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Full Length Research Paper

Crops diversity and typology of homegardens of Galim-Tignere (Adamawa, Cameroon)

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Homegardens are considered as a sustainable production system in the tropics, which contributes to biodiversity conservation. The aim of this study was the description of crop diversity, structure and management of homegardens in Galim-Tignere and their typology. For this, structured interviews had been realized beside 150 householders. These interviews were completed by dendrometric measurement on ligneous and the meteorological data were recorded. In all, 212 species were identified mainly distributed in staple food, fruit, vegetable, spice or medicinal plants. The number of strata of vegetation differed according to age and size of homegarden. The climatic conditions were moderate inside the homegardens rather than outside of them. The cluster analysis showed three groups that differed according to their composition of species. When the homegardens were kept well, they constitute an excellent area of biodiversity conservation and attenuate the more rough climatic conditions. However important efforts could be done in order to sensitize the peasants on the organization, improvement and the sustainable management of the agroforestry systems.

Keywords: Homegarden, biodiversity, climatic conditions, typology, agroforestry, crop, Galim-Tignere.

INTRODUCTION

Primary forest is frequently converted into unsustainable agricultural lands in many tropical regions including Sudano-Guinean Savannah of Cameroon. The promotion of sustainable production systems is one of the main solutions to conserve the nature (forest margins, even in protected areas) due to easy access. Tropical homegardens are generally regarded as sustainable production systems (Christanty, 1990; Torquebiau, 1992; Drescher, 1998; Abdoellah et al., 2001, Mapongmetsem et al., 2011). A homegarden is a clearly bounded piece of land cultivated with a diverse mixture of annual and perennial crops, and on which a house is built (Karyono, 1990). Especially in rural areas, the homegardens have the major functions of the subsistence production and income generation (Soemarwoto and Conway, 1992). Because of the high biodiversity existing in homegardens, a wide spectrum of multiple purpose products can be generated with relatively low labour, cash or other inputs (Christanty, 1990; Soemarwoto and Conway, 1992; Hochegger, 1998). Homegarden products have various natures. It comes from animals reared in the gardens, fruit species and others crops. It often has higher nutritional value in terms of protein, minerals and vitamins. In time or periods of scarcity, homegardens with their diverse products available year-round, contribute to food security (Mapongmetsem et al., 2002). They also fulfill many social, cultural and ecological functions (Abdoellah et al., 2001). The multi-layered, forest-like vegetation structure of homegardens contributes substantially to the sustainability of this production system. Among others,

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this structure can protect the soil from erosion, offers a habitat to wild plants and animals, promotes a favorable microclimate, and makes efficient use of light, water and other resources (Karyono, 1990; Torquebiau, 1992; Jose and Shanmugaratnam, 1993). Because of their large crop species and varietal diversity, homegardens are considered as an ideal production system for in situ conservation of genetic resources (Watson and Eyzaguirre, 2002). However, homegarden diversity varies according to its ecological characteristics or socio-economic factors of gardeners (Christanty et al., 1986). For example, species number and diversity were shown to be influenced by level of production intensity of homegardens and market access (Michon and Mary, 1994).

Homegardens was the subject of many classifications around the tropical regions. Unfortunately, there is none classification adopted. Different elements are commonly used to classify the homegardens. For example, homegarden characteristics such size and/or age were used (Millat e-Mustafa et al., 1996). Before, Nair (1985) has used further criteria to classify the homegardens. He used structure (vertical stratification), integration of livestock or socio-economic (level of inputs, subsistence or commercial production). Others authors like Christanty (1990) suggested that homegardens might be classified using the dominant plant species grown or the level of urbanization. Despite the number of classification schemes proposed for tropical homegardens, none has been agreed upon. Homegardens of Sudano-Guinean Savanah, particularly those of Galim-Tignere have been investigated in some depth (Mapongmetsem et al., 2002). On the other hand, even basic information about homegardening in the entire Sudano-Guinean region is still lacking. It is for this reason that this study was initiated. So this study aimed to describe crop diversity, structure, management, climatic parameters and classification of homegardens of Galim-Tignere.

MATERIALS ANDMETHODS

Study area

The study was conducted in Galim-Tignere, region situated at about 300 km from Ngaoundere, capital of Adamawa region (Cameroon), between 6^{e}and 8^{e}degree of north latitude. This region presents two seasons: one short dry season (November to march) and one long rainy season (March to October). The annual precipitation was1500 mm; the annual mean temperature is 23.4° C. The mean relative humidity annual rises to 66.79 %. The vegetation was shrub to arboreous. The villages retained within the context of this work were Sabongari, Mayo Sang-Nare, Wogomdou, Mayodankali, Ngouri, Tagouri, Djaligo, Mboudouaand Garbaya which are inhabited by Niza'a people. The choice has been done at the reasoned matter (easy access, opening to innovations…) with the help of vulgarization Agent of Zone (VAZ) of National Program of Vulgarization of Agricultural Researches of the region.

