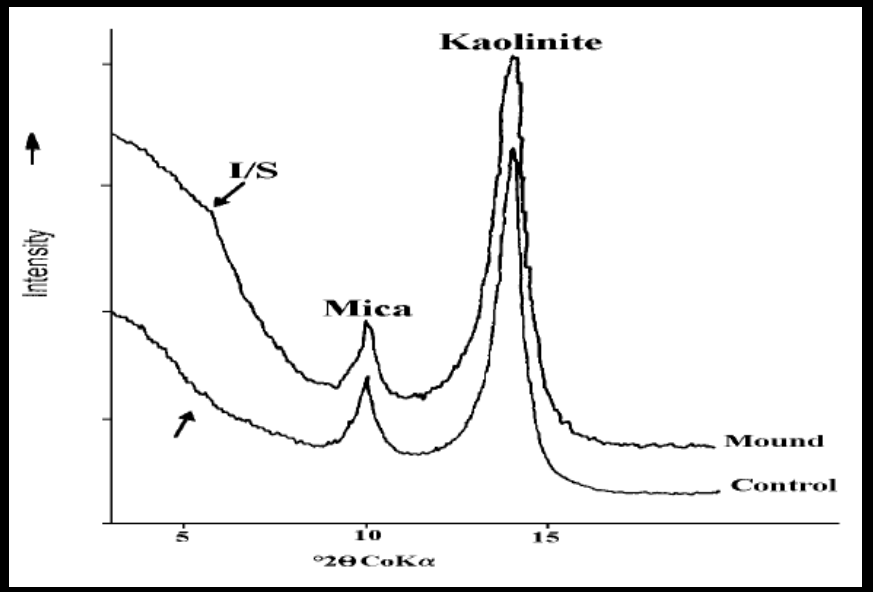
A cross-section in the termite mound



Large termite fungus comb Chambers

EFFECTS OF TERMITES ON SOIL TEXTURE AND CLAY MINERALOGY





- Increase of soil fine particles
- Increase of I/S clay mineral

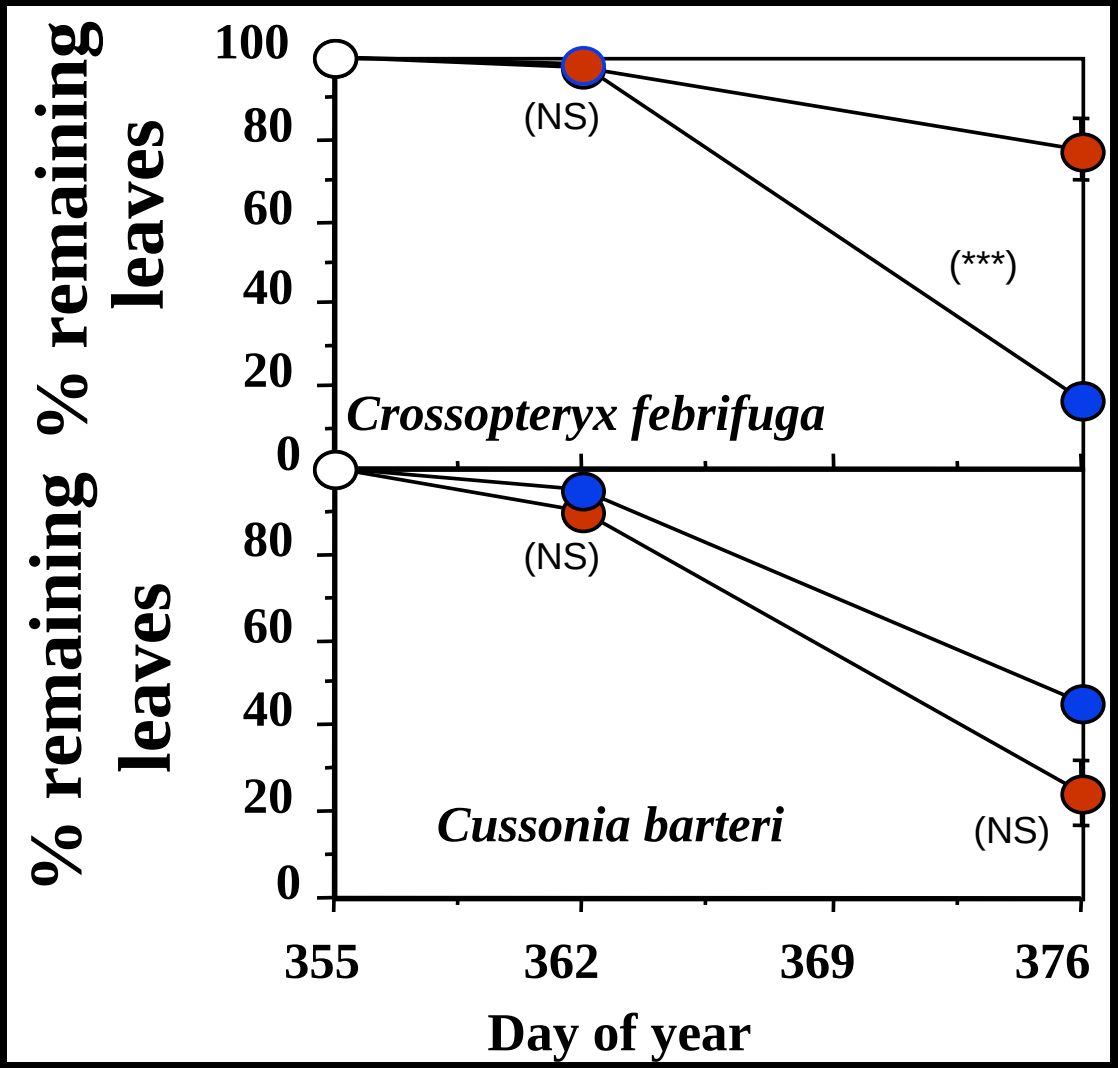
EFFECT OF TERMITES ON SOIL WATER AVAILABILITY FOR PLANTS

soil layers	Maximum water available to plants (pF4.2-pF1.5)		
