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Diversity and species structure of home gardens in South Andaman

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Abstract: A survey was conducted in 19 home gardens and 10 home - forest-gardens in South Andaman to elucidate species structure and diversity in their floristic composition. Number of ligneous species was 18 in home garden and 10 in home-forest-garden. Plantation crops i.e., coconut, arecanut; fruit plants – mango, banana, papaya and spices - clove, nutmeg and cinnamon were major species in the home garden. Density and relative frequency of arecanut was maximum in both home garden as well as in home - forest - garden. Home garden being similar in physiognomy to tropical evergreen forest, formed five tiered and home- forest-garden four tiered canopy structure. Coconut constituted top storey, arecanut and jackfruit fourth storey, mango, cashewnut and tamarind third storey, spices second storey and annuals like *Zinziber officinalis, Curcuma longa* and *Manihot esculenta* and pineapple first storey in the home garden. Home - forest - garden differed from the home garden as the former lacked spice trees and contained forest tree species only in the top storey. Similarity in species composition between home garden and home-forest-garden was 72%. Diversity of plant species was greater in home - forest - garden whereas equitability, concentration of dominance and species richness in home garden.

Resumen: Se llevó a cabo un estudio en 19 huertos familiares y 10 huertos-bosque familiares en Andaman del Sur con el fin de dilucidar la estructura y el número de especies en su composición florística. El número de especies leñosas fue 18 en los huertos familiares y 10 en los huertos-bosque familiares. Cultivos de plantación i.e., la palmera de coco, la nuez areca, plantas frutales, el mango, el plátano (banana), la papaya y las especias, el clavo, la nuez moscada y la canela fueron las principales especies en los huertos familiares. La densidad y la frecuencia relativa de la nuez areca fueron máximas tanto en los huertos familiares como en los huertos-bosques familiares. Los huertos familiares, similares en fisonomía al bosque tropical perennifolio, formaron una estructura del dosel con cinco estratos, mientras que la de los huertos-bosque familiares tuvo cuatro estratos. La palmera de coco formó el estrato superior, la nuez areca y el árbol de pan el cuarto estrato, el mango, el marañón y el tamarindo el tercer estrato, las especias el segundo estrato y las anuales como *Zinziber officinalis, Curcuma longa* y *Manihot esculenta* y la piña constituyeron el primer estrato en el huerto familiar. Los huertos-bosque familiares difirieron de los huertos familiares en que los primeros carecían de árboles de especias y contenían especies forestales arbóreas sólo en el estrato superior. La similitud en la composición de especies entre los huertos familiares y los huertos-bosque familiares fue de 72%. La diversidad de especies vegetales fue mayor en los huertos-bosque familiares, mientras que la equitabilidad, la concentración de la dominancia y la riqueza de especies tuvieron valores mayores en los huertos familiares.

Resumo: Foi efectuado um inventário em 19 hortas de casa e em 10 hortas de casa na floresta no sul de Andaman para elucidar a estrutura das espécies e a diversidade na sua

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composição florística. O numero de espécies lenhosas era de 18 nos hortas de casa e de 10 nas hortas de floresta. As culturas de plantação, i. e. coqueiro, noz de areca, fruteiras , mangueiras, banana, papaia e especiarias, cravo, noz moscada e canela eram as principais espécies nas hortas de casa. A densidade e frequência relativa da noz de areca era a maior quer nas hortas de casa quer nas hortas de floresta. As hortas de casa, sendo semelhantes quanto à fisiognomia à floresta tropical sempreverde, formam uma estrutura de cinco andares, enquanto que as hortas de floresta apresentam uma estrutura de copado de quatro andares. O coqueiro constitui o andar superior, a noz de areca e a jaqueira o quarto andar, a mangueira, o cajueiro e o tamarindo o terceiro, as especiarias o segundo e as anuais como a *Zinziber officinalis, Curcuma longa* e *Manihot esculenta* e o ananaseiro o primeiro andar nos jardins de casa. As hortas na floresta diferem das de casa na medida em que aqueles não dispunham de árvores de especiarias e só possuíam espécies arbóreas no andar superior. A semelhança na composição específica entre as hortas de casa e as hortas de floresta era de 72%. A diversidade das espécies vegetais era maior nas hortas de floresta enquanto a concentração equitativa de espécies dominantes e a riqueza específica era maior nas hortas de casa.