METHODS

The used of scientific approach was participative and reiterative. Households were randomly selected in each village. Questionnaires were managed to exploitation owners. The people number to survey was taken according to the number that we obtained previously near to the village leaders. The sample rate of surveyed people was 10% per village (Mapongmetsem, 2003). In all, 150 households were enquired. The unstructured questionnaire used included questions on age and function of the homegarden, main cultivated or reared and/or protected species, inputs and outputs, problems of homegarden management, use of homegarden products, etc. Secondary data concerning household characteristics, such as age, formal education or occupation of the household leaders was collected at the time of survey phase. Homegarden size was measured. Complete inventories were carried out to assess total plant, diversity number of species and varieties and abundance of crops and ornamentals. The occurrence of weeds was documented but not quantified. The plant identification was done at the field. Those that were not identified, the specimens were collected, dried and sent to National Herbarium of Cameroon for identification. Plants were recorded with local and/or scientific names. All individual plants were assigned to one of four strata (0-1.5 m; 1.5-3 m; 3-5 m; >5 m) for vertical structure analysis. This stratification was borrowed from Abdoellah et al. (2001) but was modified because the tree height was not the same. Based on gardeners' information and literature (Verheij and Coronel, 1992), crop species were classified into one of the following main use categories: spice, fruit, vegetable, stimulants/sugar, medicinal, staple food, wood, multiplepurpose-tree (MPT). In order to better understand the importance of homegardens in the improvement of well-being of the gardeners in the context of Galim-Tignere, the climatic parameters (relative humidity, the wind, the light and the temperature) were recorded during dry season at 6-8 h, 9-11 h, 12-14 h, 15-16 h and 17-18 hat inside of homegardens. The natural area without trees was considered.

Data analysis

Data were analyzed using the statistical package SPSS 11.0. Species density, number of spp./100 m² and Shannon-Index H' were calculated for every village. For

Table 1. Characteristicsof owners and exploitations in the nine studied villages.

	Sabongari		Mayo Sang-Naré		Wogomdou		Mayo dankali		Ngouri		Tagouri		Djaligo		Mboudoua		Garbaya	
	M	Range	M	Range	M	Range	M	Range	M	Range	M	Range	M	Range	M	Range	M	Range
Ages of household head (years)	44	25-65	44	25-61	43	22-60	46	27-71	47	29-77	55	30-85	47	29-70	43	30-80	44	20-60
Families size (no)	8	4-18	9	3-18	6	3-14	6	2-13	6	2-11	8	3-12	7	2-13	9	4-18	7	1-13
Age of homegarden(years)	22	4-40	23	12-40	22	7-46	15	2-53	11	5-18	27	6-70	12	5-20	19	4-35	25	15-45
Homegardens size (ha)	0.75	0.05-2	0.8	0.05-2	0.64	0.04-2.5	0.14	0.04-0.5	0.31	0.03-1	0.61	0.05-3	0.52	0.08-2	1.1	0.05-3.5	0.46	0.05-1.5
Permanent active number	4	1-10	3	2-4	3	2-4	2	1-5	3	1-8	4	1-11	3	2-4	4	2-8	3	1-4

M: Median

classification of homegardens, a cluster analysis considering the occurrence of crop species presence or absence was performed, applying squared Euclidean distances as a measure of dissimilarity and the average linkage method.

RESULTS

Characterization of exploitations and their management

The homegardens surveyed were established four to 70 years ago and ranged from 0.05 to 3.5 ha in size. At Wogomdou, Tagouri and Garbaya, homegardens were relatively old. In all villages, homegardens were managed by small families that had 6 to 9 persons in mean (Table 1). The main function of homegardens in these nine villages was to supply gardeners'families with non-staple food, chiefly cereals, fruits, vegetables and spices. However excess of some products was sold in order to acquire income that allow them to pay the essential products (soap, kerosene, table oil) and very often the school fees of their children. Its role during the difficult periods was considerable.

In all homegardeners, owners reared animals either for local consumption or for cultural rites or like prestige breeding. The main type of breeding practiced were poultry farming (49.2 %), apiculture (30.8 %), caprine breeding (16.2 %) and cattle (11.3 %). Ducks, dogs were signalized sporadically in homegardens. The pig breeding was not practiced in this region because according to Muslim culture, that was very dominant in the region, the breeding and the consumption of pig were prohibited.

