Schmidt, M., Agonyissa, D., Ouédraogo, A., Hahn-Hadjali, K., Thiombiano, A., Koulibaly, A., Goetze, D. & Zizka, G.(2010). Changes in plant species composition following a climatic gradient in West Africa. In: X. van der Burgt, J. van der Maesen & J.-M. Onana (eds), Systematics and Conservation of African Plants, pp. 823–828. Royal Botanic Gardens, Kew.

CHANGES IN PLANT SPECIES COMPOSITION FOLLOWING A CLIMATIC GRADIENT IN WEST AFRICA

Marco Schmidt[1], Didier Agonyissa[2], Amadé Ouédraogo[3], Karen Hahn-Hadjali[4], Adjima Thiombiano[3], Annick Koulibaly[5], Dethardt Goetze[6] & Georg Zizka[4]

[1]Forschungsinstitut Senckenberg, Abt. Botanik und molekulare Evolutionsforschung; mschmidt@senckenberg.de,
[2] Lab. d'Ecologie Appliquée, Fac. des Sciences Agronomiques, Univ. d'Abomey-Calavi, Cotonou, [3]Lab. de Biologie et Ecologie Végétale, UFR/SVT, Université de Ouagadougou, [4]Inst. für Ökologie, Evolution und Diversität, J. W. Goethe-Universität, Frankfurt am Main, [5] UFR Biosciences, Laboratory of Botany, University of Cocody, Abidjan, [6]Inst. für Biowissenschaften, Abt. Botanik, Universität Rostock

Abstract
In the BIOTA Africa research programme of the German Federal Ministry of Education and Research (BMBF), a continental network of so-called biodiversity observatories has been installed in Africa. They serve as permanent monitoring plots of biodiversity changes in the context of global change. Our study area comprises biodiversity observatories along the West African BIOTA transect in Ivory Coast, Benin and Burkina Faso, covering a climatic gradient form the south Sudanian zone to the Sahel. Their surface area of 1 km² each comprises different types of savanna. Plots of 1 ha have been placed to represent these savannas within each observatory. The complete species inventories of these plots were compared on a subcontinental scale to assess possible effects of natural environmental factors and human impact. Highest species richness was found in the north Sudanian savannas. Lowest species richness was encountered in the Sahelian zone in northern Burkina Faso. Similarities in species composition correspond to vegetation zones.

Résumé
Changements de la composition floristique suivant un gradient climatique en Afrique de l'Ouest. Le programme BIOTA Afrique, a permis la mise en place d'un réseau continental des observatoires pour le suivi des changements de la biodiversité. Les sites d'étude sont situés dans les observatoires le long du gradient qui va de la Côte d'Ivoire au Bénin en passant par le Burkina Faso. Leurs superficies respectives d'un km² renferment chacune différents types de savanes. Des placeaux d'un ha sont installés à l'intérieur de chaque observatoire en prenant en compte les différents habitats. Les inventaires des espèces des différents placeaux sont reliés entre eux sur la base des effets des facteurs environnementaux naturels et de l'impact de l'Homme. La plus grande richesse spécifique a été mise en évidence dans les savanes nord-soudaniennes et la plus faible dans la zone sahélienne notamment au nord du Burkina Faso. Les similarités de la composition floristique s'observent entre zones de végétation.

Key words: Biodiversity observatory, BIOTA Africa, grazing, monitoring, species richness.

1 Introduction

In the BIOTA Africa project (**Bio**diversity monitoring **T**ransect **A**nalysis in Africa), a network of biodiversity observatories (Schmiedel & Jürgens, 2005) has been set up across all African biomes to serve as permanent monitoring plots of biodiversity changes in the context of global change. In this paper we assess and compare the plant diversity of ten West African observatories, located between Gorom-Gorom in northern Burkina Faso (Sahelian zone) and the Comoé National Park in Ivory Coast (south Sudanian zone). In this Sudano-Sahelian zone, savannas are the prevailing vegetation type. Their presence in areas with higher rainfall is linked to human impact such as periodic fires, agriculture and grazing. Wherever possible, observatories underlying different levels of human impact have been established in each region, including sites in protected and pastured areas.

Our analyses aim at comparing the floristic composition and plant diversity in relation to climate and prevailing grazing impact.

2 Study area

The biodiversity observatories are placed along the climatic gradient from the south Sudanian zone in Ivory Coast and Benin to the Sahelian zone in Burkina Faso (Fig. 1). The observatory sites have been chosen to represent the respective biome and different land use types within the biome. In each region a pair of observatories was selected, each with a surface of 1 km^2, one in a land use area with different fallow stages under high grazing pressure and one in a protected area (e.g. Comoé National Park, Biosphere Reserve Pendjari, Pama Reserve) with very low or no grazing pressure (Fig. 1, Table 1).

