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ORIGINAL ARTICLE

Smallholder land use in the southern Yucatan: how culture and history matter

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Abstract A longitudinal survey was applied to 499 smallholder agriculturalist households in Mexico's southern Yucatán region to determine whether different cultural expectations had led to the formation and coexistence of different types of human–environment interactions. A three center cluster analysis was used, and two agricultural adaptive strategies were found to coexist: a diversified subsistence strategy built largely by individuals who were smallholder agriculturalists in their place of origin, and one generated mostly by non-agriculturalists who migrated to the southern Yucatán to make agriculture their business during the last agrarian reform. Each strategy followed unique family trajectories and established distinct human–environment interactions. The findings suggest that those who emphasize commercial agriculture have a better standard of living. Nevertheless, their improved on-farm livelihoods—judged by material, physiological, and educational indicators—comes at the cost of higher risks to their adaptive system and adverse environmental consequences.

Keywords Adaptation · Peasants · Colonization · Calakmul · Migration · Household's developmental cycle

Introduction

Access to markets (Cancian 1989; Ortiz 1973; Smith 1977), socio-economic stratification (Acheson 1980; Barlett 1977; Brondizio 2004), population density (Boserup 1965), social and kinship demands (Sahlins 1972), access to off-farm employment (Gurri and Moran 2002; Netting 1993), cultural priorities (Bennett 1976; Hanks 1972), and environmental conditions (Turner and Ali 1996) affect the composition, productive activities, and agricultural choices of smallholder agrarian households. Under certain conditions, foremost in subsistence-oriented cultivation, the consumer/worker ratio plays a major role in agricultural decisions as conceptualized by Chayanov (1986). According to Binswanger and McIntire (1987, 75–78), these conditions are consistent with those exhibited by geographically isolated areas and include low population density, abundant cultivable land with no or minimal market value, institutions permitting access, low levels of technology, and high transport and communication costs. In these conditions, the household's developmental cycle (Fortes 1949; Goody 1958) becomes an important predictor of land use (Bennett 1980; Dove 1984; Durrenberger 1979; Moran et al. 2003). In recently colonized tropical forests with low population densities, therefore, household composition itself may become an important determinant of household productive activities (Dove 1984) and agricultural choice (Brondizio et al. 2002; Moran et al. 2003).

With globalization, markets reach remote rural peoples and areas so that, even in the most recently colonized tropical forests, Binswanger and McIntire's (1987) conditions may be difficult to match. According to Netting (1993), access to markets will generate some form of intensification among subsistence agriculturalists and with it upset the association between consumer/worker ratio and amount of effort invested in agriculture. Some empirical studies support this assertion; deviations from the Chayanovian ideal increase as degree of isolation or distance to the market decreases (Chibnik 1987). Market participation

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encourages the combined planting of commercial and subsistence crops (Turner and Ali 1996; Von Rotenhan 1968; Wiber 1985) and generates opportunities for off-farm employment (Barber 1960).

The relationship between household structure composition and land use may also be affected by the household's cultural or socially determined needs and regulations. Cultural values (Greenwood 1976), culturally determined consumption level expectations (Bennett 1969; Tannenbaum 1984), understandings of the market and market mistrust (Cancian 1972; Forman and Riegelhaupt 1970), unexpected changes in household needs (Tannenbaum 1984), and desire for local prestige or political influence (Sahlins 1972) have all been shown to affect market participation, type and amount of household demands, and agricultural choices independently of consumer/worker ratio and household's developmental stage. Furthermore, cultural or individual differences between households may promote the coexistence of distinct adaptive strategies with different household trajectories and degrees of market participation (Sahlins 1972; Tannenbaum 1984).

In this paper, I use the concept of adaptive strategy (Bennett 1980) to assess whether and how market participation and or cultural choices affect household productive activities, structure, family trajectories, and land use in the most recently colonized and isolated area of the *municipio* of Calakmul in southeastern Mexico (referred to as the southern Yucatan in this special feature). The socioeconomic characteristics of settlements and the land management strategies have been the subject of extensive research (Abizaid and Coomes 2004; Chowdhury 2006; Chowdhury and Turner 2006; Haenn 2005; Geoghegan et al. 2001; Radel and Schmook 2008; Vance and Geoghegan 2004). So far, however, these works do not address the question of land management and its sustainability implications as part of a way of life.

This analysis identifies household life ways as a means to explain productive choices and focuses on local variability to clarify causal priority of some variables over others (Barlett 1980). Household productive activities, composition, structure, and the regulations that guide the decision-making process for survival and reproduction vary along three axes (Wilk 1997). Variations along any of these axes can affect how households transform environmental resources into household wealth. Household wealth itself is part of the morphological axis (Wilk and Netting 1984; Wilk and Rathje 1982) and can be classified and thus vary according to the relationship between its members, type of residence, number of members, household developmental stage, and the capital and consumer resources at their disposal (Pryer 1993; Wilk 1997). In this study, household wealth is divided into land, consumer goods, and capital goods. Land and capital goods (e.g., tractors, pumps, and cattle) can help generate more wealth through the productive activities in which the household members engage. These are part of the activity axis, which may be classified in three categories: productive activities; structural activities (e.g., inheritance, distribution, social and biological reproduction), and household maintenance (Wilk and Netting 1984; Wilk and Rathje 1982). Finally, families are also cultural units that share codes, rules, rights, and responsibilities. These shape and constrain individual behavior affecting household wealth, mostly by modifying the activity axis (Carter 1984; Netting et al. 1984). In this model, elements of the morphological axis such as household composition, land availability and tools limit what a household can do, while the cultural axis modifies and establishes the rules that sanction who can carry out which activity, and how the resources obtained should be used and distributed.