Some gardeners considered the production of fruits, vegetable, tubers and medicinal plants which come from their work sufficient for their families. In spite of all their importance, the productivity of these systems seems widely underused. For example, the management of fruits was left between the hands of vulnerable social levels (women and children), men dealt with works that required strength and nevertheless the annual production of fruit was important (16 tons) and could be a productive sector of income.

Few or no external inputs (chemical fertilizer or pesticide) were applied in homegardens. Instead of external inputs, 80% of gardeners used traditional methods to reduce pest and parasitical attacks (spraying soap-suds, cutting off infested plant parts, dusting with ash) and all of them applied organic fertilizers mainly animal manure and mulch or ash. These practices varied from one village to another.

Crop diversity

A total of 212 crop species were identified in homegardens of Galim-Tignere region. Their frequency varied according to exploitations and the characteristics of owners. Some crops species were classified according to their predominant use each as spice, fruits, vegetable, medicinal, or wood and timber plants. The remaining species were used for staple food, fodder, wrapping or handicraft; a few species were considered as multi-purpose trees. The cultivated species most frequently were mango (*Mangifera indica*), banana (*Musa paradisiaca*), avocado (*Persea americana*), lemon (*Citrus lemon*), guava (*Psidium guajava*), tomato, lemon grass (*Cymbopogon citrates*), taro (*Colocasia esculenta*), macabo (*Colocassia sagitifolium*), sweet potato (*Ipomoea batatas*), maize (*Zeamais*), groundnut (*Arachis hypogea*), bean (*Phaseolus vulgaris*), cassava (*Manihot esculenta),*

Table 2. Crop density of homegardens in nine villages of Galim-Tignere

	Garbaya	Mboudoua	Djaligo	Tagouri	Ngouri	Mayo dankali	Wogomdou	Mayo Sang Naré	Sabongari
Total species (no)	103	140	129	154	143	120	162	135	115
Mean spp/garden	63	75	68	37	68	78	67	97	58
Mean spp density (no/100 m²)	6.13	8.34	7.68	9.17	8.51	7.14	9.65	8.04	6.85
Mean Shannon index H'	2.36	1.92	2.09	1.8	2.2	2.3	1.9	2.01	2.4

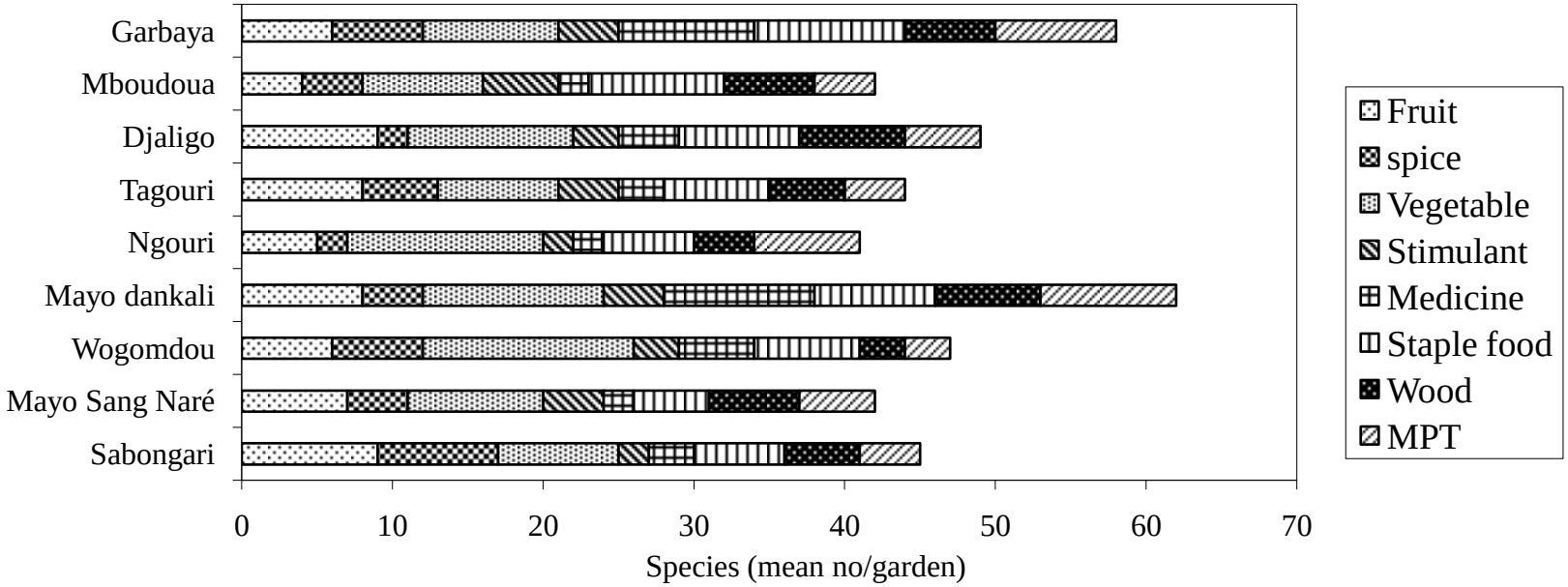

Fig. 1. Plant species (mean no.) of different use categories per garden in nine villages