	mound soil	contol soil	mound-control
0 - 30 cm	54	50	4
30 - 60cm	58	34	24
0 - 60 cm	112	84	28

► The maximum soil water content available for plants was substantially higher on the termite mound than in the surroundings (28 mm high)

Konaté et al 1999
(Plant and Soil)

IMPACTS ON TREE PHENOLOGY



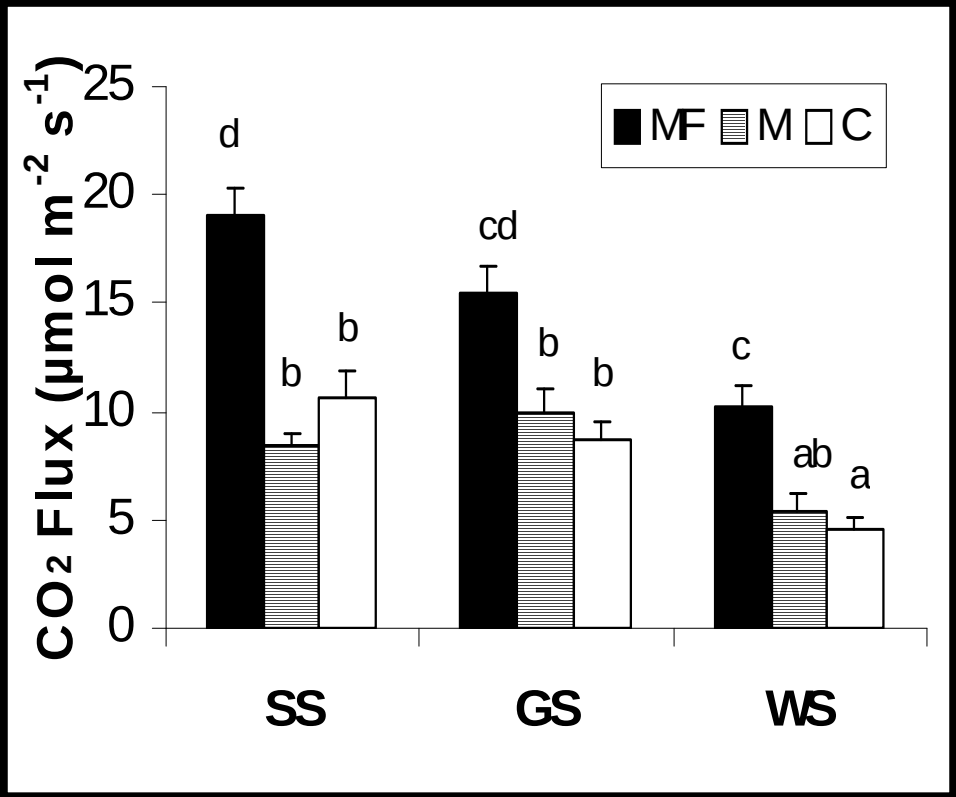
Termite mound

Control
(i.e. savanna soil)