Background

Prior to 1970, the *municipio* of Calakmul was scarcely inhabited. The Maya descendants of the "*indios pacíficos*" of Icaiché (Ferré 1996; Haenn 2005), temporary workers from the lumber companies dedicated to the extraction of precious wood, and a few survivors from an earlier rubber boom (Fort 1979; Haenn 2005; Revel 1980) made up the bulk of the less than 4,000 inhabitants (Turner et al. 2004). In 1970, the Escárcega-Chetumal highway was completed connecting the SY to the rest of the country. In addition, the federal government opened the area for colonization through the formation of *ejidos*, agricultural land grants stipulating that the land may be used but not sold by community members (Farfán 1996; Leal 1996). By the year 2000, there were 187 communities, and the population had grown to 23,115 people (INEGI 2000). Colonists from 23 different Mexican states, but particularly from Michoacán, Guanajuato, Durango, Coahuila, Veracruz, Tabasco, and Chiapas colonized the area (Farfán 1996). Some, especially those from Chiapas, were agriculturalists escaping violence in their home towns who migrated to Calakmul to preserve their way of life. Most of the migrants, however, were urban, landless workers looking for land to start their own business (Rodríguez 2003).

In spite of rapid growth, population density remains low (1.5 people per km^2), and there is plenty of land available for cultivation. Among those sampled in this study, 82% cultivated their own land whether it was private or *ejido* (communal). Dry farming took place in well-drained flat or undulated parcels with soils 5–50 cms deep. Together these plots averaged 2.85 has but were divided in two. One for "jalapeño pepper" (*Capsicum annum* L.) cultivation and the other for *milpa* cultivation focused on maize. Primary or very old forest may be cut down for "jalapeño pepper"

cultivation. After the first year, jalapeño peppers may be cultivated again or new forest may be cleared for this cultigen and the plot used for *milpa* agriculture (see Hernández et al. 1995 for a description of the *milpa* system in the Yucatan Peninsula). Cleared plots will be used for a maximum of three agricultural cycles and left to rest a minimum of 5 years, usually more than 10. Only a few families with access to tractors make more intensive use of selected plots, mostly for jalapeño cultivation (Gurri 2002).

Most *milpa* products are grown for household consumption, and to collect government subsidies from a program designed to increase national grain production. The *milpa* requires relatively little effort and hardly any money is spent on it. Of its produce, only squash seeds are commercialized. Most agricultural investment is dedicated to jalapeño pepper production that requires good land high inputs in pesticides and herbicides as well as tending throughout the growing season (Keys 2004). This crop has to be harvested and bagged all at once in order to have it ready for pickup by intermediaries. This harvest requires the cooperation of the entire family, kin and hired community and outside labor. If the jalapeño does not sell or any is left over, it must be dried in outside ovens to be sold as "chipotle" later in the season. This strategy requires much labor because chipotle is not sufficiently profitable to warrant the use of hired labor (Gurri 2002).

Method

A combination of the activity, cultural, and morphological axes was used to obtain a working definition of the household. This includes the identification of all family members as well as their means of production, wealth, and reproductive behaviors. All individuals living in a shared backyard were considered to belong to the same family unit. Non-resident family members were also included when residents considered them part of the household. In general, non-resident household members were single, contribute to household income, or were dependents living out of town, such as high school students. Finally, the category "household head" was defined as the authoritative figure recognized by the rest as their leader. This person was usually an adult man, but some female-headed households existed.

A randomly chosen sample of households from 29 communities in the most southern part of the *municipio* close to the border with Guatemala (Fig. 1) was visited on three separate occasions. Three interviews were considered necessary to capture seasonal variation in household activities throughout the year. The first interview season was from August to October of 1999, the second from February to March of 2000, and the third from July to the first week of August of 2000. These communities were