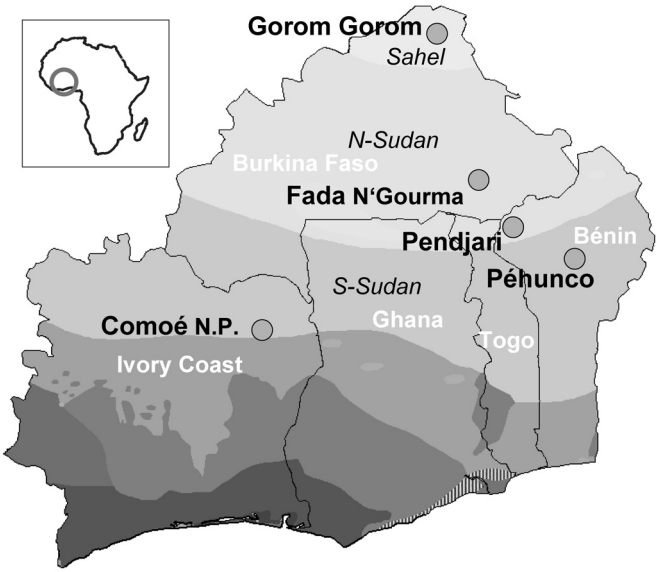

Fig. 1. Position of the study areas within the West African countries Burkina Faso, Benin and Ivory Coast.

In the Sahel the observatory selected as low grazing pressure turned out to be also under high pressure, and no alternative sites with lower grazing pressure could be found. In the Comoé region in Ivory Coast the inventories in the land use areas were hindered by the outbreak of civil war.

In each observatory the different vegetation types were pre-stratified by use of satellite images and field investigations in order to identify several representative 1-ha plots for species inventory.

TABLE 1. The pastured and protected observatories for each study area are listed with the number of inventoried hectare plots in parentheses.

Region and zone	**Observatory and number of 1-ha plots**	
	protected	**under pasture**
Gorom-Gorom (Sahel)		Kolèl (5), Yomboli (5)
Fada N'Gourma (N-Sudan)	Natiabouani (5)	Kikidéni (5)
Pendjari (N-Sudan)	Pendjari-P (2), Pendjari-C (2)	Pendjari-T (4)
Péhunco (S-Sudan)	Albori (10)	Village (10)
Comoé (S-Sudan)	Comoé (6)	

3 Methods

In each 1-ha plot all plant species were inventoried. The nomenclature was standardised according to names accepted by the African Plants Database (http://www.ville-ge.ch/cjb/bd/africa/index.php) and all infraspecific taxa were normalised to species level. The inventories were clustered using the Community Analysis Package 2.0 (Pisces Conservation, 2002) with Ward's method and Euclidean distances. The mean species richness and standard deviation were calculated for the hectare plots.

4 Results

The highest species richness (Fig. 2) was found in north Sudanian plots, especially in the pasture site in Kikidéni. The Sahelian plots show the fewest species. The differences between pasture and protected plots are ambiguous: in the Fada N'Gourma and Péhunco areas, a higher species richness was found in pastures, while in the Pendjari region, the plots in the national park were richest in species.

To analyse floristic similarity, the species inventories of the 1-ha plots were clustered using Ward's method and Euclidean distances (Fig. 3). They clearly correspond to the distinction of vegetation zones: the Sahelian plots were separated from the Sudanian plots and within the latter, the north Sudanian were separated from the south Sudanian plots. In most cases, the plots belonging to one region were grouped together. In the north Sudanian observatories, the protected ones (Pendjari P/C and Natiabouani) were more similar to each other than to their corresponding utilised counterparts. In general, a plot of an observatory is most similar to the other plots of the same observatory. Only in the Péhunco region were some plots of the Village observatory more similar to the protected plots of Alibori.

