Chapter 5

Discussion

General characteristics of ethnic homegardens

Hmong Homegarden

The Hmong are mountainous people, who prefer to live at high elevations, normally at 1000–2000 m altitude (Oranratmanee 2013) where they establish homegardens on both flat and sloping terrain. Most plants in Hmong homegardens are grown on the flat areas which are easier to take care of and harvest. Therefore the scarcity of flat area was one of the most important factors determining the characteristics of Hmong homegardens.

Most Hmong homegardens are made up of two separate zones, the front and the back yard. The house style of Hmong has been influenced by Chinese architecture (Oranratmanee 2013) which is also similar to Lisu and Yunnan Chinese house style. Lack of terrain force Hmong people to build their houses very close together, so generally there was no side yard as part of Hmong homegardens. Most plants in the front yard were ornamental species kept in pots and some small trees at the corners of the homegardens.

As for most ethnic group, yard and homegarden boundaries were two important places for keeping plants. But, because of the scarcity of flat areas, pots were also commonly found in Hmong homegardens. Pots are one of the most suitable ways to solve the problem of limited space because pot plants require only a small space and could be horizontally arranged (Cruz-García and Struik 2015).

The number of species found in Hmong homegardens was high, compared to homegardens of other mountainous people like Lisu or Yunnan Chinese. This was because Hmong people were good in conserving their traditional plants and adapting to new plant species (Srithi et al. 2012). A good example of the conservation habits of Hmong people was that they still kept many traditional species and vegetables that they used for the chicken soup, which is one of the most important signature of Hmong cuisine.

Although the number of species found in Hmong homegardens was relatively high, comparing to other mountainous ethnic groups in this study, it was lower than in Nan province where more than 400 species were found in Hmong homegardens (Srithi et al. 2012). One important reason for this difference was the range of elevations. In this study, two Hmong villages were located at 1000–1200 m elevation while the study in Nan province covered the range from 220–1252 m elevation. However, when only villages at the same elevation were considered, the number of all species and average species per homegarden were quite similar (there were 138 species and 17 species/homegarden from Hmong in Nan province while in this study there were 123-127 species and 13-15 species/homegarden). This result suggested that elevation was an important factor in determining the richness of species in homegardens.

Because of the scarcity of area, trees were rare in Hmong homegardens, and only 49 species were found. Trees require quite large spaces (Abdoellah et al. 2002; Hodel et al. 1999; Kehlenbeck 2007), so without enough area the gardeners did not have space for planting any trees in their homegardens. The most common species included common food species *Psidium guajava* L., *Persea americana* Mill., and *Carica papaya* L. Moreover, because they lived at high elevations, temperate fruit species like *Persea americana* Mill. were common there. Beside fruit species, *Dracaena fragrans* (L.) Ker Gawl., a common ornamental species, was also common in Hmong village. This species was easy to grow; the habit includes a slender stem with a small canopy, and with the auspicious name in Thai language make it popular in Hmong homegardens. It should be noted that these species were common among the homegardens in Thailand and none of them were culturally important species (Srithi et al. 2012).

The most common species found in Hmong homegardens were food *additive species* including *Alpinia galanga* (L.) Willd., *Capsicum annuum* L., *Curcuma longa* L., and *Cymbopogon citratus* Stapf. These species were used on a daily basis in Hmong dishes. All of them were small herbs and easy to propagate. For these reasons, these plants were very common in Hmong homegardens. Other non-woody species favored by Hmong people were *Gynura bicolor* DC, one of the important ingredient of chicken soup which is the signature dish of Hmong. This species was common in Hmong homegardens (Srithi et al. 2012).

Unlike most other ethnic homegardens, those of the Hmong had a high proportion of medicinal species. The knowledge of medicinal plants was more restrict to the cultural boundary than other knowledge (Quave and Pieroni 2015). Therefore in the conservative knowledge like that of the Hmong people (Srithi et al. 2012), the knowledge of medicinal plants was still well conserved. Moreover, it should be noted that most information about medicinal plants in Hmong homegardens were provided by female informants. Hmong society is patrilineal, so normally the member of family who had contact with other ethnic groups would be the male members. Many women in the Hmong village cannot speak or understand the Thai language. This limitation resulted in the less knowledge of modern medicine practices. The Hmong women still had well preserved knowledge of their traditional medicine which mostly was used to cure their children which was their direct and important duties.

Karen Homegarden

The Karen are one of the largest ethnic groups in Thailand. Their communities are located in various locations, ranging from the flat land at low elevation (Mae Tom village at 826 m elevation) to the mountainous area at high elevation (Khun Tuen Noi village at 1185 m elevation). This elevation range directly affected the total number of species found in Karen homegardens in the same way as for the Hmong homegardens. Despite the variation of the location of their villages, there were many common characteristics among the different Karen village.

Generally, Karen people had the homegarden surrounding their houses, so there was a front yard, back yard and two side yards. The proportion of each area could vary from house to house, and place to place depending on the location of their house and the preference of the owners. The homegardens of Karen had cleared borders that separated one homegarden from other ones or the public area. From these characteristics, most plants in Karen homegardens were found in the yard and homegarden boundary zone.

Because of the large area left for planting, Karen homegardens had high numbers of plants. The recorded species richness was similar to that of some other homegardens elsewhere in Thailand (Lattirasuvan et al. 2010; Moreno-Black et al. 1996; Panyadee et al. 2012) and nearby countries (Milow et al. 2013; Trinh et al. 2003). Most plants in Karen homegardens are common elsewhere in Thailand. The Karen in Thailand migrated from Mynmar (Schmidt-Vogt 1999) where the ecosystems and plants species are similar to what is found in their current territory in Thailand.

Yards were found in all studied homegardens. The high inncidence of yards in Karen homegarden is similar to the situation in other homegardens in northeast Thailand (Cruz-García and Struik 2015).

Karen planted many species at the homegarden border to delimit their territory, especially along the backyard. These species were most commonly *Cestrum nocturnum* L., *Euphorbia cotinifolia* L., and *Jatropha curcas* L., but also included some others. Unlike a fence made of wood or bamboo, these living fences are more durable. The front yard, which is connected to the village road, and the side yard, which is always connected to other homegardens, need clear borders, and it is, therefore, fences are made.

Many homegarden front yards were clear and clean areas because they were used for drying farm products. But unlike Hmong or Yunnan Chineses homegardens, there were always plants in this area.

Many plants with *environmental uses* were cultivated along this fence together with many *food* and *food additive* species. Homegarden boundaries were found in at least 78% of homegardens in each village (100% in Khun Tuen Noi and Mae Tom village). The percentage is higher than in homegardens elsewhere in northeastern Thailand (Cruz-García and Struik 2015). The difference may be the result of the studied plant categories. In this study, *environmental use* was included while the other studies included only wild edible species. Omnipresent domestic animals, such as chicken and pigs, are kept in a shelter so fenced plots were quite uncommon in most of the studied Karen homegardens.

Mango and jackfruit were the only two species that were common and abundant in all villages. The mango is very easy to cultivate (Alam 2012) and it is found in many homegardens throughout Thailand (Gajaseni and Gajaseni 1999; Panyadee et al. 2016; Panyadee et al. 2012) and the tropics (e.g., Abebe et al. 2010; Alam 2012; Kabir and Webb 2008a; Vlkova et al. 2010; Wezel and Ohl 2006).