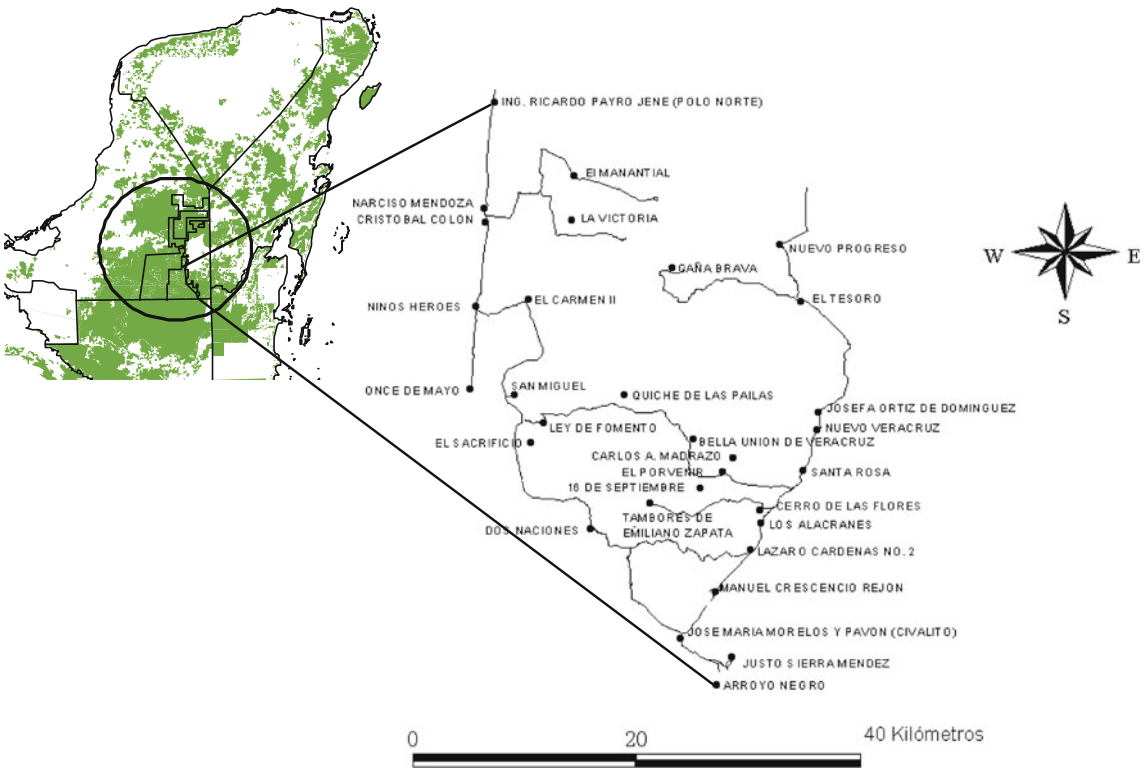

Fig. 1 Localization map: communities where the survey was carried out in the *Municipio* of Calakmul, Campeche, Mexico. Calakmul's biosphere reserve is shown for reference

chosen because their households were most likely headed by migrants who had inhabited the area for a similar time period and to reduce environmental variation. Their lands were officially granted in the 1980s, and their communities were established between three and five years before their *ejidos* were officially recognized. They are therefore the youngest communities in the area, and they are all located in the most humid part of the forest ecocline of the SY (Vester et al. 2007).

The surveys were used to determine household type by the variables characterizing each one of the axes noted previously (Table 1). All questions related to agricultural strategies were done during the summer of 1999 regarding the 1997–1998 agricultural cycle. A three *k*-means cluster analysis was chosen to group households into strategies. Three clusters were preferred to two or four because they provided larger Euclidean distances between final clusters and more significantly different variables between groups (ONE WAY ANOVAs). Each variable was transformed into a ratio level variable and standardized into z scores. All statistics were performed using the SPSSPC V10 statistical package (1999).

In the survey, the morphological axis was approached using 19 variables divided into two categories (Table 1). The first category included seven variables that described household size and structure and identified residence patterns. The Household Dependency Ratio used here is equivalent to the total dependency ratio (TDR) applied independently to each household but was not multiplied by 100 in order to deal with a value between 0 and 1. The second category of variables describes the household's productive capital, consumer goods, and the destiny of its outputs (Table 1). Three indices were calculated: the Agricultural Diversity Index, estimated as the total number of cultigens cultivated by a family over the total number of cultigens produced by all those in the sample; the Husbandry Diversity Index, estimated as the total number of animal systems worked by a family over the entire number of animal systems encountered in the sample; and the Fragmentation Index, estimated as the number of individual parcels (spatially separated) cultivated by a family over the total number of hectares cultivated by them. The value of each animal system was calculated in Mexican pesos from the year 2000, and the relative value of each system was estimated as a fraction of the sum of all animal systems.

The second axis describes the productive activities in which all household members over the age of 10 engaged. It contains seven composite variables (see Table 1) derived from all the productive activities undertaken per household. These were obtained from questionnaires applied to each household member during the first and third seasons. Household chores and hunting are self explanatory. Paid agricultural labor includes all agricultural and forestry activities performed in public or on somebody else's land in

Table 1 Variables used to classify households into strategies by axes

Morphological axis	Activity axis	Cultural axis
Family structure and composition		
Age of household head	Paid agricultural labor	Distance from place of origin
Household dependency ratio	Agricultural activities for household	Family type index
Family size	Household chores	Time residing in the area
Fertility in 5 years	Hunting	Fraction living at home
Male female ratio	Local non-agricultural salaried work	Marital age distance
Number of houses	Migrant work	Stops in migratory route
Proportion sons and daughters	Community work	Formal education household head
Wealth and means of production		
Agricultural diversity index		
Animal diversity index		
Backyard animals relative value		
Mixed animals relative value		
Cattle relative value		
Cultivated hectares		
Horses relative value		
Number of backyard vegetable species		
Self provisioning index		
Productive capacity		
Value of capital goods		
Value of consumer goods		

the *municipio* for which the individual received some form of payment. Agricultural activities for the household are those performed in any lands belonging to, rented or borrowed by any member of the household. Community work refers mostly to *fajinas*, but it may include other not remunerated work in the community. *Fajinas* are a set amount of hours per month that an *ejidatario* household must work in his community for free. This time varies per *ejido* and may be used for school or town maintenance or to build local infrastructure. Local non-agricultural salaried work is only for activities in the *municipio*, and migrant work includes any kind of remunerated activity outside the *municipio*. Each variable measures the number of individuals over the age of ten that performed them relative to household size.