- The leaf shedding patterns of *Crossopteryx febrifuga* shrubs located on mounds were less pronounced

Konaté et al, 1999
(Plant and Soil)

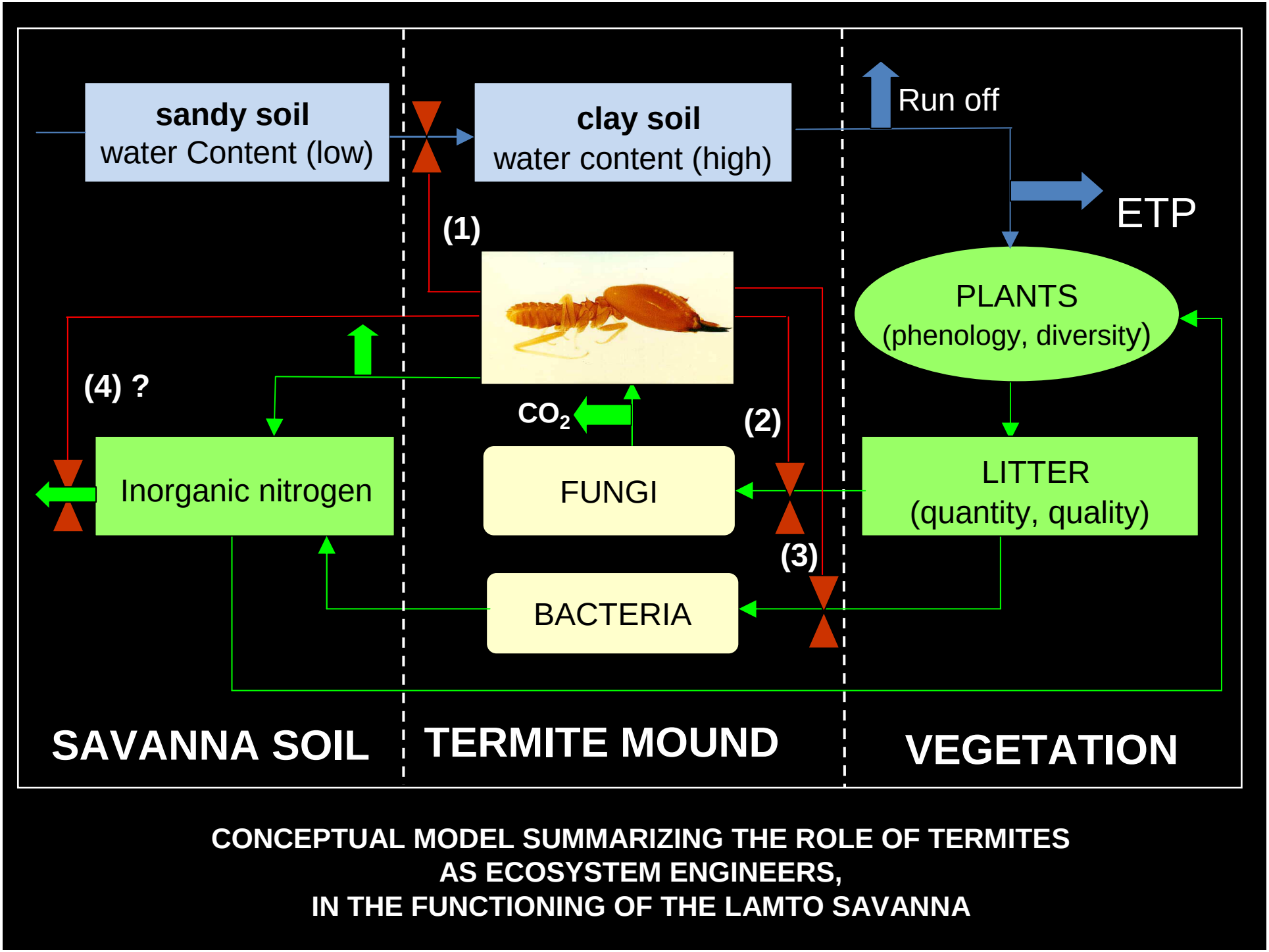
EFFECT OF TERMITES ON SOIL RESPIRATION RATES (CO_2 fluxes)



In Lamto, CO_2 emission due to the termites is 27.2 g C m^{-2} $year^{-1}$, represented **4.9% of the total aboveground NPP** and **11.3% of the carbon not mineralised by annual fires.**

► Open question: How termites could contribute as **sources or/and sink CO_2** , depending on feeding groups ?