The jackfruit, like the mango, is easy to cultivate, and it is, therefore, also found in many homegardens around the world (Gajaseni and Gajaseni 1999; Kabir and Webb 2009; Kabir and Webb 2008b; Kehlenbeck and Maass 2004; Srithi et al. 2012; Trinh et al. 2003). The ripe fruits provide a delicious dessert while leaves were eaten as spicy salad. The jackfruit is also mentioned as one the most common species in homegardens from other regions (Kabir and Webb 2008a; Milow et al. 2013; Trinh et al. 2003). The ripe fruits provide a delicious dessert while raw fruits can be cooked as a curry.

Taro (*Colocasia esculenta* (L.) Schott) was the most common species of all Karen villages. This species was used mainly to feed pigs. The taro can grow in a wide range of environmental conditions (Wilson and Siemonsma 1996). Taro is also shade tolerant which makes it suited for being cultivated under tree species in homegardens. Moreover this plant is also easy to propagate, using various vegetative parts such as small corms, cormels, stolon, suckers, and head-sets. For these reasons and its usefulness, taro is commonly found in any homegarden.

Lahu Homegarden

Lahu are mountainous people, traditionally, they lived at high elevation at 1000–1,300 m altitude. Lahu homegardens were created on both flat and sloping areas like those of other mountainous ethnic groups. Land scarcity was one of the important factors determining the characteristic of their homegardens.

The homestead of Lahu people is composed of a house and the space around it. This character was like the Karen homegarden but Lahu people preferred a cleared space rather than planting any plants around their houses. Most plants in Lahu homegardens were found in the back yard and along the border of the back yard. The front and the side yards were mostly left as clear space.

The number of species found in Lahu homegardens was very low. One reason is the limitation of the land, but also because of their life and housing style. Normally, there was no clear border separating one homegarden from another. Unlike, Hmong or Lisu which at least had a clear border at back yard, Lahu homegarden garden seemed to not have any clear border. Some homegardens were completely surrounded by others. The lack of clear borders in their homegardens resulted in a less possessive feeling to the land which leads to the reduced numbers of plants in the homegardens.

Another possible explanation for the low number of plants in Lahu homegardens is the level of dependence on their homegardens. Most Lahu people had their own crop fields outside the villages. Most of their vegetables came from these fields and the forest between their field and village. The less they relied on the homegardens, the less plants would they cultivate.

Pots were uncommon in Lahu homegardens, even if they were constrained by the lack of flat land like many mountainous ethnic groups, e.g. the Lisu and Yunnan Chinese. Lahu people preferred to solve this problem by planting their plants in crop field or by gathering plants from the forest rather than keeping them in homegardens.

Food plants were still the most important use category in Lahu homegardens, as also found in other ethnic homegardens. However, Lahu homegardens had very low proportion of plants with *environmental uses*, compared to other ethnic groups. As mentioned above, Lahu people got most of their plant products from outside the homegardens. The time they had available for their homegardens was less than in other ethnic groups. In this case, planting ornamental plants (which was the main sub-group in *environmental uses*) which need time and energy to take care would not have suited their life style. The common trees in Lahu homegardens were mango and guava tree common species which could be grown easily across the world.

Lawa Homegarden

Lawa is one of the oldest indigenous groups in northern Thailand who nowadays live scattered in various geographical areas. I studied two studied Lawa villages located in very different geographical areas. One was in a remote mountain area while another was located in flat lands near to Yuan communities. The total number of species was high, and similar to those in many studied groups in Thailand (Lattirasuvan et al. 2010; Moreno-Black et al. 1996; Panyadee et al. 2012) and nearby countries (Milow et al. 2013; Trinh et al. 2003). Despite being scattered in many different places, there are many common characteristics for the Lawa homegardens.

Normally the yards of Lawa homegardens were divided into front, back, and side yards with clear boundaries. Most of the plants were found in yard and along their boundaries. These zones were found in all studied homegardens which is similar to Thai Yuan homegardens (Panyadee et al. 2016).

Yard and homegarden boundaries were the two most common horizontal zones in all Lawa homegardens. As mentioned above, there were always at least three parts of the yard in Lawa homegardens which at least one of them always had some plants.

Lawa homegardens, normally, had a clear border which encouraged the homegardeners to cultivate many plants along this zone. Without a clear border between the homegardens, planting could cause conflicts between the neighbors. Moreover, a clear possession of the land also promotes the richness in homegarden.

Pots were also important and they were found in most Lawa homegardens. However, unlike Hmong or Yunnan Chinese, most pots in Lawa homegardens were not there because the garden was lacking area and most of them were not vertically arranged. The main reasons that Lawa gardeners kept plant in the pots was because they needed to separate them from other species to make it easier to take care of them and harvest them. Some pots were kept in their houses, especialle ones that contained spice plants like *Allium hookeri* Thwaites used in dishes daily.

Woody species in the Lawa homegarden were different from place to place especially when it came to the common species. All common woody species in both studied villages were cultivated as fruit and ornamental species. Although these villages were located in very different geographic areas, the main force behind the difference was the gardener’s preference which is one of the important factor determining homegarden characteristics (Bardhan et al. 2012; Cruz-García and Struik 2015; Milow et al. 2013; Moreno-Black et al. 1996; Srithi et al. 2012). Only the mango was common in both villages. The mango is easy to cultivate (Alam 2012) and it is found in many homegardens throughout Thailand (Gajaseni and Gajaseni 1999; Panyadee et al. 2016; Panyadee et al. 2012) and the tropics (e.g., Abebe et al. 2010; Alam 2012; Kabir and Webb 2008a; Vlkova et al. 2010; Wezel and Ohl 2006).

Unlike common woody species, most common herbaceous species were found in both Lawa villages. Most of them were *food additives* that were used on a daily basis in their cuisine. These species included *Alpinia galanga* (L.) Willd., *Curcuma longa* L., *Cymbopogon citratus* Stapf, and *Piper samentosum* Roxb. It could be said that the preference of the owners was one of the important factors that determineed the presence of any species in the Lawa homegardens.

Two main plants group in Lawa homegardens were plants used for *food* and those with *environmental uses.* This was similar to other ethnic group and what has been reported around the world (e.g., Abebe et al. 2006; Gajaseni and Gajaseni 1999; Wezel and Ohl 2006). Keeping food for immediate uses in daily life was the main purposes of the homegardens. While the increase of species with *environmental uses*, especially ornamental species, had demonstrated the effects of urbanization (Milow et al. 2013; Peyre et al. 2006).

Lisu Homegarden

The Lisu live mostly in mountain areas, at 1300–1700 m elevation. Their homegardens are set up on both flat and sloping ground. The number and species found in Lisu homegardens varied from place to place according to the availability of land and economic status of the owners. There were, however, some common characteristics among the Lisu homegardens.

The Lisu house style was similar to that of the Hmong and Yunnan, so their homegardens shared some common characteristics: they had two separate yards; a clear space at the front and a cultivated space at the back. The houses were close to each other, normally witout a clear border between them. Most plants at the front yard were ornamentals while edible species were kept mostly at the back yard.

Most plants in Lisu homegadens were found in the back yard and along the borders which is similar to the gardens of most other ethnic groups. However, because of the lack of flat land, pots were present in many Lisu homegardens. This was like the Hmong and Yunnan Chinese homegardens. Most of the pots were vertically arranged, which may be related the lack of the land for planting. The lack of land also caused the low species richness found in Lisu homegardens.

The number of species found in the two Lisu villages in this study differed much especially in size which was one of the important factors (Abebe et al. 2006; Albuquerque et al. 2005; Kabir and Webb 2009; Lattirasuvan et al. 2010).