Finally, variables that may vary between groups of different cultural background were used to classify variation along the cultural axis. These are the household head's place of birth measured as distance from place of origin, migration history measured as the number of places where a family stopped before establishing themselves in the *municipio* of Calakmul, age difference between the household head and spouse, and type of family. The latter identifies compound households, that is, households where more than one nuclear married couple cohabitate, using an index sensitive to the number of nuclear families living in a household.

Results

The cluster analysis draws on a total of 499 households that were surveyed across the 29 communities (Table 2). The best solution divided the households into three clusters:

Table 2 Total number and total classified households per community in Calakmul, Campeche

Community	Total households	Households classified
16 de Septiembre (Laguna de Alvarado)	11	10
Los Alacranes	31	15
Arroyo Negro	24	10
Bella Unión de Veracruz (Los chinos)	12	5
Caña Brava	15	5
Carlos A. Madrazo	9	5
El Carmen II	53	30
Cerro de las Flores	14	10
Cristóbal Colón	69	25
Dos Naciones	28	15
El Sacrificio	39	10
José María Morelos y Pavón (Cibalito)	44	10
Josefa Ortíz de Domínguez (ICAICHE)	32	25
Justo Sierra Méndez	17	10
Lázaro Cárdenas No. 2 (Ojo de Agua)	49	20
Ley de Fomento Agropecuario	25	25
El Manantial	52	24
Manuel Crescencio Rejón (Frontera Sur)	47	20
Narciso Mendóza	41	15
Niños Héroes	37	20
Nuevo Progreso	7	5
Once de Mayo	43	20
Quiché de las Pailas	45	20
San Miguel	15	10
Santa Rosa	46	25
Los Tambores de Emiliano Zapata	25	15
El Tesoro	55	20
La Victoria	23	10
Hermenegildo Galeana	18	10
Guillermo Prieto	21	10
ING. Ricardo Payro Gene (Polo Norte)	112	30
Nuevo Veracruz	32	15
Total	1,091	499

Cluster 1, 202 households; Cluster 2, 225; and Cluster 3, 72. Table 3 shows the results of one-way ANOVAS performed on each of the standardized values of the variables used to generate the clusters. The value of *F* was obtained from the between-cluster mean square to the within cluster mean square for that variable. In Table 3, the cluster mean for each variable is expressed in standard deviation (SD) units from the overall cluster mean for that variable. Because the overall mean is 0, negative values indicate cluster means lower than the overall mean, and positive values are greater than the mean. For instance, the Animal Diversity Index in Cluster 1 is 0.63 SD units below the overall cluster mean, while in clusters 2 and 3, it is 0.16 and 1.27 SD units above it, respectively. The difference between the means of clusters one and three for this variable is almost two SD units. Variables are arranged by their *F* value in descending order. This arrangement may be viewed as ordering the variables from those that distinguish better between groups to those that are more alike between them. No significance values were added to the *F*'s, because the clusters were generated to characterize differences and are thus not random samples.

For Cluster 1, the average family is nuclear and has the smallest average family size. They cultivate fewer hectares in very few plots (largest fragmentation index), depend on a lesser variety of cultigens and maintain a high backyard

Table 3 Cluster centroids ordered by *F* value in descending order

	Cluster			*F*
	1	2	3	
Animal diversity index	−0.63	0.16	1.27	168.74
Cattle relative value	−0.28	−0.23	1.51	156.65
Backyard animals relative value	0.53	−0.16	−0.96	85.94
Cultivated hectares	−0.57	0.18	0.91	82.46
Fragmentation index	0.58	−0.34	−0.44	61.69
Agricultural diversity index	−0.53	0.45	−0.05	59.54
Family size	−0.50	0.37	0.23	50.73
Horses relative value	−0.49	0.38	0.19	48.74
Proportion sons and daughters	−0.39	0.44	−0.28	48.44
Value of capital goods	−0.16	−0.17	0.96	45.99
Distance from place of origin	−0.06	−0.24	0.90	41.77
Age of household head	−0.27	−0.03	0.84	38.05
Household dependency ratio	−0.32	0.39	−0.33	36.20
Number of backyard vegetable species	−0.35	0.23	0.26	22.53
Family type index	0.16	0.08	−0.69	22.40
Value of consumer goods	−0.01	−0.19	0.63	19.62
Time residing in the area	−0.26	0.14	0.27	12.01
Fertility in 5 years	−0.03	0.15	−0.39	8.34
Formal education household head	0.21	−0.17	−0.07	8.18
Number of houses	−0.21	0.11	0.25	8.08
Agricultural activities for household	−0.19	0.19	−0.05	7.86
Mixed animal systems value	−0.17	0.11	0.13	5.28
Household chores	−0.06	0.14	−0.25	4.91
Hunting	−0.14	0.05	0.23	4.28
Migrant work	0.15	−0.09	−0.14	4.00
Marital age distance	−0.07	−0.02	0.27	3.22
Male female ratio	0.07	−0.12	0.16	2.97
Paid agricultural labor	0.11	−0.04	−0.19	2.81
Community work	0.11	−0.05	−0.17	2.63
Fraction living at home	−0.02	0.07	−0.17	1.75
Local non-agricultural salaried work	0.05	0.02	−0.19	1.61
Self provisioning index	−0.07	0.02	0.11	0.87
Stops in migratory route	−0.03	0.01	0.05	0.17
N	202	225	72	499

animal value. In contrast, Cluster 3 possesses the largest average compound families with the oldest household heads. They cultivate the greatest number of hectares in many different plots and plant a greater variety of cultigens, practice animal husbandry and have capital invested in cattle, capital goods, and consumer goods. Cluster 2 is intermediate between the other two.