Key words: Diversity, equitability, home garden, home – forest – garden, profile diagram.

Introduction

Home garden is a least understood traditional agro - ecosystem in the world. It forms a dominant and promising land use system in many parts of the tropics (Michon *et al.*1983; Singh 1987; Soemarwoto 1987) particularly in Islands and coastal areas (Nair 1993). Home gardens (syn. Homestead farm) maintain high levels of productivity and stability (Michon *et al.* 1983; Soemarwoto & Conway 1991; Thaman 1988). Species diversity in tropical home garden is reported to be very high due to species having different life forms, height and canopy structure (Babu *et al.* 1982; Soemarwoto & Conway1991). Distribution of species in the home garden creates a forest like multistorey structure (Singh 1987). Structure of home gardens varies from place to place depending upon the socio-economic and ecological conditions (Soemarwoto 1987).

Home garden is a most prominent cropping system in the Andaman islands which owes its origin from forests. The islands were thickly covered with forests before the British colonial rule. During the late mid 19th century the British rule established penal colonies with the mutineers, rebellions and convicts of murder, robberies, decoity and frauds from occupied India and Burma that could not continue ever long and was abolished an year before the India was set free and those willing were repatriated. Subsequently, the Govt. of independent India rehabilitated these islands, in phases, from mid 20th century with the ex-convicts who resorted to stay back, refugees of East Pakistan, ex-servicemen and poor landless people of India from different parts of the country (Chak 1967; Kloss 1971; Majumdar 1975). The settlers were provided with 2 ha of forested hilly land, 2 ha of valley (low lying ricefields) and 0.4 ha land for house construction (Bandopadhyay 1998). However, size of the allotted land varied across the islands being greater in the beginning. Settlers clear, felled the forests, constructed houses and raised coconut, arecanut, fruit and other trees in their premises to serve their maximum basic needs because transportation and organized market were completely lacking. This led to the development of homegarden. Home - forest - garden, relatively recent in origin in these islands, is under the process of conversion of forest into home garden. Immigrants from mainland territory of India, immigrated in want of job after the settlement, encroached the forests, girdled the trees gradually and felled them upon death and planted arecanut and coconut in the tree gaps. It differs from the home garden having a great number of natural forest trees. Bandopadhyay (1998) have made socioeconomic studies of the systems whereas,

information on species composition, their vertical distribution and diversity is lacking. Present study describes the species composition, species diversity and their horizontal and vertical distribution in home garden and home - forest - garden of South Andaman.

Study area

The study was conducted in home gardens of South Andaman (10°30' and 13^0 42' N lat. and 92° 14' to 94° 14' E long.) located in south-east Bay of Bengal. Altitude ranged from 50 to 350 m above mean sea level. Forest (87 %), homegarden (4.6 %) and rice fields (1.3 %), covering together around 93% of the total geographical area, are three major land uses in the islands (Basic Statistics 2001). The islands are characterized by hills, hillocks and valleys. Narrow to large; flat bottomed vallies are interspersed in between two hillocks, and hills. Home gardens are located on the hillocks and hill slopes, whereas rice fields in the valleys. Some hills are still virgin thickly covered with tropical rain forest.

Predominant soils in the islands are alfisols, entisols, inceptisols and mollisols. Inceptisols and entisols are most important agricultural soils found abundantly on the hillocks and valleys. Soils on the hillocks are shallow to moderately deep owing to erosion, well drained, generally gravelly loamy in texture, acidic in reaction and low to moderate in nutrients. However, soils of the valleys are alluvial, relatively deeper, imperfectly drained and clayey to clay-loamy (NBSS LUP 1991).

The island experience a true maritime climate round the year with a little variation in temperature between 23.1°C to 30.1°C. Maximum temperature occurs in May and minimum in December. Mean annual rainfall is an average 3000 mm, distributed unevenly throughout the year. Maximum 73% of total rainfall occurs from southwest monsoon from June to October, and 27% from northeast monsoon. Average relative humidity ranged from 71% to 89% maximum in October and minimum in January.