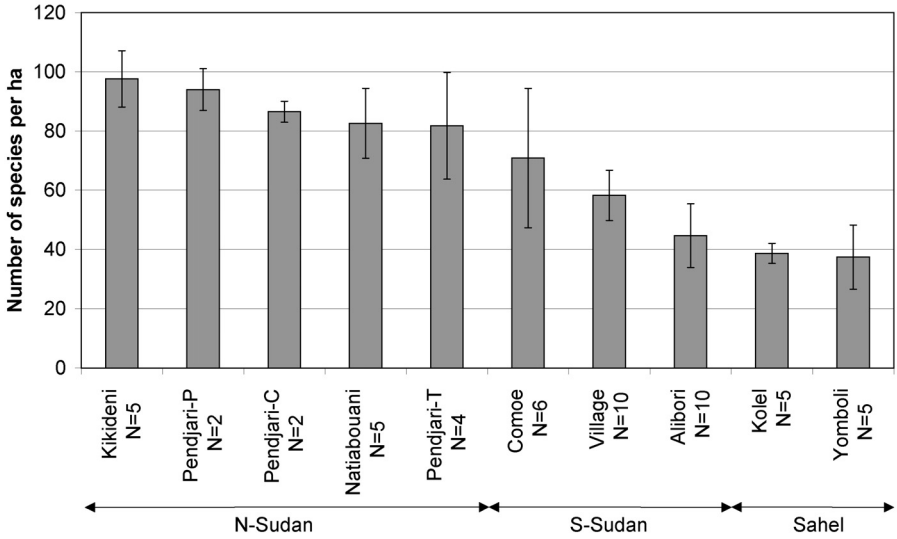

FIG. 2. Mean species richness of the 1-ha plots of the biodiversity observatories. Error bars indicate standard deviations; the number of plots is indicated below the observatory name.

5 Discussion

As the biodiversity observatories were strictly clustered according to the sequence in vegetation zones, the climatic gradient appears to be the most important parameter determining the pattern of plant species composition. The only exception occurred in the north Sudanian zone where the protected plots of the Pendjari National Park (Pendjari P) and the hunting zone (Pendjari C) were most similar to those from Natiabouani in the Pama Reserve. It may be concluded that the exclusion from agriculture and pastoralism was in this case more influential than the difference in climate. Both sites are located within a continuous system of protected areas, the so-called WAP complex, and only c. 150 km apart.

Another irregularity within the north Sudanian zone is the clustering of some plots from the pasture Village observatory together with the plots of the Alibori observatory. This could be explained by heterogeneity between the Village plots caused by different soil conditions. Shrub savanna colonises shallow stony soil while woodlands and savanna woodland prevail on deep sandy-clay soil. The shrub savannas are under a higher grazing pressure than woodland, savanna woodland and fallows (Agonyissa, 1996; Sinsin, 1993). These denser vegetation types are represented in the plots clustering with the Alibori plots.

Species richness on a landscape scale in West Africa is expected to rise with precipitation towards the South (Wieringa & Poorter, 2004; Adomou, 2005; Schmidt *et al.,* 2005), however in this study it showed a peak in the north Sudanian zone. The Péhunco and Comoé (Koulibaly *et al.,* 2006) regions which present the more humid savannas, exhibited species richness values lower than all the north Sudanian observatories.

Grazing pressure leads to an increase in plant diversity in the Fada N'Gourma and Péhunco regions as may be expected according to the intermediate disturbance