A graphic comparison of "age of household head" distribution per cluster in Fig. 2 suggests that while clusters 1 and 2 have different means, their distributions are similar. The distribution of Cluster 3, however, is notably different. Most Cluster 2 household heads range between the ages of 30 and 45, whereas the majority of Cluster 1 household heads are under the age of 35, most between 20 and 30 years of age. Cluster 3 households bifurcate into those with heads between 30 and 40 years of age and those whose heads are older than 50. Cluster 3 households headed by men 40 years and younger have demographic characteristics similar to those of Cluster 2 households (Fig. 3). Younger Cluster 3 household heads and Cluster 2 households are mostly nuclear and some extended, while older Cluster 3 households tend to be compound. Cluster 2 households have relatively more sons and daughters than any other strategy, and Cluster 1 families have fewer children than the rest. Cluster 1 houses often have no children, and those that do have only one or two, invariably less than 11 years old. Children of Cluster 2 households and Cluster 3 households with heads younger than 40 years old have children who are mostly between 5 and 15.

There are qualitative differences in the types of investments and land-use patterns of each household type. Table 4 shows a percentile distribution on the value of consumer, capital goods, and animals held per family type. As in Fig. 3, Table 4 divides Cluster 3 households into

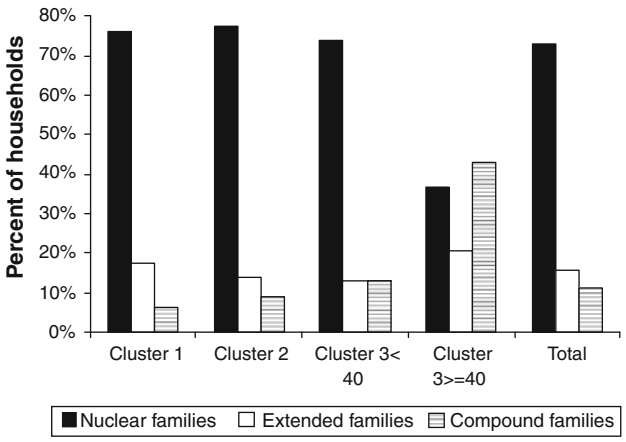

Fig. 3 Type of family per cluster with Cluster 3 divided by age of household head

those headed by men who are less than 40 and those headed by individuals 40 years of age or older. As expected, the consumer and capital goods value of Cluster 3 families is considerably greater than those of the other families. The upper 25% of the Cluster 3 houses headed by men who are less than 40 years old, however, are considerably wealthier than the Cluster 3 houses headed by older individuals. This is particularly so when we consider capital goods, such as heavy agricultural equipment (e.g., tractors), suggesting differences in land-use management.

Differences in investment and capital accumulation are also seen in the animal systems each type of family has. While the total value of animals is similar across households in Cluster 3, the composition of ownership is different, with young households owning cattle and old households relying on horses (Fig. 4). Cattle are typically held as a long-term investment, while horses are used as

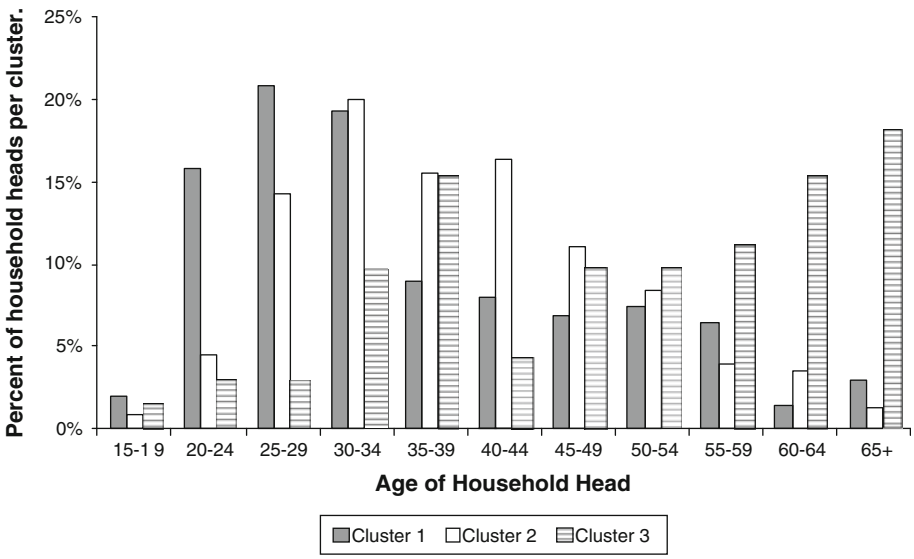

Fig. 2 Household heads by 5-year age group per cluster shown as percentage of total household heads per cluster by cohort