Potential natural vegetation in the study area is a tropical rainforest. Moist deciduous forest represented by *Pterocarpus dalbergiodes*, *Lagerstoemia hypoleuca*, *Terminalia bialata* etc., occupy mostly the foot hill, whereas semi-evergreen forest dominates on the hill slope. Few evergreen species *Dipterocapus grandiflora, Artocarpus chaplasha, Hopea odorata* Roxb. etc. are interspersed among the deciduous species, particularly in the clay rich depressions and increases with the altitude on the hill slope and replacing others, *D. alatus* Roxb., *Amoora wallichii, D. gracilis, Calophyllum* sp. etc. occupy the hill top. On the interface of the sea and land mass mangrove vegetation is found which protect the islands from sea invasion. Mangrove includes *Rhizophora mucronata., R. apiculata, Bruguiera cylindrical, B. parviflora, Avicenia officinalis, Heritiera littoralis, Ceriops tagal, Kandelia candal, Xylocarpus mollucensis, Sonneratia caseolaris, Excoecaris* spp. Littoral forests, found on the sea beeches, are dominated by salt tolerant *Manilkara litoralis, Erythrina variegata, Pandanus tectorius*, *P. leram* and *P. odoratissimus* (Anonymous 1980).

Materials and methods

To know the species structure and diversity of the home gardens, 19 home gardens and 10 home - forest - gardens were selected randomly in South Andaman. Five quadrats, 10 x 10 m in size, were laid in each home garden and home - forest - garden. Number of individuals in each quadrat were counted and their height was measured. Frequency and density were calculated following Curtis & McIntosh (1950). Profile diagram of home garden and home - forest - garden was constructed according to appearance and height of the species.
Simpson's diversity was calculated as

$$D = 1 - \left(\sum_{i=1}^{s} (ni - N)^2 \right)$$

where, D = Simpson's index; S = total number of species, ni = number of individuals of ith species, N = total number of individuals in the plot (Simpson 1949.)
Shannon- Weaver's diversity was calculated as:

$$H = \left(3.3219 \log_{10} N \sum_{i-1}^{S} ni \log_{10} in \right)$$

where, ni = number of individuals of the species i, N = total number of individuals in the plot. Species richness was calculated as S-1/log$_{10}$N (Margalef 1958), where, S is total number of species and N is total density of all the species. Equitability was worked out following Shannon & Weaver (1949)

as: E = H'/Hmax, where, Hmax is the maximum dispersion (taking into account the number of species present in the plot), and Hmax = 3.3219 $\log_{10}$ S, where, S is the total number of species. Per cent similarity between home garden and home - forest - garden was calculated on the basis of density of species following Motyka *et al.* (1950) formula, 2MW/(MA + MB) x100, where, MW = the sum of the smaller values of density of the common species of the home gardens, MA = the total density of the species present in home garden and MB = the total density of the species present in forest-home-garden.

Results and discussion

Plant species and their density in the studied home gardens and home-forest-gardens are given in Table 1. Arecanut contributed maximum (54 to 76%) followed by coconut to the density in both home - forest - garden as well as home garden. Arecanut : coconut ratio was always higher in both the homesteads indicating that peasants preferred arecanut most as it provided economic security to house, whereas coconut served the subsistence. Arecanut was a highly remunerative crop 4 - 5 years before when open trade policy was not

Table 1. Density, relative frequency and height of species in home garden and home - forest - garden of South Andaman.