The common trees in Lisu homegardens included the common fruit species, *i.e.*, mango (*Mangifera indica* L.), jackfruit (*Artocarpus heterophyllus* Lam.), guava (*Psidium guajava* L.), and papaya (*Carica papaya* L.). These are common species, easy to grow and distributed throughout the tropics (Soepadmo 1991; Soetopo 1991; Sukonthasing et al. 1991; Villegas 1991).

Capsicum frutescens L. was the only common species in Lisu homegarden. This *food additive* species is easy to grow and is used in most cuisines. Most of *C. frutescens* found in the studied homegarden were self-grown plants in the yard area.

Thai Yuan Homegarden

The Thai Yuan are the majority people of northern Thailand. They live mostly in flat areas at low elevations. The sufficiency of land, the long occupation, and the location of Thai Yuan villages has shaped their homegardens which are quite different from those of other ethnic groups.

Most plants in Thai Yuan homegarden were kept within the yard and boundary. These two zones were found in all studied homegardens. Normally the homestead of Thai Yuan includes a house, a large yard mostly behind the house, fences made from permanent materials like concrete or wood. The yard is the largest area and found in all studied homegardens. Because the Thai Yuan live in flat areas, the gardeners have enough yard area for planting trees and making vegetable beds.

The boundaries of Thai Yuan homegardens were very clear and different homegardens were clearly separated from each other. Most plants around this zone were small trees because they might cross the border to the neighbor homegardens too much if they were too big.

Thai Yuan homegardens had the highest plant diversity and richness among all the studied ethnic homegardens. The reasons behind this could be the larger size of the homegardens (Abebe et al. 2006; Albuquerque et al. 2005; Kabir and Webb 2009; Lattirasuvan et al. 2010), or that the land was suitable for planting because of the long occupation (Perrault-Archambault and Coomes 2008; Pinho et al. 2011; Trinh et al. 2003; Vlkova et al. 2010). Moreover, their village location was easy to access, encouraging the import of new plants to their homegarden (Kabir and Webb 2009).

The mango tree was the most common species in Thai Yuan villages. The commonness of this species was also reported in many homegardens across the world (e.g., Abebe et al. 2010; Alam 2012; Kabir and Webb 2008b; Vlkova et al. 2010; Wezel and Ohl 2006) because of it is easy to cultivate (Alam 2012) and the fruits are delicious. Papaya was another common species in Thai Yuan villages. This species was easy to cultivate, and most papaya plants found in this study were self-sown. Besides these two species, other common woody species differed in each village. In Ta Kai, the most common woody species were food species while in Tong Phai the most common species were ornamental species.

Other common woody species differed between the Thai Yuan villages. In Ta Krai common species were fruit trees while in Tong Phai the common species were ornamentals. Competition between food and ornamental species for being the most common group in homegardens is common in the communities near the urban area (Milow et al. 2013; Peyre et al. 2006). Thong Phai is located nearer to the urban center than Ta Krai. Moreover, in Ta Krai agriculture is the most important occupation, whereas in Thong Phai it is handicraft, especially cotton weaving.

The dominant species in Ta Krai and Thong Phai were also different from each other. Only two species, mango and papaya, were dominant in both villages. In Ta Krai the white fig (*Ficus virens* Aiton) was an important dominant species. This tree provided young leaves, which are favored by villagers in Ta Krai and nearby villages. However, the important dominant species were two ornamental species *Codiaeum variegatum* (L.) Rumph. ex A. Juss and *Cordyline fruticosa* (L.) A. Chev. Besides their aesthetic function, these two plants were used regularly in flower offerings to Buddha. As mentioned above, the important causes of this difference were the distance to the urban centers, the main source of income, additionally, the preference for the food of the villagers.

The two largest plant categories of non-woody species in both Thai Yuan villages were plants used as *ornamentals* and *food*. These two categories were, like woody species, always mentioned as important in homegardens around the world (e.g., Abebe et al. 2006; Gajaseni and Gajaseni 1999; Wezel and Ohl 2006). It should be noted that in both villages, the largest groups was that of *ornamentals* which indicated the influence of urbanization (Milow et al. 2013; Peyre et al. 2006). Among many common species of each village, only four were shared: galanga (*Alpinia galanga* (L.) Wild.), turmeric (*Curcuma longa* L.), holy basil (*Ocimum tenuiflorum* L.), and *Piper sarmentosum* Roxb. The first three of them were common and important spices while the last one was an important vegetable in the Thai Yuan cuisine. The rhizomes of galanga are used commonly in nearly all cuisines in South-East Asia (Scheffer and Jansen 1999) along with turmeric. These two Zingiberaceae were easily grown at elevations up to 1200 m (Dahal and Idris 1999; Scheffer and Jansen 1999) where the Thai Yuan communities lived.

Unlike galanga and turmeric, holy basil was used in a few cuisines. This plant is a small shrub which is usually self-propagating. The reasons that most gardeners left holy basil in homegardens were that they might be used sometimes and the plant was small so there were no reasons to delete them.

Piper rostratum Roxb. is a popular vegetable in the Thai Yuan cuisine. This plant was often used as condiment and side dish. Moreover, the plant was propagated very easily by means of their stolons.

Yunnan Chinese Homegarden

The Yunnan Chinese were one of the most recent ethnic groups to immigrate to northern Thailand. Most of their homegardens were created over less than two generations. They live mostly in mountain areas so their homegardens were constructed on both slopes and flat areas. The scarcity of land and the housing style were two important factors determing their homegarden characteristics.

The house style of the Yunnan Chinese was influenced by Chinese and it is similar to Hmong and Lisu house style. So, normally, Yunnan Chinese homegarden are composed of two separate yards, the front and the back yard. Most of their homesteads were occupied by their house and front yard, with only a small area left for planting, mostly at the back side of their houses and along their borders. The front yard was always left as open space and used to dry their agricultural products. Most trees were found along the homegarden boundaries, while most herbaceous plants were kept in pots.

Because of the limited area, trees were rare in Yunnan Chinese homegardens. All of them were ornamental or food species. The rarity of trees in this ethnic homegardens was the result of the land scarcity. Among many common species found in each village, only *Capsicum frutescens* L. was reported as common in both villages. This *food additive* species is easy to grow and it is used in most cuisines. Most of *C. frutescens* found in the studied homegarden were self-propagating in the yard area.

Pots are common in Yunnan Chinese homegardens. The commonness of this horizontal zone was the result of the lack of the land and many of them were vertically arranged to exploit the limited space in the best possible way.

The number of plants found in Yunnan Chinese homegardens was very low and most of them were common species. The low of species richness was the resulted of the limited amounts of land, as mentioned earlier. Moreover, their homegardens were not old enough to accumulate more plant and improve the soil quality for planting more (Perrault-Archambault and Coomes 2008; Pinho et al. 2011; Trinh et al. 2003; Vlkova et al. 2010).

Diversity and Richness of Ethnic Homegarden

Species richness in homegardens

The number of species found in each village was different from place to place, ranging from 42 species in a Lisu village to 300 species found in a Thai Yuan village (Table 5.1). There might be many factors behind these differences including their geographic location or ethnicity.

The effect of elevation

Elevation negatively affected the number of species found in homegardens (Table 5.2), which means that the higher the elevation of a homegardens, the lower the number of plant species they possessed. Increase of elevation is associated with decrease of temperature (Karyono 1990; Hodel et al. 1999) which is one of the important growth factors. Normally homegardens, in the same region tend to have higher richness at lower elevation than those at higher elevation (Tesfaye 2005; Kehlenbeck et al. 2007). However, it should be noted that the R^2 is moderate; homegardens at lower elevation do not absolutely have higher richness than homegardens at higher elevation. For example, Khun Tuen Noi (1185 m elevation) had higher species richness than many villages located at lower elevation.