Table 4 Percentile distribution of the total value of consumer goods, production goods, and animal holdings per cluster in Mexican pesos

	Percentile distribution per system								
	Consumer goods			Production goods			Animal holdings		
Strategy	50	75	95	50	75	95	50	75	95
Cluster 1	1,260	1,550	4,709	700	700	25,630	500	920	3,842
Cluster 2	1,260	1,480	3,603	700	1,300	25,000	2,440	3,200	6,816
≤40 Cluster 3	1,550	3,780	7,244	2,700	27,700	85,480	9,520	28,820	94,524
>40 Cluster 3	1,540	3,270	6,475	2,000	25,700	61,650	6,660	32,030	105,250

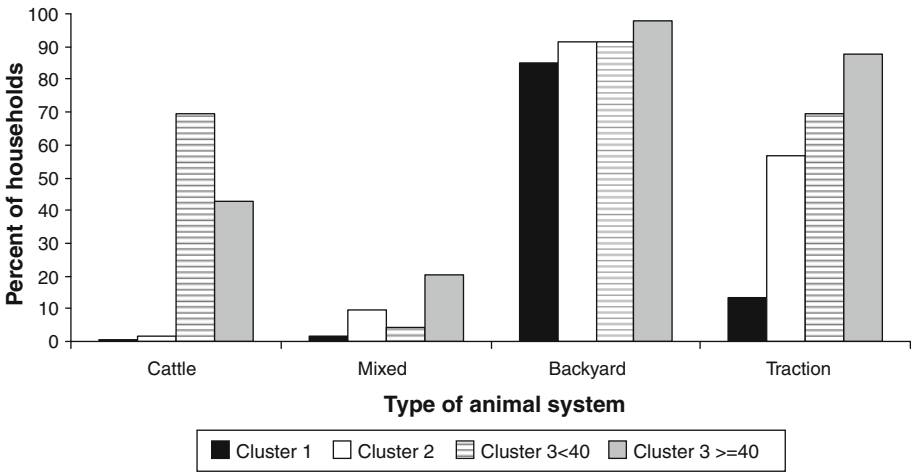

Fig. 4 Percentage of households with specific animal systems per cluster

an agricultural tool for transport. The pattern of animal ownership in Cluster 2 mirrors that of the older households in Cluster 3, although with fewer animals. Cluster 1 families appear not to have much more than backyard animals.

The similarities between the older Cluster 3 households and Cluster 2 households, and those between Cluster 1 and young Cluster 3 households can also be appreciated in their agricultural production (Table 5). Consistent with expectations, both Cluster 3 families worked more hectares in 1998 than all the other families. Older Cluster 3 households, however, planted considerably more than young Cluster 3 households, and the latter did not plant many more hectares than Cluster 2 households. Both older Cluster 3 and Cluster 2 families planted more plots in the same number of hectares and a greater variety of cultigens than any of the other two strategies. Younger Cluster 3 and Cluster 1 households planted fewer hectares, in less fractioned fields and concentrated on fewer cultigens. This strategy is consistent with the use of agricultural inputs and mechanized agriculture suggested by the capital wealth of the younger Cluster 3 families.

Discussion

At first blush, the positive association between wealth, family size, and the age of the household head is suggestive

Table 5 Mean cultivated hectares, number of plots, fragmentation index, and diversity index per cluster during the 1998–1999 agricultural cycle in Calakmul, Campeche

Strategy	Cultivated hectares		Number of plots		Fragmentation index		Diversity index	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cluster 1	4.69	3.32	1.62	0.73	0.53	0.42	0.25	0.12
Cluster 2	9.66	5.07	1.81	0.97	0.23	0.16	0.4	0.14
≤40 Cluster 3	11.58	9.26	1.67	0.48	0.22	0.14	0.31	0.13
>40 Cluster 3	15.76	10.76	2.15	1.09	0.19	0.16	0.33	0.12
Total sample	8.48	6.61	1.76	0.89	0.34	0.32	0.33	0.15

of a Chayanovian-like pattern by which the amount of household wealth generated and the size of agricultural land utilized per agricultural cycle depends on the household life cycle and in particular on the ratio of dependents to laborers (Chayanov 1986). The pattern seen in Fig. 2 with respect to "age of household head", however, casts doubt on this interpretation. While the percentage of Cluster 1 and Cluster 2 households both decreases with the age of the head, the Cluster 3 category, which tends to be wealthier, appears to have at least two household head age groups.

The first one, headed by men aged 30–45 and with the same demographic characteristics as in Cluster 2, lives in nuclear and some in extended families with young and adolescent children. Unlike Cluster 2 smallholders but like those in Cluster 1, they depend on investment in technology, high inputs commercial agriculture, hiring labor (non-household labor), cultivation of large contiguous plots, and the accumulation of capital goods and wealth in cattle and bank accounts. The second group, a household with the characteristics of a land rich peasant addressed by Chayanov (Durrenberger 1979; Tannenbaum 1984) is headed by a 45-year-old or older man who presides over a compound family with children of all ages, including adult married sons and grandsons. Unlike younger Cluster 3 smallholders, however, their agricultural practices are similar to those of Cluster 2 smallholders, and their spending in consumer goods is similar. In this sample, Cluster 3 older households have fewer capital goods but do rely on horses for transporting the harvest from their parcels. Although they plant many more hectares than younger rich smallholders, they do so on much smaller plots that exhibit greater variation.