Species	Home garden			Home- forest-garden		
	Density (no.ha^{-1})	Relative frequency (%)	Height (m)	Density (no.ha^{1})	Relative frequency (%)	Height (m)
		Trees				
Anacardium occidentale (Cashewnut)	2 ± 2	0.7	8.4	30 ±14	3.2	8.4
Areca catechu (Arecanut)	1995 ± 103	31.0	12.0	1760 ± 91	10.6	12.5
Artocarpus heterophylla (Jack fruit)	2 ± 1	0.7	11.2	10 ± 9	1.1	10.0
Azadirachta indica (Neem)	4 ± 3	12.4	5.0	0	0	0
Ceiba pentandra (Ceiba)	13 ± 6	2.8	18.3	40 ± 15	4.3	12.4
Cocos nucifera (Coconut)	124 ± 24	9.7	15.5	70 ± 24	5.3	15.5
Mangifera indica (Mango)	7 ± 4	2.8	9.3	60 ± 21	5.3	8.0
Tamarindus indica (Tamarind)	13 ± 6	3.5	6.0	20 ± 12	2.1	6.0
		Shrubs				
Carica papaya (Papaya)	4 ± 2	2.8	4.4	0	0	0
Cinnamomum tamala (Bay leaf)	5 ± 4	9.7	4.0	0	0	0
Cinnamomum zylanicum (Cinnamon)	24 ± 6	0.7	4.3	0	0	0
Citrus limon (Lemon)	2 ± 1	0.7	5.0	0	0	0
Gliricidia sepium (Gliricidia)	2 ± 1	0.7	2.0	0	0	
Manihot esculenta (Tapioca)	2 ±1	2.1	1.5	0	0	0
Murraya koenigii (Kari leaf)	5 ± 4	2.8	2.0	0	0	0
Musa paradisiaca (Banana)	59 ± 14	0.7	3.5	125 ± 21	4.3	4.0
Myrisitca fragrans (Nutmeg)	40 ± 9	9.7	4.1	0	0	0
Syzygium aromaticum (Clove)	3 ± 2	1.4	4.8	0	0	0
		Herb				
Ananas comosus (Pineapple)	303 ± 78	2.8	0.5	190 ± 130	4.2	0.5
		Natural Forest Trees				
Albizia lebbeck (Koko)	0	0	0	50 ±21	4.3	15.0
Artocarpus chaplasha (Tounpinne)	0	0	0	7 ± 3	2.8	9.0
Bombax insigne (Didu)	0	0	0	150 ± 25	9.6	18.0
Diptercarpus grandiflora (Gurjan)	0	0	0	180 ± 34	9.6	30.0
Lagerstroemia hypoleuca (Pyima)	0	0	0	160 ± 27	9.6	21.0
Mangifera andamanica (Jungli aam)	0	0	0	30 ± 20	2.1	16.0
Pajanelia rheedii (Jhingam)	0	0	0	40 ±20	3.2	17.0
Pterocarpus dalbergioides (Padauk)	0	0	0	160 ± 28	9.6	35.0
Pterocymbium tinctorium (Papitha)	0	0	0	160 ± 45	8.5	15.0
Terminalia procera (Badam)	0	0	0	50 ± 25	3.2	20.0

effected. Arecanuts were distributed in closer spacing (≤ 60 cm) because natural growth from fallen seeds (nuts) always supplemented the population of the species which resulted into high density. Generally arecanut was distributed under coconut, but in bigger size home gardens a separate block of arecanut are grown mainly for maximization of house income. Banana particularly var. champa, locally known as "Cheena kela" is most common contributing 85% to the total banana population. Pineapple was another fruit crop found relatively greater in the home garden. Its density was high but frequency low indicating uneven distribution across the home gardens. Only few peasants (6%) were found to grow the fruit species for commercial purpose but maximum (94%) for house consumption. In maximum home gardens labour intensive cumbersome cultivation of pineapple is avoided because Govt. services are major source of house income in south Andaman. An average 1.5 person (range 1-2) per family is engaged in Govt. offices. But, perennial ligneous species like tamarind and *Ceiba pentendra* were found generally in each home garden. The former serves as food, whereas later provides flosses which are used for making beds and pillows. Tree spices like clove, nutmeg and cinnamon were found in the home garden, but relative frequency of cinnamon was lowest perhaps due to higher labour input, in harvesting, debarking and drying and comparatively low return (Rs. 200 per kg) at two years interval. Rotation cycle of cinnamon is generally 2 years, but few farmers make delayed harvesting for higher yields. However, the former species once starts flowering produce yields continuously for around 50 years at minimum input and give reasonably good return (Rs. 300 per kg; Rs. 290 per kg or Rs. 1 per nut, respectively). Spices were absent in the studied home-forest-garden indicating that it was aimed for maximum space utilization. Compared to arecanut, spices require 2 times greater space. Total number of woody species was 10 in home - forest - garden and 18 in home garden. Number of ligneous species in present homesteads was relatively low compared to other home gardens in India and other countries. Mohan Kumar *et al.*(1994) found 127 woody species across the homestead of 14 districts and 3 to 25 species per homestead in Kerela. However, Nair & Sreedharan (1986) reported 30 arboreal taxa from the selected home gardens of Kerala. High number of tree and shrub (301 species) have been reported also in Mayan home gardens of Yucatan, Mexico (Rico-Gray & Wienen 1963), 168 species in Santa Rosa in the Peruvian Amazon (Padoch & de Jong 1991) and 179 species in home gardens of Java (Soemarwoto 1987). In present home garden natural forest tree species are almost absent perhaps due to high forest cover (86%) in near by area, which fulfilled, though illegal, the fuel wood requirement of the farmers. Cooking gas is easily available to farmers in the islands. However, each family brings an average 5 kg fuel wood daily from near by forests (Pandey *et al.* 2002). On the contrary, number of forest tree species were abundant in home - forest - garden because this system was under the process of forest conversion (Table 1). Similarity in species composition between home garden and home - forest - garden was 72 percent.