Konaté et al., 2003 (Functional Ecology)



CONCEPTUAL MODEL SUMMARIZING THE ROLE OF TERMITES AS ECOSYSTEM ENGINEERS, IN THE FUNCTIONING OF THE LAMTO SAVANNA


AN EXAMPLE OF ECOLOGICAL ENGINEERING WITH TERMITES BASED ON THEIR ROLE AS ECOSYSTEM ENGINEERS
(The Zaï system : An African traditional soil restoration system, Burkina Faso)
BIOTA
West Africa

- In Burkina Faso about 25% of the country's arable lands are highly degraded (Zougmoré et al 2003)

-A variety of measures have been developed for reducing soil degradation :
Half moon, Mulching, Zaï

► The Zaï: a West African traditional practice, which can potentially be extended to many dry areas in Africa.

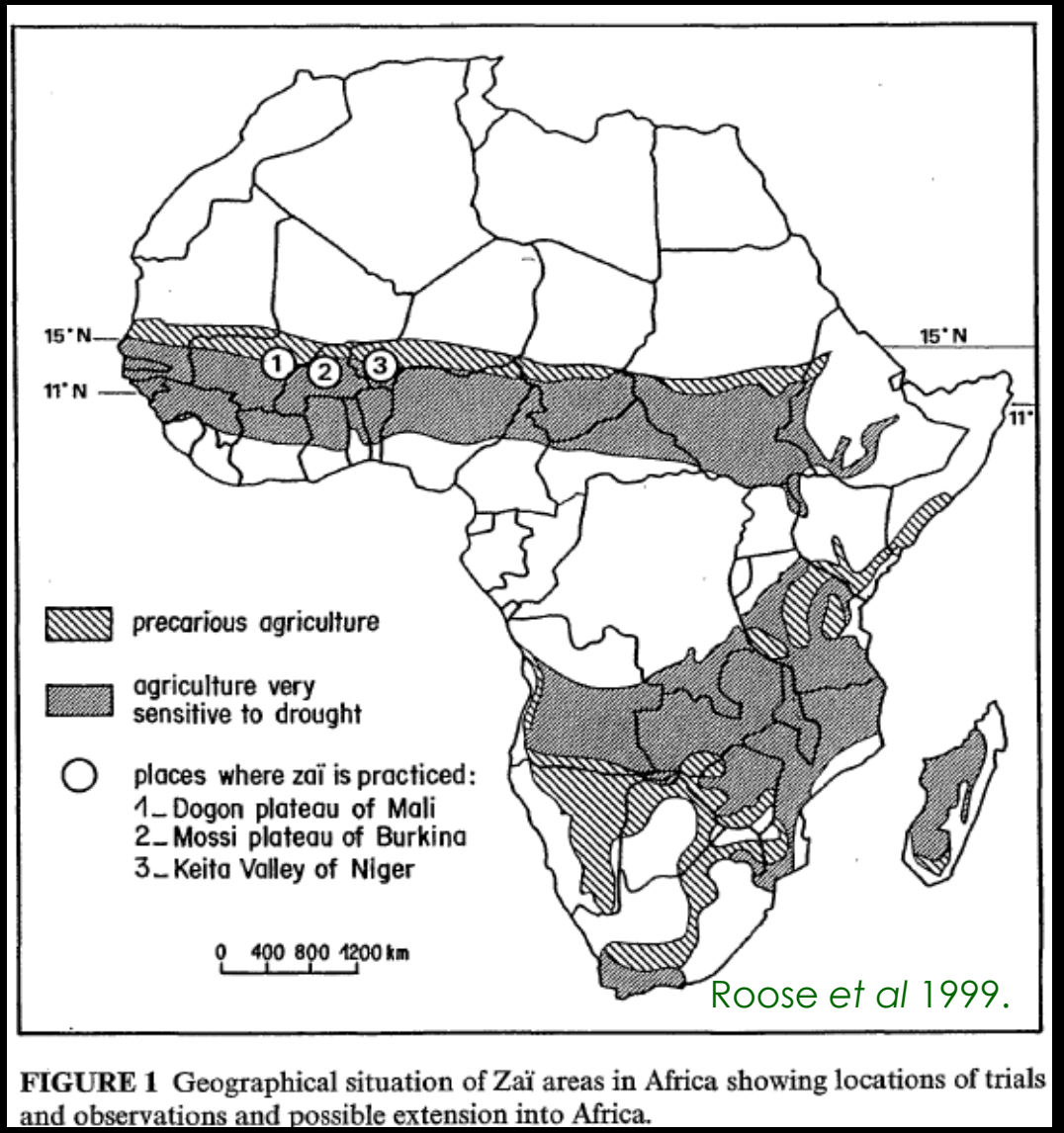


FIGURE 1 Geographical situation of Zaï areas in Africa showing locations of trials and observations and possible extension into Africa.