When analysed in more detail, elevation is related to the number of species only in the *food* and *social uses* groups (Table 5.2). Food plants are one of the main components of the homegardens while plants with social uses contributed only slightly to the overall number of species found in homegardens. So, it could be said that the relation between the species and elevation was mostly determined by the relation of food plants and elevations. The decrease of food species was the result of the decrease of growth factors available at high elevation (Karyono 1990; Hodel et al. 1999).

However, elevation was not related to the diversity of plants in the homegardens. Many villages at higher elevations (such as Khun Tuen Noi, Muser Pak Tang) had higher diversity than those located at lower elevations (such as Arunothai, Suk Ruethai) (Fig 5.1). The unpredictable trend of tree abundance in homegardens (Table 5.3), according to the elevation, is the cause of low predictive value of the correlation between species richness (trees + non-trees) and elevation as described above.

In conclusion, increase of the elevation might be the cause of the decrease in numbers of food plant in homegardend which directly affected the number of total species. However, this factor had low predictive power and was not related with the diversity and number of other plant groups.

Table 5.1 Comparing for each village, the species richness and diversity in all studied ethnic groups (*only woody species were used for the calculation; three largest number marked with **bold**).

Species richness and diversity indices	Ethnicity														
	Hmong		Karen			Lahu		Lawa		Lisu		Thai Yuan		Yunnan Chinese	
	Doi Kam	Pha Nok Kok	Huai Hia	Khun Tuen Noi	Mae Tom	Muser Pak Tang	Huai Phak Dap	Ban Hor	Meuang Ka	Huai Nam Dang	Khun Jae	Ta Krai	Thong Phai	Aruno thai	Suk Ruethai
Average no. of generation lived	2	2	2	3	2	2	2	2	3	1	1	3	3	1	1
Elevation (m.a.s.l.)	1200	1003	725	1185	826	1306	593	532	612	1141	1292	320	512	583	755
No. of species	123	127	103	146	100	58	80	116	**156**	42	107	**300**	**211**	83	75
No. of plant families	57	55	48	65	47	32	41	48	**66**	32	49	**87**	**69**	42	36
Mean of species in each homegarden	13	15	23.38	30.4	20.1	12	13	20	**34**	7	21	**32**	**36**	14	10
Med. of Richness*	3	5	7.5	**10.5**	6	8	**10**	4	5.5	1	5	8	**16**	2	3

Table 5.1 (continued)

Species richness and diversity indices	**Ethnicity**															
	Hmong		Karen			Lahu		Lawa		Lisu		Thai Yuan		Yunnan Chinese	
	Doi Kam	Pha Nok Kok	Huai Hia	Khun Tuen Noi	Mae Tom	Muser Pak Tang	Huai Phak Dap	Ban Hor	Meuang Ka	Huai Nam Dang	Khun Jae	Ta Krai	Thong Phai	Aruno thai	Suk Ruethai
Med. of Abundance*	6	5.5	13.5	**16**	13	**13**	15	6	7	2	8	8	**22**	2	2
Med. of Gini-Simpson*	0.67	0.78	0.83	0.78	**0.86**	0.7	0.8	0.75	0.78	0	0.76	**0.84**	**0.91**	0.5	0.7
Med. of Shannon*	1.1	1.59	2	1.71	**2.21**	1.8	1.9	1.39	1.62	0	1.52	**1.97**	**2.59**	0.7	0.5
Med. of Evenness*	0.94	1	0.82	0.88	0.78	0.9	0.9	**0.95**	0.94	1	**0.95**	0.92	0.88	**1**	**1**

Table 5.2 The correlation between some factors and number of species found in homegardens

	No. of species	Mean of species in HG	No. of animal food	No. of environmental use	No. of food	No. of food additive	No. of material	No. of medicinal	No. of selling	No. of social use
Elevation (m.a.s.l.) [a]	-0.520*	-0.426	0.024	-0.482	-0.625*	-0.354	0.368	-0.276	0.078	-0.575*
Distance from nearest urban center [a]	-0.133	0.081	0.152	-0.093	-0.166	-0.195	0.228	-0.393	0.436*	-0.063
Average no. of generation lived [b]	0.782**	0.740**	0.406	0.697**	0.848**	0.721**	0.256	0.350	0.164	0.526*

[a] Linear r (Peason) test; [b] Sperman's rank test

* $p < 0.05$; ** $p<0.01$

Table 5.3 The correlation between factors and the diversity (Spearman's rank test)

	Abundance	Gini-Simpson	Shannon
Elevation (m.a.s.l.)	-0.063	-0.439	-0.286
Distance from nearest urban center (length of dirt road)	-0.009	-0.303	-0.264
Average no. of generation lived	0.676**	0.864**	0.915**

** P<0.01

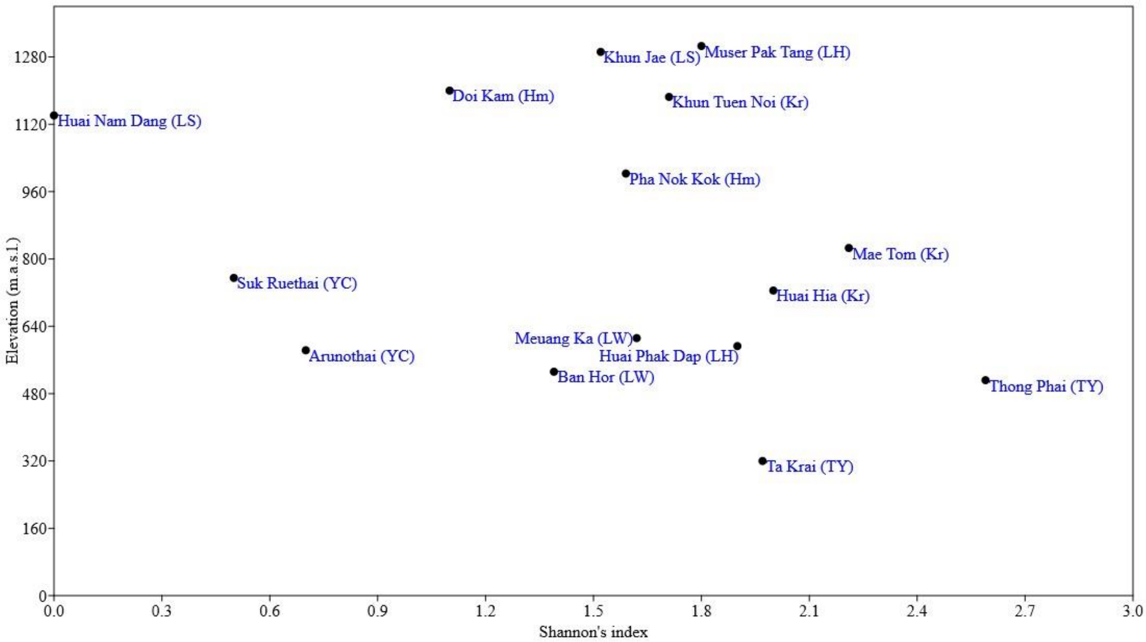

Fig. 5.1 the scatter plot between the elevation and Shannon’s index.

Distance from nearest urban center

Only the number of commercial species was affected by the distance from nearest urban center (Table 5.2). Villages located farther from the urban center had more commercial species than villages near the urban centers. The promotion from the government could be the best explanation of this situation. Villagers were encouraged to plant economic plants, especially *Coffea arabica* L. and *Litchi chinensis* Sonn., to improve their income and livelihood.