It would appear, then, that in Southern Calakmul, there are at least two distinctive clusters of agricultural households. Because the agricultural production of Cluster 1 and young Cluster 3 nuclear households is similar, and Cluster 2 looks much like older Cluster 3 compound households, in regard to animal, and capital holdings and agricultural production, it is proposed that Cluster 1 smallholders and young Cluster 3 smallholders belong to different developmental stages of a single adaptive strategy and Cluster 2 and Cluster 3 older households belong to different developmental stages of another.

Existing research on smallholders classified during this investigation allowed us to compare each strategy in terms of reproductive behavior (Gurri 2003), adaptability (Alayón and Gurri 2007a), vulnerability (Gurri and Vallejo 2007), and sustainability (Alayón and Gurri 2007b, 2008). In addition, in-depth interviews and participant observation with a subsample of these families provide insights into their motivations to migrate and their attitudes toward agriculture (Rodríguez 2003).

The first strategy includes a developmental path that goes from Cluster 2 nuclear households to older compound Cluster 3 households in a Chayanovian fashion. Cluster 3 land-rich compound households are organized around a patriarchal figure that makes most of the production and distribution decisions affecting his immediate nuclear family and that of his married male sons living in his household. Young married men remain within the household and cooperate with the household head, eventually adding their own plots to the household's worked parcels (Dove 1984). In areas like Calakmul (i.e., hollow frontiers, Busch and Geoghegan this volume), a sufficient family size (labor pool) is required before a new household can be created (Netting 1986). Households classified in this Cluster 2–Cluster 3 compound strategy depend mostly on household labor, which may explain why Cluster 2 household heads are relatively old in spite of the fact that they start their reproductive life early on (Ortega and Gurri 2003). All of them have at least one adolescent child. Moreover, studies by Balderrama (2005) and Alayón and Gurri' (2007a) suggest that to separate from the Cluster 3 Compound household and become a Cluster 2 household, the male head of a nuclear family would have to have at least one daughter old enough to help her mother, who is approximately 10 years of age.

These smallholders depend on a high variety of cultigens, which in the southern Yucatan region are planted in small separate plots slightly bigger than one hectare (Gurri 2002). Families grouped in this strategy generally do not have savings. They depend on multiple economic activities throughout the year that include salaried work, jalapeño (chili) commercial agriculture, long- and short-cycle swidden, fallow field and/or forest harvesting, which includes hunting and gathering, and the strategic use of different government payments (Alayón and Gurri 2007b; Gurri and Vallejo 2007). As would be expected of subsistence-oriented swidden cultivators (Bennett 1980; Durremberger 1984), the total number of plots and therefore the overall number of hectares under cultivation increase as Cluster 2 households become older Cluster 3 compound households, and more hands become available to work on them. They use very few agrochemicals, and almost none has mechanized fields (Alayón and Gurri 2007b, 2008). Neither Cluster 2 nor compound older Cluster 3 households invest much in agricultural inputs. Most of their money is spent on consumer goods.

The Cluster 2–Cluster 3 compound households together appear to form a traditional household agricultural strategy whose main purpose has been described as survival and reproduction (Foster 1988; Hoffman 1996). They pursue a risk-averse strategy that generates few if any overstocks and instead depends on a diversified seasonal strategy that includes commercial and subsistence agricultural

production as well as seasonal salaried work and other subsistence activities such as hunting and gathering (Atran et al. 1993; Kearney 1996; Netting 1993; Gladwin 1979; Lipton 1968). While this strategy has been referred to historically in many ways (Kearney 1996; Redfield 1956; Turner and Ali 1996; Wolf 1966), it is referred to here as household subsistence agricultural strategy (HSA) recognizing that subsistence agriculture also includes the planting and selling of commercial crops, in this case "jalapeño peppers." Furthermore, judging by the lack of changes in the colonist's reproductive histories (Ortega and Gurri 2003), and their migration histories (Rodríguez 2003), it appears that most of Calakmul's HSA families were agriculturalists before moving to Calakmul and are reproducing their local survival system.

Unlike HSA, the reproductive behavior of the second strategy composed of Cluster 1–Cluster 3 nuclear households differs from that of their parents, suggesting that this strategy was adopted in the region (Ortega and Gurri 2003). Also unlike HSA, the life histories recovered so far (Rodríguez 2003) suggest that these households were not necessarily agriculturalists in their place of origin. In fact, most of them were not, and they came to Calakmul to make agriculture their business.

As mentioned previously, Cluster 1 and Cluster 3 nuclear households depend on investment in technology, high-input commercial agriculture, hiring labor (non-household labor), the accumulation of capital goods, and wealth in cattle and bank accounts (Alayón and Gurri 2007a, b, 2008). Cluster 1 smallholders have fewer heads of cattle but are relatively well-stocked with their own pesticide–herbicides pumps, and sundry agricultural equipment. This raises the question as to how household heads younger than those of Cluster 2 could get access to relatively expensive farm capital.