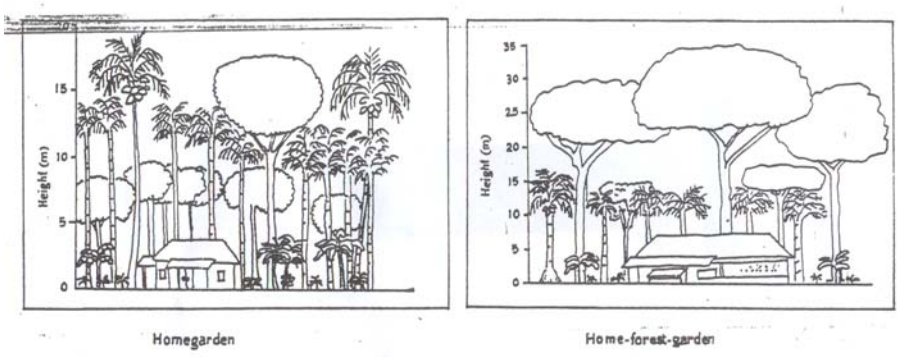

Fig. 1. Pictorial presentation of home garden and home – forest – garden of South Andaman, India. (Homegarden, I storey: < 2.0 m, II: 2-5 m, III: 5-10 m, IV: 10-15 m, and V: 15-20 m; home-forest-garden, I storey: < 2.0 m, II: 5-10, III: 10-15 m, IV: 20-35 m).

Profile diagram of home garden and home - forest - garden is given in Fig.1. Physiognomically, both the home garden and home- forest-garden were similar having multi-layered canopy structure resembling to tropical evergreen forest (Soemarwoto 1987). Home garden formed 5 storied, whereas home-forest-garden 4 storied structure (Fig.1). In home garden top fifth storey (15 to 20 m) was always occupied by coconut (tall cultivar, Andaman tall and Katchhal tall) whereas fourth storey (10-15 m) by arecanut and jackfruit. *Ceiba pentendra* is present in both the stories, but maximum in fifth storey. Trees like mango, cashewnut and tamarind formed the third storey (5-10 m). Fruit trees were mostly closer to the house. Spices like nutmeg, cinnamon, clove, neem and papaya occupied second storey (2-5 m). Clove was found in both second as well as in third storey. Cinnamon, requiring high humidity, was grown mostly under the arecanut and occasionally under coconut. Whereas banana requiring greater water and sunlight was grown relatively in open where water of house drained. These indicated that peasants were having knowledge of ecological requirements of the trees which they accumulated over generations. Houses had no specific pattern of its distribution, but was preferred on the up lands to avoid stagnation of rain water. First storey (< 2 m) comprises short height annual crops like *Curcuma longa*, *Zingiber officinalis*, *Manihot esculenta*, *Ammorphophallus campanulatus*, grasses and pineapple (*Ananas comosus*). But, this was not prominent, found occasionally in the home gardens, mainly due to giant African snails which being nocturnal and voracious caused severe loss to the crops. Grasses and legumes were seasonal ephemerals found greater during rainy season. Flowers like crossandra (*Crossandra infundibuliformis*), tuberose (*Polianthes tuberosa*), marigold (*Tagetes erecta*) and jasmin (*Jasminum grandiflorum*) were in meager in the front of houses and ixora (*Ixora parviflora*) and mussaenda (*Mussaenda frondosa*) on the home garden's boundary, but their contribution to the structure of the home garden was extremely low, hence not studied in detail. Forest trees were found rarely in the home gardens. Unlike home garden, top storey in home-forest-home garden was constituted by both evergreen (*Dipterocarpus grandiflora*) and deciduous (*Pterocarpus dalbergiodes)* forest species. Moreover, tree species in second storey were completely lacking.