Vigna unguiculata, Solanum tuberosum and *Dioscorea* spp. These results were similar with those of Mapongmetsem et al. (2011). In addition to crops, ornamental and weed species were identified. The majority of weed species were considered to have medicinal value. The spectrum of species present in homegardens was different among the nine villages.

However there was a higher similarity of species

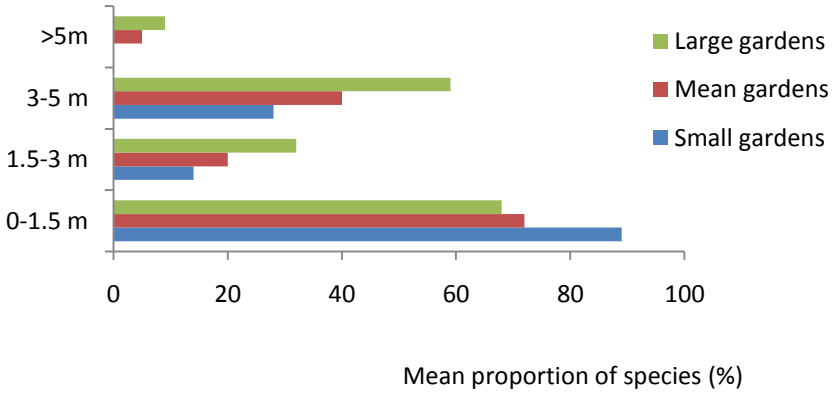

Fig. 2. Mean proportion of crop species occurring in different strata in small, mean and large homegardens in nine villages of Galim-Tignere

composition between villages for the cultivated species. The common species to all villages included the fruits (banana, mango, guava, lemon and avocado); the root and tuber crops (cassava, sweet potato, yam and taro); the spices (*Capsicum* sp, lemon grass); the cereals. Crop species including yam and potato grown mainly for sale were found also in the homegardens of all villages. Likewise, some species were found in the homegardens, among them mainly forest tree species used for construction, fuel wood, shade tree, medicine and fruit or for mystical reasons.

Total number of crop species as well as average number of species per garden, species density and diversity (Shannon's H') were highest in the homegarden of all villages. It varied from 1.8 to 2.4 (Table 2). A significantly lower mean number of spice, stimulant and medicine, and a greater number of vegetable, fruit and staple food were grown in Ngouri and Djaigo compared to the Garbaya, Mayo dankali and Wogomdou (Figure 1).

Structure of homegardens

In all homegardens, crop species number decreased from the lower to the higher strata, however, not continuously. A higher proportion of crop species was found in the third than in the second layer. In all strata, the mean gardens occupy the second row in term of proportion of species. In small gardens (<0.5ha), the highest proportion of crop species occurred in the first layer (0-1.5 m), while in large gardens (>1ha), it was contained in the third layer (3-5 m) (Figure 2). In small gardens, the proportion of species in the upper strata (>1.5 m) was generally smaller than in the mean and large gardens. In most of the small gardens, no strata higher than 5 m were found.

Unlike the vertical distribution of species, the proportion of crop plant individuals per garden decreased continuously towards higher strata (Figure 3). Small gardens showed a higher proportion of individuals in the first stratum (0-1.5 m), however, a significantly lower proportion in the higher strata than the large gardens.

Climatic parameters

The daily evolution of relative humidity, temperature, lights and the wind was presented in figure 4. The analysis of the figure shows that all of the categories of homegardens present a high relative humidity (more than 85%) between 6 and 8 o'clock but decrease rapidly at nine o'clock. This decrease varied from 13.02% to 14.84% respectively for outside of homegarden and the large homegarden. It continues up to maximum varying according to the types for 3 hour p.m.

The curves of temperature present a hyperbolic form. The temperatures were low at the first hours of the morning and at the evening. In proportion as the sun rise, the temperature increases up to optimum varying according to the categories of homegardens decreases. The maximum temperature was registered in homegardens of small area between 12 and 14 o'clock (28.88°C) whereas the lowest was observed in large homegardens (21.13°C). As for the velocity of the wind, it was early in all of the types of homegarden.