The distance from urban centers or the market could negatively affect the total plant richness due to the accessibility of the new exotic ornamental and economic plant because homegardens were always used as experimental sites for growing new plants. However, the factors could increase the richness in homegardens (Kabir and Webb 2007).

Distance from urban centers could affect the richness in homegardens differently from place to place. In this study, this factor only affected the number of commercial species and did not affect the richness or the diversity in the homegardens in different ethnic groups.

Ethnicity

The richness of plants found in homegardens was related with ethnicity. For example, Thai Yuan homegardens seem to have high values for both richness and mean. On the other hand, the Lahu, Hmong and Yunnan Chinese tended to have low values for richness and mean. The Karen and Lawa homegardens seemed to have low total values of species but high number of species per homegardens, however this characteristic did not seem to be related with the ethnicity as clearly as for the previous ethnic groups. Lisu homegardens were clearly different from each other: homegardens in Huai Nam Dang has very low number of species per homegardens and low total species while homegardens in Khun Jae village had moderate mean species.

However, in some ethnicities, the richness of plant species in the homegardens seemed to be unrelated with their ethnicity, for example Karen homegardens could have high richness and mean (Khun Tuen Noi) or moderated in both numbers (Huai Hia and Mae Tom).

Difference in ethnicities could result in differences in many ways: e.g., plant preferences, the preferred location for establishing their villages, and the way they build their houses and homegardens.

Yunnan Chinese, Hmong, and Lisu shared a common house style (Fig 5.2). The two largest part of their homestead were house(s) and a clean yard, mostly at the front. Sometimes, this yard was shared with the neighbors. There was a small area left for homegardening. Moreover, these people always had their own area for agriculture far from the villages for their cash crops like maize or tomato. These fields always had some space left for growing many plants. They could get enough plant products used in their daily life without relying too much on their homegardens. The less they relied on homegardens, the less richness there was.

The house style of Lahu people differed from the three ethnicities mentioned above. The area around their house was like them: the house was surrounded by the cleared clean area and sometimes the yard was shared between neighbors. This ethnic group, like those mentioned above, always had separated agricultural area far from the village where they could also get plants from. These common characteristics of their life style resulted in the low number of plants in homegardens and, consequently, low total richness in their villages.

Thai Yuan, on the other hand, tended to keep many plants in their homegardens. These people lived in flat terrains at lower elevation where the land was more suitable for planting. Their house style was also differed. The characteristics of their homegardens are described and discussed in the next chapter.

So, it could be said that the richness of plants in homegardens could be used for describing the identity of homegardens in some ethnic groups. However, in many groups this characteristic might be not suited because of their diverse in richness and mean number of species in homegardens.

Age of homegardens

The age of the villages is another important factor related with richness and diversity in homegardens. The number of generations who had lived in a village was significantly related with the number of species and diversity found in the homegardens (Table 5.2). Moreover, it also related with average number of species in the homegarden. Homegardens in older villages have had a better chance to accumulate plants than younger ones (Blanckaert et al. 2004; Tesfaye 2005; Coomes and Ban 2004; Quiroz et al. 2001) and the soil was better for planting.

This age-factor could describe the differences in species richness in Karen villages. One Karen village (Khun Tuen Noi) had higher richness than the other two villages (Fig. I). Khun Tuen Noi village is an older village with at least five generations having lived thee while the other two were about 3-4 generations old.

The number of species in many plant groups were also related with the age of homegardens, including: *environmental uses, food, food additives,* and *social uses.*

Among these, three of them were main components in homegardens (except *social use*) which significantly related with the total species found in homegardens (Table 5.4).

Fig 5.2 House style of (a) Yunnan Chinese, (b) Lisu, and (c) Hmong which shared many common characteristics influenced by Chinese house style.

Table 5.4 the correlation between the total number of species found and number of species in each use category (Linear r (Peason) test; ** p< 0.05)

	No. of species
Mean of species in each homegarden	0.847**
No. of animal food species (%)	0.391
No. of environmental use species (%)	0.964**
No. of food species (%)	0.767**
No. of food additive species (%)	0.943**
No. of material species (%)	0.197
No. of medicinal species (%)	0.578
No. of selling species (%)	0.017
No. of social use species (%)	0.402

Plants with *social uses* were those used for social purposes which are not food nor medicine. Most of those found in this study were used for regional purposes. In older villages, the number of plant in this category, generally, was larger than in younger villages. The explanation of this might be the time as for other groups as described above.

Size of the homegardens

At the village level, the number of species found in the homegardens was obviously related to the size of the homegarden (r = 0.68; p = 0.005; Pearson's correlation test). In many studies the size of the homegardens was unrelated to the richness or diversity of their plants which was the results of the owners' preferences.

This also happened in this study when all homegardens (regardless where or what they are) were used to calculate the correlation with the species found (r = 0.12; p = 0.256). So, at the village level the influence of their owners were limited. The effect of the size of the homegarden to the number of plants was also reported in many other studies (e.g., Abdoellah et al. 2002; Hodel et al. 1999; Kehlenbeck 2007; Quiroz et al. 2001).

Evenness of woody plant in homegardens

The evenness of woody species in all studied villages was very high. This demonstrated that the similarity of numbers of each species found in homegardens was mostly one individual per a species in each homegarden. Land is one of the important limitations of homegardens, especially in those located in mountainous area like Hmong, Yunnan Chinese, Lahu, Lawa, or Karen.

Woody species required large space in homegardens (Panyadee et al. 2016) so selecting woody plants for the homegardens is important task. Most products or services from homegardens, in this study, were used for self-consumption. Therefore, in a situation in which the lands are limited, planting different species would be a good strategy because it would fulfill the diverse needs of their owners. Moreover, without commercializing their products, only one or two individuals of a species are enough for the homegardeners' family and their neighbors.

Similarity of Plants in Homegardens

When all plants found in homegardens were used to compare the similarity among the villages, it turned out that the similarity was low to moderate (Fig. S1). Similarities ranged from 9–40% (Jaccard's similarity index; table 5.5). The result showed that some ethnicities tended to have similar plants regardless the place they were (Thai Yuan, and Hmong). On the other hand, some the similarrities between some ethnicities were affected by other factors, regardless of their identity (in term of ethnicity).

Hmong homegardens were unique regarlress of the place they were (although the similarity was about 30%). *Food* and *food additive* were two use categories that make these Hmong village similar and unique, regardless of their location. The uniqueness of Hmong homegardens was the result of the traditional plants that they had brought along when they migrated to new land (Corlett et al. 2003; Srithi et al. 2012). Moreover, the conservative habits of Hmong people also promote the similarity of the homegardens between the difference villages (Srithi et al. 2012).

The Thai Yuan homegardens had many common characteristics and plants. They kept many species in their homegardens, so there was more chance that the two villages would share some species although they were located far apart. The large number of plants in their homegardens was the result of manyth generations lived, and larger homegardens, as mentioned above. *Food* and *food additives* were two important categories that contributed to this similarity. The similarities of these groups were 43% and 40%, respectively (which was higher than the overall similarity). Besides the ethnicity, the similarity of their geographic location might be one of the important factors behind this. Among these ethnic groups, Thai Yuan lived in the same environments (flat land, low elevation, and long occupation). This also explained why the plants in homegarden in Muang Ka (MK, Lawa) were more similar to Thai Yuan homegardens than in Ban Hor which was of the same ethnicity. Although the people in Muang Ka village are Lawa but the location and environments around their village were more similar to Thai Yuan village than Bah Hor village which was located in a mountainous area at higher elevation.