Percent distribution of species and their individuals is given in Fig. 2. In the studied home gardens, maximum species were distributed in third and fourth stories. However, in the home gardens of Kerala (Mohan Kumar *et al.* 1994; Nair & Sreedharan 1986) and West Java (Michon *et al.* 1983) maximum species are reported to be found in first storey (ground layer). In these home gardens, cereals like rice, finger millet, maize; pulse like green gram, black gram; tuber crops like cassava, sweet potato, yams, elephants foot yams, taro, coco yam etc. are grown in the first storey due to low holding. However, in the present home gardens mostly first storey was not cultivated for crops mainly due to African giant snail and partly owing to greater holding. Farmers grow vegetable crops

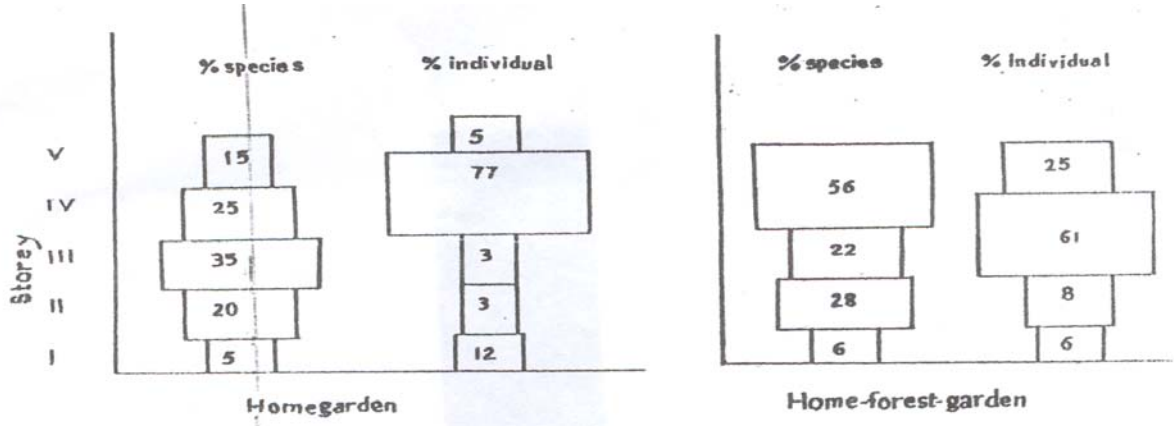

Fig. 2. Per cent species and individuals in home garden and home-forest-garden of South Andaman, India. Canopy stories as given in Fig. 1.

Table 2. Species diversity, equitability, concentration of dominance and species richness in home garden and home- forest-garden of South Andaman.

Parameters	Home garden	Home-forest-garden
Simpson index	0.4018	0.698
Shannon- Weaver index	1.380	3.164
Equitability	4.3219	4.087
Concentration of dominance	0.598	0.303
Species richness	5.559	4.834

in the rice fields adjoining to the home garden. Compared to home gardens, maximum species was distributed in fourth storey in home - forest - garden. Low per cent of species in second and third storey in home - forest - garden was mainly due to meager number of fruit species. The multilayered structure of the system indicated that the position, height and shade tolerance of plants were important traits that they had acquired with time (evolutionary) to suit the different niches in the homegardens. Michon *et al.* (1983) argued that the gradient of light and relative humidity creates different niches in home gardens.

Species diversity in present home gardens corresponds with the diversity value (0.739) reported for the home gardens of Kerala (Mohan Kumar *et al.* 1994), but is lower from that of evergreen forests (0.90) of western ghats (Pascal 1988). Inspite of lower species richness species diversity in home- forest- garden was greater than that in the home garden (Table 2). Higher diversity index but low species richness in the home - forest - garden indicated that the diversity of the system was controlled mainly due to equitability. Low equitability in home - forest - garden indicated distribution of maximum individuals among few number of species. Farmers developed the home - forest - garden system with few cash crop species, as commercialized farming system, whereas homegarden was tended relatively more towards subsistence farming. Thus, the study concludes that the homegardens ensure crop diversification, provide diversified products though low in amount but nutritious in nature (Pandey *et al.* 2006), conserve plant genetic resources and evolutionary processes (Esquivel & Hammer 1992) in the Andaman islands.

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