It increases rapidly between nine and 11 o'clock. This rising of the velocity varies to 0.97 $m.s^{-1}$to 1.03 $m.s^{-1}$ respectively in large homegarden and control. It continues till an optimal value according to the types and its decrease.

The luminosity varies according to the daily periods and of one group to other. In the morning, (6-8 h am), it was of 215.2 Lux in large homegardens and of 597 Lux at outside of homegardens (control). It increases rapidly from 9 to 11 a.m., reaches an optimum varying according to categories in the day (12-14 o'clock). Between 15 and 16 pm, it decreases in all types of homegarden. Among the different types, the light quantity is not the same. The large homegardens receive the low quantity of the light when the small homegardens receive the higher quantity. Nevertheless, the quantity of light keeps the same pace in all types of homegardens.

Classification

Applying cluster analysis, three groups of homegardens were distinguished (Figure 4). Groups 1 were constituted by seventy-four gardens, mainly from five villages (Sabongari, Mayo Sang Naré, Wogomdou, Mayo dankali and Ngouri), while the two other group included forty- three

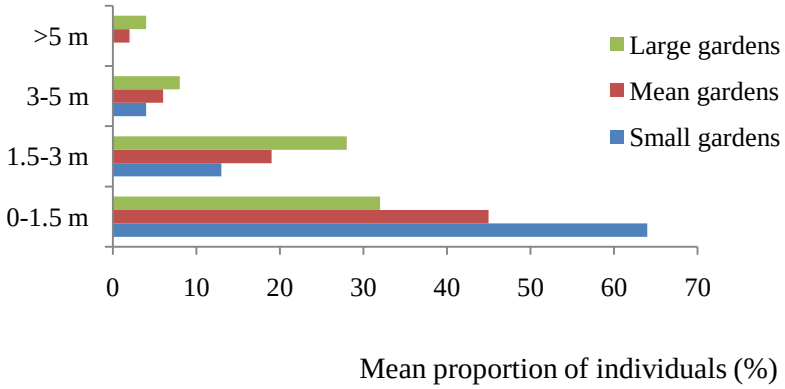

Fig. 3. Mean proportion of individuals of crop species occurring in different strata in small, mean and largegardens in nine villages of Galim-Tignere.

and thirty-three gardens, respectively. It was predominated by the homegardens coming from Ngouri, Tagouri, Djaligo and Mboudoua for the second group and from Djaligo, Mboudoua and Garbaya for the third one.

In all homegardens of group 1, Taro and sweet potato were grown, but only some tree species. Only 26 species, of which 35% were spices, occurred in the majority of these gardens, 10 % of them represented staple food. In the gardens of group 2, fruit or tree species such as avocado, banana, guava, mangoes and lemon were always present. Of the 19 species, which were common to the greater part of these gardens, 24% were fruit species and only 12 % were spices. The majority of these species was used for familial consumption. In all homegardens of group 3, maize and cassava occurred. Only 16 species were common to the majority of these gardens, among them 29% of fruit species, 19% of stimulant species and frequently multipurpose tree species. All gardens of group 3 were managed by monogamous owners, including one garden which was owned by polygamous.

Although the cluster analysis was performed only on the basis of species composition, marked differences were also found with regard to mean garden age and size, number of crop species and Shannon index among groups 1 to 3. On the basis of species composition (Figure 5) and these additional garden characteristics, the 150 homegardens were classified into the following major types:

Small, moderately old, species- and tree-poor spice gardens

Medium-sized, old, species-rich fruit tree gardens

Large, rather young, species- and tree-poor gardens

DISCUSSION

Classification

The cluster analysis of crop species presence or absence appears to be an important, practicable method for a reproducible classification of homegardens. Many others authors had used this method in tropical region (Maponmetsem et al., 2011). In the case of homegarden of Galim-Tignere, the difference of species could be explained by the education level. According to Leivaetal.(2002), these similar differences in species composition were caused by ethnicity of gardeners in Guatemala. Moreover, other characteristics such as garden age and size or importance of diversity were important and could be used in classification of homegardens. In this study, a classification of homegardens based on common criteria, which were easy to assess such as homegarden size, number of vegetation layers, integration of livestock, level of inputs did not seem practicable because in reality there were appeared that many homegardens were identical in terms of size. Generally, these exploitations were created for some subsistence-needs. A classification based on some characteristics such as traditional, subsistence-oriented versus modern, market-orientated production, as suggested by Christanty (1990), could be more interesting, however could be biased by individual ways of assessing these selected criteria by the researcher. Cluster analysis of crop species composition has been applied in the case of homegarden only recently by the researchers of the Central and Latin America like Leiva et al. (2002) in Guatemala and Quiroz et al. (2002) in Venezuela.