The distance between the homegardens could not be used for describing the similarity between the homegardens. The Mantel test revealed that there was no significant relation between a similarity matrix and the distance between the villages ($R = -0.247$, $p = 0.9699$). So, the high similarity could be observed both between closely located and far apart villages (Fig. 5.3). A similar situation was also found in other studies (Milow et al. 2013; Aguilar-Støen et al. 2009). This uniqueness of homegardens in each village could be used to promote and contribute to the conservation sites for the plant species (Milow et al. 2013).

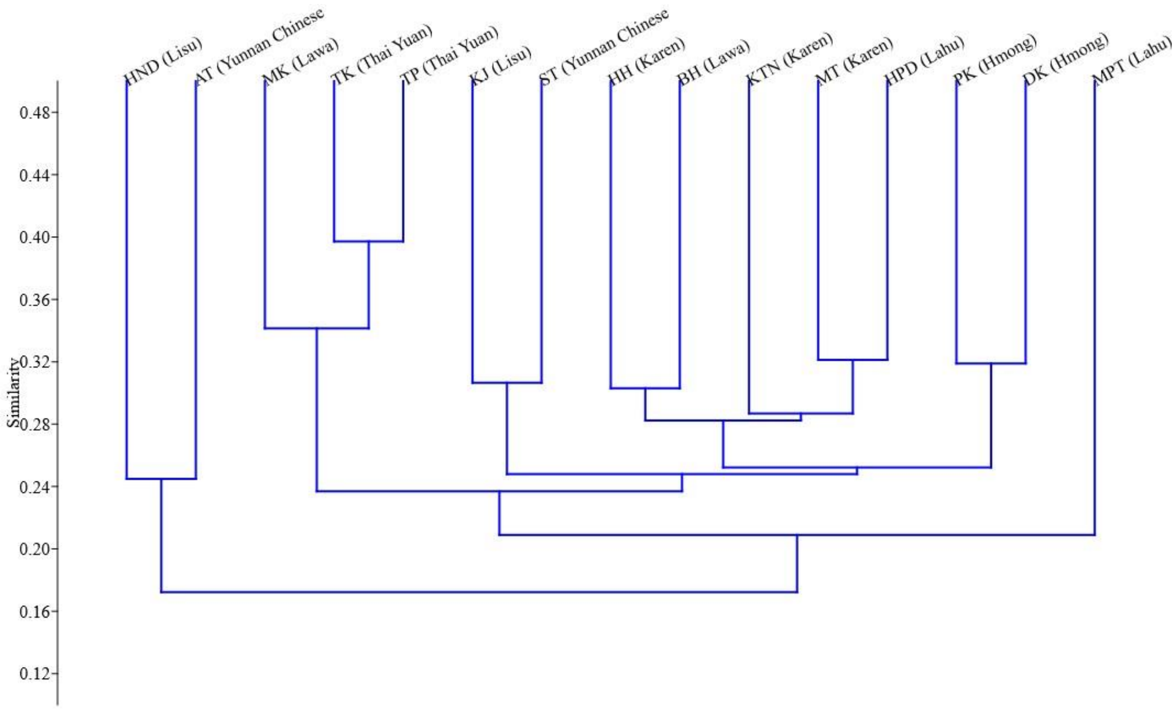

Fig. 5.3 Cluster analysis of the villages according to plants found in their homegardens (Jaccard's similarity index; UPGMA). The abbreviations were stand for the village name.

Table 5.5 Jaccard's similarity score for each village.

	DK	PK	HH	KTN	MT	HPD	MPT	BH	MK	HND	KJ	TK	TP	AT	ST
DK (Hmong)	1.00	0.32	0.22	0.28	0.25	0.24	0.20	0.32	0.26	0.16	0.29	0.20	0.29	0.18	0.25
PK (Hmong)	0.32	1.00	0.23	0.24	0.21	0.25	0.17	0.28	0.25	0.15	0.25	0.21	0.28	0.21	0.18
HH (Karen)	0.22	0.23	1.00	0.25	0.30	0.30	0.28	0.30	0.27	0.14	0.21	0.21	0.22	0.14	0.22
KTN (Karen)	0.28	0.24	0.25	1.00	0.30	0.28	0.18	0.30	0.22	0.13	0.26	0.22	0.26	0.19	0.20
MT (Karen)	0.25	0.21	0.30	0.30	1.00	0.32	0.23	0.28	0.25	0.16	0.27	0.20	0.21	0.19	0.23
HPD (Lahu)	0.24	0.25	0.30	0.28	0.32	1.00	0.29	0.27	0.27	0.22	0.27	0.21	0.24	0.23	0.31
MPT (Lahu)	0.20	0.17	0.28	0.18	0.23	0.29	1.00	0.23	0.18	0.16	0.23	0.12	0.15	0.11	0.26
BH (Lawa)	0.32	0.28	0.30	0.30	0.28	0.27	0.23	1.00	0.32	0.12	0.24	0.22	0.30	0.20	0.27
MK (Lawa)	0.26	0.25	0.27	0.22	0.25	0.27	0.18	0.32	1.00	0.13	0.22	0.31	0.38	0.19	0.26
HND (Lisu)	0.16	0.15	0.14	0.13	0.16	0.22	0.16	0.12	0.13	1.00	0.23	0.10	0.12	0.24	0.20
KJ (Lisu)	0.29	0.25	0.21	0.26	0.27	0.27	0.23	0.24	0.22	0.23	1.00	0.16	0.21	0.22	0.31
TK (Thai Yuan)	0.20	0.21	0.21	0.22	0.20	0.21	0.12	0.22	0.31	0.10	0.16	1.00	0.40	0.16	0.19
TP (Thai Yuan)	0.29	0.28	0.22	0.26	0.21	0.24	0.15	0.30	0.38	0.12	0.21	0.40	1.00	0.21	0.24
AT (Yunnan Chinese)	0.18	0.21	0.14	0.19	0.19	0.23	0.11	0.20	0.19	0.24	0.22	0.16	0.21	1.00	0.24
ST (Yunnan Chinese)	0.25	0.18	0.22	0.20	0.23	0.31	0.26	0.27	0.26	0.20	0.31	0.19	0.24	0.24	1.00

The structure of homegardens

Yard (Y), pot (P), and homegarden boundaries (HB) were three main homegarden horizontal zones that were found with high frequency in most villages (Fig. 5.4). However, the frequencies were different from place to place and ethnicity to ethnicity. Pots were the most varied part, and could be found in all homegardens in the village (Yunnan Chinese village) or in number as low as about 20% in Lahu villages. Moreover, the frequency of pots was negatively related with the frequency of yard (r = -0.32, viations used in the figurep<0.05). As mentioned above, pots are one of the most the suitable ways to solve the problem of limited space because pot plants require small space and could be horizontally arranged.