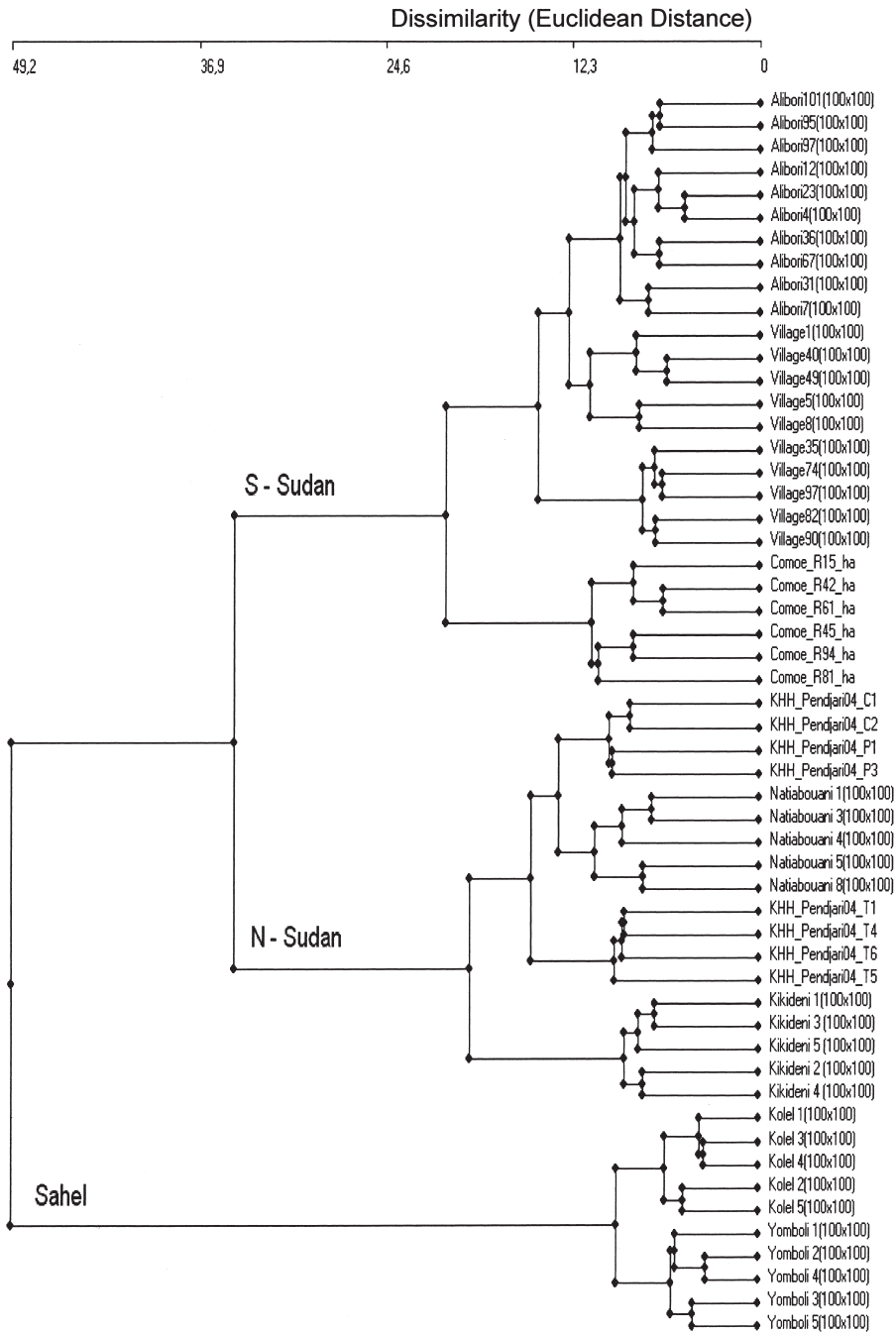

FIG. 3. Clustered relevé data (species presence/absence) from 10 biodiversity observatories (Ward's method, Euclidean distances).

hypothesis (Connell, 1978), whereas in the Pendjari region protected areas are richer in species than the pastured plots. The latter might be due to a very high grazing pressure in the area which leads to a decrease in species on the fallows. For the Fada N'Gourma region, a more detailed comparison was accomplished by Hahn-Hadjali *et al.* (2006).

Acknowledgements

We thank the German Federal Ministry of Education and Research for financing the BIOTA Africa project (funding code 01LC0617D1).

References

Adomou, A. C. (2005). *Vegetation patterns and environmental gradients in Benin: implications for biogeography and conservation*. Dissertation Wageningen University.

Agonyissa, D. (1996). *Productivité et capacité de charge des pâturages naturels au Bénin*. Mémoire d'Ingénieur Agronome. Faculté des Sciences Agronomiques. Université d'Abomey-Calavi.

Connell, J. H. (1978). Diversity in tropical rain forests and coral reefs. *Science* 199: 1302–1310.

Hahn-Hadjali, K., Schmidt, M. & Thiombiano, A. (2006). Phytodiversity dynamics in pastured and protected West African savannas. In: S. A. Ghazanfar & H. J. Beentje (eds.), *Taxonomy and ecology of African Plants: their conservation and sustainable use. Proceedings of the 17th AETFAT Congress Addis Abeba*, pp. 351–359. Royal Botanic Gardens, Kew.

Koulibaly, A., Goetze, D., Traoré, D. & Porembski, S. (2006). Protected versus exploited savanna: characteristics of the Sudanian vegetation in Ivory Coast. *Candollea* 61 (2): 425–452.

Pisces Conservation (2002). *Community Analysis Package 2.0*. Pisces Conservation Ltd, Lymington.

Schmidt, M., Kreft, H., Thiombiano, A. & Zizka, G. (2005). Herbarium collections and field data-based plant diversity maps for Burkina Faso. *Diversity & Distrib.* 11 (6): 509–516.

Schmiedel, U. & Jürgens, N. (2005). Biodiversity Observatories. A new standardised monitoring tool for biodiversity studies. In: M. Veste & C. Wissel (eds.), *Beiträge zur Vegetationsökologie der Trockengebiete und Desertifikation*. UFZ-Bericht 01/2005, pp. 87–91.

Sinsin, B. (1993). *Phytosociologie, écologie, valeur pastorale, production et capacité de charge des pâturages naturels du périmètre Nikki-Kalalé au Nord-Bénin*. Thèse de Docteur en sciences agronomiques. Université Libre de Bruxelles.

Wieringa, J. J. & Poorter, L. (2004). Biodiversity hotspots in West Africa; patterns and causes. In: L. Poorter, F. Bongers, F. Kouame & W. D. Hawthorne (eds.), *Biodiversity of West African forests. An ecological atlas of woody plant species*, pp. 61–72. CABI Publishing, Oxford.