Diversity

As most of the gardens studied did not play an outstanding role, the total plant diversity of the homegardens investigated, including 212 crop and ornamental species, as well as the average per garden were rather high and comparable to plant diversity of homegardens studied in other localities of tropical region.

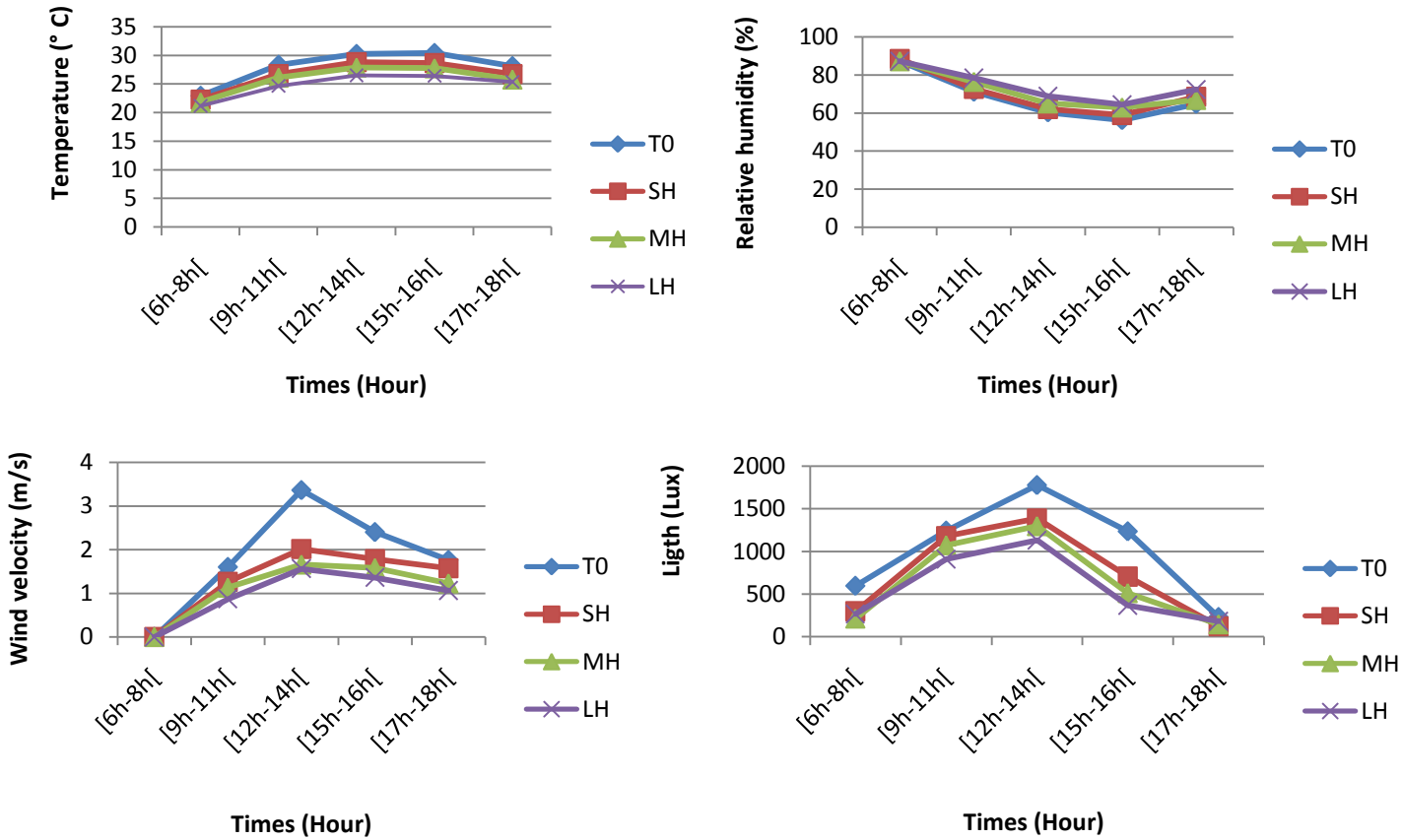

Fig. 4. Daily **e**volution of the climatic parameters in the different categories of homegarden. T0: Natural area (outside of homegarden) ;SH : Small homegarden; MH: Mean homegarden; LH: Large homegarden

Researching one single village in Java each, Abdoellah et al. (2001) listed a total of 195 plant species in 92 homegardens while Mapongmetsem et al. (2000C) documented 122 plants pecies in homegardens of the Kandal province (Cambodge) in South East Asia. Wezel and Bender (2003) only registered a total of 101 crop species with also considerably lower mean Shannon indices 1.63-1.79 per village in a comparable study performed in 31 homegardens of 3 villages in Cuba. Mean Shannon indices vary widely in tropical homegardens and are reported from 0.93 in rural Zambia (Drescher, 1998) to almost 3.0 in West Java, Indonesia (Karyono, 1990).