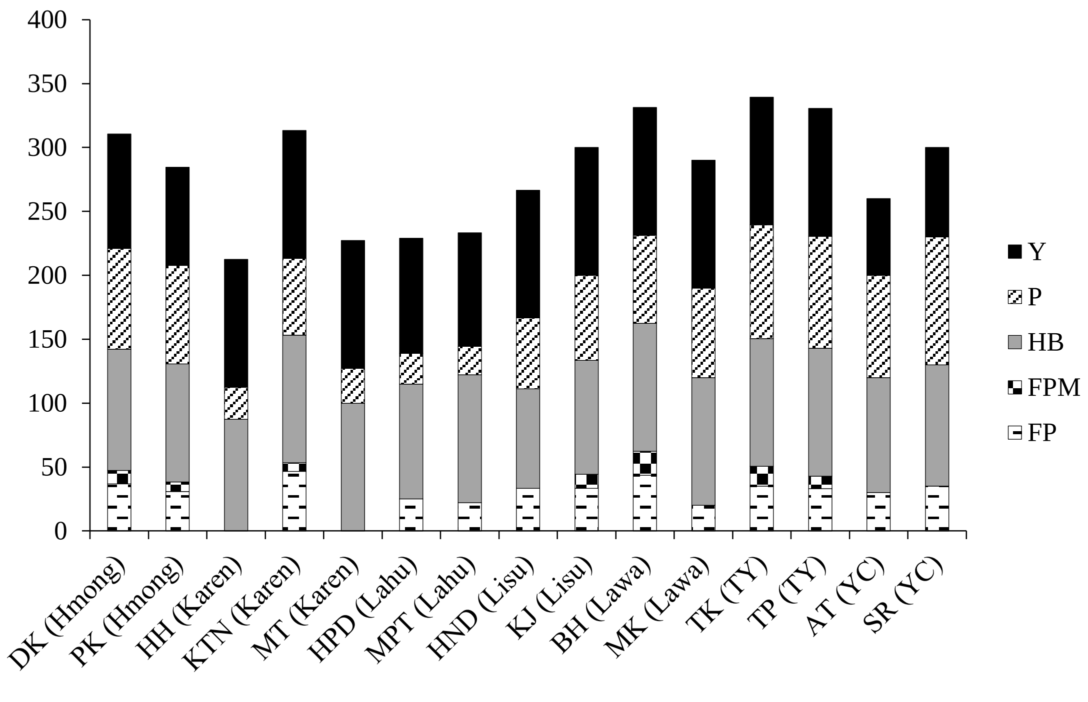

Fig. 5.4 The proportion of each homegarden zonation found in each village. (Abrevation: Y: yard; P: pot; HB: homegarden boundaries; FPM: fenced plot margins; FP: fenced plot; TY: Thai Yuan; YC: Yunnan Chinese)

Although the existence of yards was related to the pots the variation was not as high as for the pots. Most ethnic homegardens had plants in their yard because it occupied most of their homegardens. However, in some homegardens where the land is limited, the homegardeners had to sacrifice their yard for other activities, especially drying of their agricultural products, for which reason plants were removed from their yard. But it should be noted that ethnicity also play a role in this situation because it seemed to be limited to Yunnan Chinese, Lahu, and Hmong homegardens. In other ethnicities, some homegardens had very small yard but still had some plants like the Lisu homegardens which had similar size to Hmong homegardens but all of them still had some plants in their yard.

On the other hand, the variation of homegarden boundary frequency was very small; it could be at least 75% of homegardens in the villages. Additionally, plants were found in all homegardens boundary in every homegarden in most studied villages. Plants along the homegarden boundaries could be either trees or small herbs. One reason to plant trees along the homegarden boundaries was to delimit the homegarden border from other homegardens or public areas. Another reason was saving a clear area in yard. As we known, trees need much space, so planting them in the yard would decrease the area for other activities, for example drying product area. Moreover, among some ethnic groups where the yard area was too small most trees were planted along the borders. Additionally, *Phyllanthus acidus* (L.) Skeels was planted at the front border of the homegarden because of their Thai name (*Ma Yom*) which meant admiring. By planting this plant in the front of the homestead, the owners believed that it would help promote their attractiveness among the neighbors.

The reasons for planting herbs along the border of the homegardens were different from the reasons for planting trees; at least the space was not the matter. Along the border, herbs were well protected from being accidentally destroyed by any activities. However, the number of these plants was too small to make the fences for protecting. Moreover, many ornamental plants were planted along the front border, which could indicate their social status and preferences.

The village types: *according to the frequency of the components found in their homegardens*

The variation in the frequency of yard and pots among the village resulted in the three village types according to the frequency of them in homegardens (Fig. 5.5).

Group I: village with low frequency of yards but high frequency of pots (the two Yunnan Chinese villages)

Group II: village with very low frequency of pots (two Lahu villages and two Karen villages). They kept most their plants in yards and homegardens boundaries. Additionally, they also kept plants in fenced plot.

Group III: village with relative high frequency of yards but low frequencies of pots (included the rest of the studied villages). Additionally, this group had higher proportion of fenced plot than Group II. Moreover, there were two sub-groups which seemed to be related with the ethnicity of the villages: the Thai Yuan villages which had very high frequency of both yard and pots; and Hmong village which had lower frequency of both yards and pots.

The cluster of the village was not related with the distance between them (Mantel test; $r = 0.19$; $p = 0.09$). So, it could be said that the ethnicity of the village could affected the structure of the homegardens.

The similarity of the frequency of each component in the homegardens in the village was also related to the similarity of plant in each village (Mantel test; $r = 0.23$; $p<0.05$). This means that the more similar the homegarden components, the more similar their composition of plants.

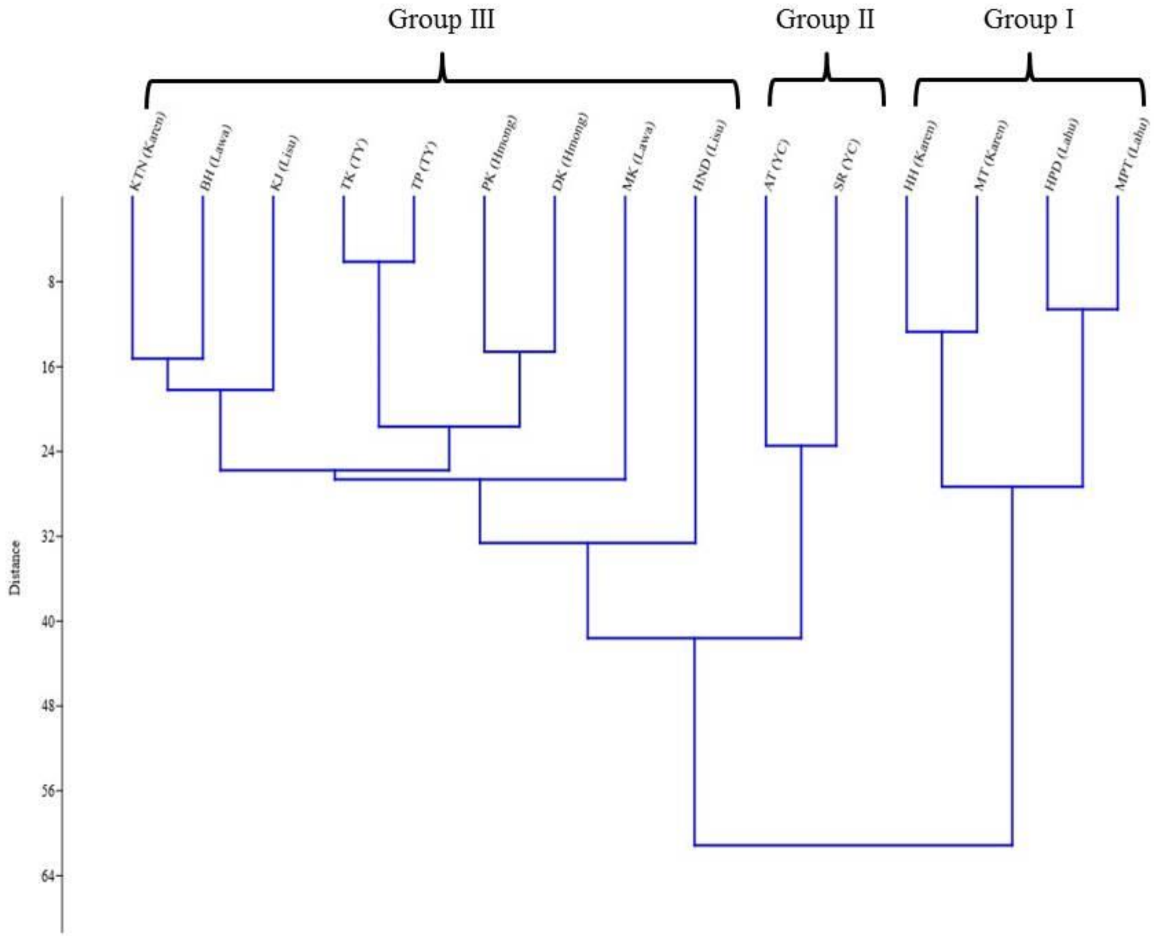

Fig. 5.5 Cluster analysis of the studied village according to the proportion of homegarden components found in each village (Euclidean; UPGMA)