Abandoned during the wet years (e.g. 1950-1970), it was revived in Burkina Faso in the 1980s after the dry season of 1970s.

(1) Microwatershed, combined with bands of stone line for runoff capture and limitation of the soil erosion

(2) organic matter from domestic and farming activities to attract termites

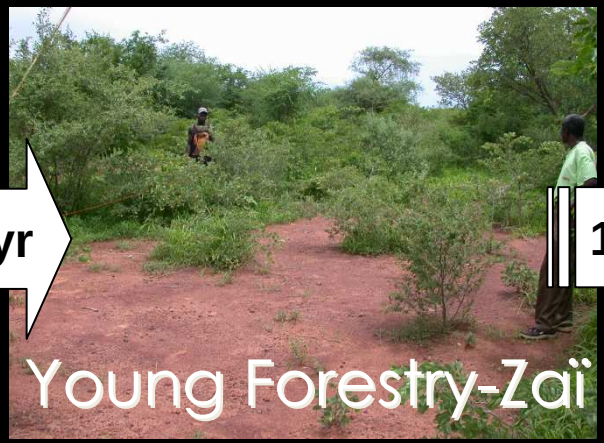
(3) Termites to bore channels in crusted soils

(1) Agricultural-Zaï

After 5 years of Zaï cultivation → fallow

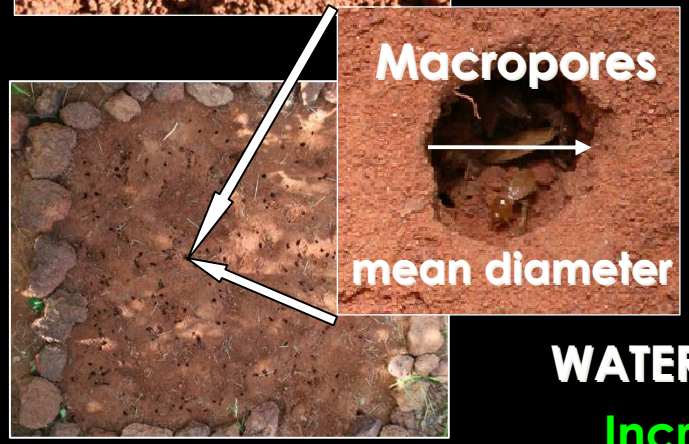
(2) Forestry-Zaï

10yr



10yr

EFFECT OF TERMITES :



SOIL BIOTURBATION/ TURN-OVER:

1 kg Herb-Consumption ⇨

4-10 kg Soil-Sheeting-Production

KEY TERMITES GROUPS IN THE ZAÏ :

Odontotermes sp. as an ecosystem engineer in the Zaï system, *Macrotermes* sp.

MEAN NUMBER of MACROPORES

after FEEDING of 1 kg Herb: 260 / m^2

MACROPORES – mean diameter:

Odontotermes: 3.48 mm (s.d. 1.44)

Macrotermes: 8.71 mm (s.d. 3.51)

WATER INFILTRATION CAPACITY (mm/h):

Increase: 2-10 fold

Kaiser et al. 2015

A MODEL OF ECOLOGICAL ENGINEERING FOR SOIL RESTORATION

A complex system based on termite activities
Understanding and improving the system will need to consider the interaction between all its components

The human society :
- traditional knowledge
- local socio-economy

From ecosystem engineering by termites

to ecological engineering by humans for soil restauration

CONCLUSION

(1) Termites & Ants : key organisms in West Africa

(2) Decrease in diversity of termites and ants with decreasing rainfall and increasing land use intensification

(3) Termites from the **Humivorus** feeding group and ants from the subfamilly Myrmicinae (the genus **tetramorium**) show a sensitivity to habitat degradation:**Good candidates as bio-indicator for habitat degradation**

(4) Termites play a key role as ecosystem engineers in savannas, for ecosystem functionning (Lamto) and soil restoration (Ouahogouya).

(5) Potential use in ecological engineering and agriculture

Acknowledgements

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THANK YOU !

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