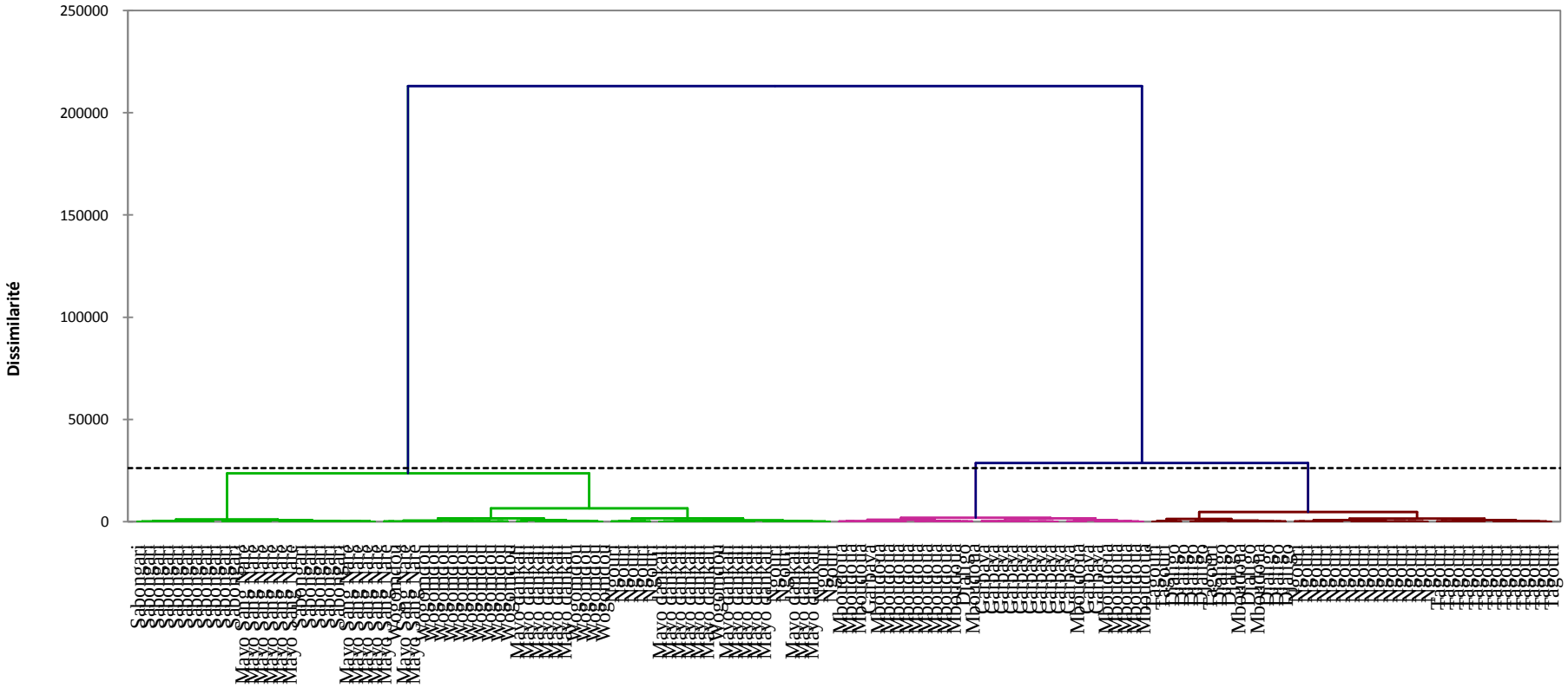

Fig. 5: Dendrogram classifying 150 homegardens in nine villages of the Galim-Tignere region, Adamawa, Cameroon, according to their species composition