Homegarden functions

In all studied villages (that also means all ethnicities) the *food* category was in rank 1 or 2 (Fig 5.6). Food plants are always important for the composition of any homegarden, regardless the place. Many studies across the world have demonstrated the importance of food plant for the homegardens (e.g., Balooni et al. 2014; Dash and Misra 2001; Huai et al. 2011; Méndez et al. 2001; Perrault and Coomes 2008; Vlkova et al. 2010). In other words, homegardens are important places for keeping the diversity of plants that provide food security to the members of their owner's family (Trinh et al. 2003) and to the community (Kortright and Wakefield 2011). For most homegardens, their main function is producing food for the family (Abebe et al. 2006; Gajaseni and Gajaseni 1999; Wezel and Ohl 2006). It should be noted that food plants included both woody and non-woody species. They always are in the first or second rank in both forms.

Most species with *environmental uses* are ornamentals and some are shading plants. In most villages, this group contained the second highest number of plants followed by the *food* category. Most of these ornamental plants were non-woody species, which did not require large area for planting. Most of them were exotic species, at least in the studied area. Moreover, some of them had accidentally appeared in homegardens but were kept becauseof their beautiful flowers or leaves. Urbanization might be one of the reasons behind the high number of ornamental species (Panyadee et al. 2012; Hodel and Gessler 1999; Poot-Pool et al. 2015; Quiroz et al. 2001; Trinhet al. 2003). The owners' preferences was also an important factor as many species in very distant Karen villages were transferred from the forest like *Remusatia pumila* (D. Don) H.L. & A. Hay and *Hedychium aureum* C. B. Clarke & H. Mann ex Baker. Although most ornamental species were grown for decorative purpose, some of them — in addition — play crucial roles in human health and psychology (Amingad and Lakshmipathy 2014).

Another important group in most homegardens were the plants used as *food additive.* These plants were used as processing agents or as additive ingredients during the food preparation. The most common ones were *Capsicum annuum* L. and *Alpinia* *galanga* (L.) Willd., the two most common spices in many countries in South East Asia. The products from this group were used in small quantity and could also be bought from the markets. Many homegardeners also mentioned the sharing of the food additive products among neighbors. For these reason, although this use category was just as important in daily life as *food* plant, they were still less commonly found in homegardens.

The ranks of other use categories were different from place to place for the same reasons. For example, there was no *animal food* in many of the studied villages. In Yunnan Chinese villages, the main reason for not having any *animal food* plants was for lack of space in their homegardens as this was also the case in the Lawa villages. However, in Karen villages these plants were grown outside the homegardens, in the fields, while most area in their homegardens was used mostly for human activities.

In conclusion, it can be said that homegardens of the ethnic groups in Chiang Mai provice were used mainly to support their owners' health as in terms of body (food and food additive) and mind (ornamental species). Furthermore, they also served other needs but such ones could be different from place to place.

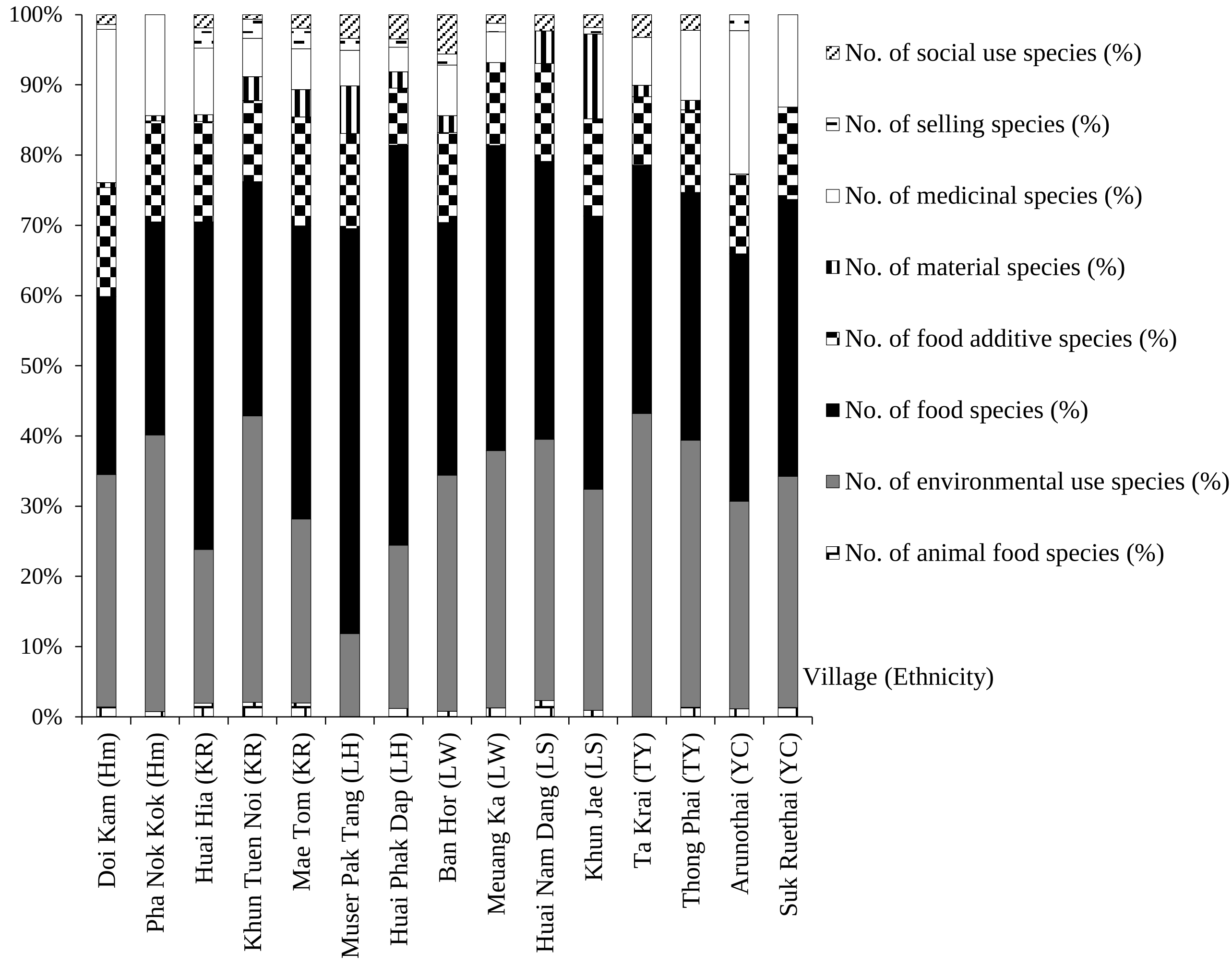

Fig. 5.6 The percentage of plant groups, according to their functions, in term of number of species found in homegarden of each village