Depending on the socio-economic status and occupation of the gardener, garden functions ranged from ornamental to kitchen garden. However, typical differences were found among gardens of the nine villages. The higher crop diversity in the almost village (Table 2) could

have resulted from weak market access, which encouraged subsistence-orientated production. The surrender of fruits between the hands of vulnerable social level (women and children) shown at wish that the homegarden species are not destined to sell but rather that the homegardens were created for subsistence production. However, some villages had more species than others. The lower crop diversity in Garbaya and Sabongari, on the other hand, may have resulted from the availability of fruits, vegetables, spices and medicines which could be sent in the neighboring markets of Galim-Tignere and Tignere. It is known that proximity of markets and the associated commercialization may lead to a loss of homegarden diversity as reported by Michon and Mary (1994). The homegardens play a more important role in the production of staple crops. This is illustrated by the higher presence of vegetable, fruits, maize and other consumable crops in the nine villages. Besides ethnicity, soil fertility may also have played an important role. Unfortunately, in this study, the analysis of soil element content had not been done. However, the gardeners explained that for improvement of the soil fertility, they used sweepings, ashes and other organic manures. Low soil fertility could be among the reasons for the lower mean number of spice and vegetable species per homegarden in some villages like Mayo Sang-Naré and Ngouri (Figure 2). Since personal preferences of the gardeners might also have influenced diversity and species composition, research is needed to quantify the effects of particular factors on crop diversity in these homegardens in Galim-Tignere region. A better understanding of these dependencies could prove crop diversity to be an integral factor of sustainability for tropical homegardens.

Structure

Not all homegardens investigated possessed a multilayered vegetation structure, which offers advantages in reduction of soil erosion or efficient use of resources. Smaller homegardens as well as the younger ones often lacked the upper strata. Abdoellah et al. (2001) also observed the lack of vegetation layers higher than 5 m in the majority of small homegardens. Karyono 1990 reported only 1.3% of all species and 5.7% of all individuals in the upper layer (>10 m) in Javanese homegardens with an average size of 230 m². Hochegger 1998, on the other hand, noted 32% of all species in the layer above 10 m for homegardens in Sri Lanka, which were rather old and very large.

Age and size of homegardens could influence their vegetation structure. Contrary to the findings of Christanty et al.(1986) or Jose and Shanmugaratnam (1993), the vegetation structure of old and large homegardens of the Napu Valley was very different from that of the natural primary forest nearby. Height, density and diversity of vegetation were not comparable to forest, a finding also reported by Gajaseni and Gajaseni (1999) and Hochegger (1998). The homegardens investigated resembled rather a secondary forest kept in its young state as suggested by Jensen (1993).

In some homegardens, there were patches without ground cover or litter layer due to repeated hoeing and burning of all residues. Ground cover and litter layers protect the soil from erosion (Hochegger, 1998; Karyono 1990). As a consequence of this clearing, parts of some homegardens in the Galim-Tignere region suffered from soil erosion and loss of soil organic matter. Therefore, the sustainability of gardens managed in the same way should be questioned. The insufficient use of available farm yard manure or organic fertilizers by some gardeners may have accentuated the low soil fertility. This probably has restricted the full expression of this system's production potential, despite its high crop diversity and the wide range of resulting products. The contribution of homegarden products to the livelihood of garden keepers not only in Sulawesi but throughout the tropics should be improved through education and extension services, which have largely ignored this system as such.

Climatic parameters

The homegardens constitute an environment where the climatic parameters are moderate. In small homegardens, the conditions were not different with control (outside of homegarden). The lack of upper strata and the density of species could explain it. Here, the tree peaks were not joined and that the light can reach the inside of homegarden increasing the climatic parameters. Beside that the presence of trees in their homegarden is their culture; unfortunately the space homegarden cannot be enough for introduction of trees. Since the space is weak for all species, the gardeners prefer to consecrate it to consumable species. The difficult selling of tree products could be another reason to explain this situation. On the other hand, the gardeners had understood the role of trees. Indeed, trees decelerate erosion of the soil and participate to improve the soil fertility by their litters. The trees intervene in the struggle against the wind action. Thus in large homegardens where all strata were present and the tree density is high, the velocity of wind, the temperature, the light and the relative humidity are almost same to the forest.

CONCLUSION

This study had allowed to bring out the importance of agroforestry systems in the biodiversity conservation. In some homegardens, the repeated hoeing and burning of all residues mean that there were patches without ground

cover or litter layer. As a consequence of this clearing, parts of some homegardens in Galim-Tigneremaysuffer from soil erosion and loss of soil organic matter. Therefore, the sustainability of gardens managed in the same way should be questioned. The insufficient use of manure or organic fertilizers by some gardeners may have accentuated the low soil fertility; this probably has limited the full expression of this system's production potential, despite its high crop diversity and the wide range of resulting products. The importance of tree diversity has produced the best climatic conditions inside the homegardens and this permitted to gardeners to suffer les the influence of climatic change. This contribution of homegarden to the livelihood of gardeners not only in Galim-Tignere but throughout the tropical region should be improved through education and extension services, which have largely ignored this system as such.

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