Most Cluster 1 household heads are young. Men set up their households at least 10 years earlier than HSA men. Unlike young HSA men, Cluster 1 men have their own farm land and their own homestead. Moreover, each married male member of a Cluster 1 strategy considered himself a household head even if he cultivates very few hectares of his own or none at all. Subsequent ethnography carried during the second season on 36 of the classified households, plus observations of Cluster 1 and Cluster 3 nuclear family ties suggests that young Cluster 1 and Cluster 3 nuclear households were likely to form patrilineal household networks of labor and resource exchange as described by Estrada and Bello (2005) in the neighboring state of Quintana Roo. These networks are particularly important for commercial transactions between patrilineally related independent households.

In our sample, many Cluster 1 houses were located on plots given to the male household head by his father, and they were involved in unequal reciprocity networks with other family units, particularly with their father's, which was most likely a Cluster 3-nuclear household, in which labor was exchanged for access to capital goods. Irrespective of whether they planted their own plots, Cluster 1 household heads continued to work their father's land and care for his cattle. Older Cluster 1 smallholders have more capital goods, and by observing their transactions, it became apparent that as households accumulated capital goods, they would share them with their brothers and father's. For example, several related smallholders would cooperate to buy tractors and trucks, but only one would be the owner. The only owners in our sample were Cluster 3 nuclear in kind, but Cluster 1 household heads had access to them. Cluster 1 household head's exchange of labor for access to resources is more clearly observed among those smallholders with access to range land. Cluster 1 smallholders with cattle often use their father's pasture and in return tend his cattle. Some Cluster 1 household heads tended their father's cattle even if they did not have cattle of their own. While there is cooperation and sharing of capital goods and rangeland, each household head privately owned his land, cattle, and spray pumps so that if their agricultural business went well, young Cluster 1 smallholders could expect to eventually accumulate enough land and agricultural inputs to head their own patrilineal business. Because Cluster 1–Cluster 3 nuclear households have made agriculture their business, this second smallholder grouping has been named household commercial agricultural strategy (HCA). As with the HSA, it bears emphasizing that farmers in this category pursue a hybrid production strategy that combines commercial and subsistence cultivation.

Based on the results of in-depth interviews in the sample used in this study, Rodríguez (2003) concludes that the decision as to which strategy to use is determined before migration; indeed, it motivates migration. For most of the HCA colonists from central and northern Mexico, the agrarian reform offered them access to new lands and an opportunity to be their "own bosses." While the commercial crop of choice, chili, may have been a local opportunistic decision (Keys 2004, 2005; Keys and Chowdhury 2006; Vance and Geoghegan 2004), HCA colonists travelled south to take possession of their own lands to make agriculture their business. HSA colonists, on the other hand, were already subsistence farmers elsewhere. Many of them fled from violence in Chiapas with the intent of maintaining a way of life.

Regardless of their geographical origins, HSA and HCA strategies established different human–environment interactions. The strategies' internal dynamics influenced the choices that affect the well-being and standard of living of

its members, shape their land management practices and thus their environmental impact, and places restraints on their ability to respond to external stimuli, such as local market constraints or environmental hazards, such as hurricanes.

Alayón and Gurri (2007a) and Gurri (2005) discovered that HCA smallholders provided a better standard of living than HSA, and they did not suffer from the physiological effects produced by a negative energy balance during the yearly scarcity seasons. In addition, both male and female HCA youngsters are likely to miss fewer days of class, and unlike their HSA female counterparts who abandoned grade school to take on responsibilities at home, HCA adolescent women stayed in school (Balderrama 2005).

Household Commercial Agricultural Strategy households have a better standard of living in general, but their land-use system is much more vulnerable to shocks and stresses from the environment and economy (Gurri and Vallejo 2007). While HCA smallholders harvest more than one commercial crop throughout the year (Gurri 2002; Vance and Geoghegan 2004), only the profits from their yearly jalapeño harvest allow them to generate the savings they need to weather the scarcity season, buy medicines, pay wage labor, and invest in the agrochemicals, seeds and equipment they need to start a new cycle (Alayón and Gurri 2007b, 2008; Gurri and Vallejo 2007). Unfortunately, reliance on this crop is risky, as plagues, droughts, and market fluctuations make the associated income streams highly variable (Keys 2004, 2005). When hurricane Isidore hit the area in 2001, HCA farmers made a futile attempt to salvage the jalapeño harvest by investing energy, time, and savings that would otherwise have been invested in other subsistence crops, needed equipment, and cattle to increase savings (Gurri and Vallejo 2007). Indeed, recent research indicates that some commercial farmers elsewhere in the region, apparently HCA smallholders, increased migration to the United States, shifting their household income to include remittances after recent chili cultivation failures (Radel and Schmook 2008; Schmook and Radel 2008; Schmook and Vance 2009).

Local agricultural practices have negative environmental impacts, especially in terms of the draw-down in available soil phosphorous and bracken fern invasion (Lawrence et al. 2007). While the relative contribution of each smallholder type to these processes is still under investigation, the intensive, high input agriculture, cattle raising, and market dependence of HCA smallholders (Alayón and Gurri 2007b, 2008) have been positively linked to deforestation (Chowdhury 2006; Chowdhury and Turner 2006; Geoghegan et al. 2001; Schneider and Geoghegan 2006), suggesting that commercial smallholders place greater stress on individual land parcels than do HSA.

Conclusion

This paper uses the concept of adaptive strategy to assess whether and how market participation and or cultural choices affect household productive activities, structure, family trajectories, and land use in the most recently colonized and isolated area of the *municipio* of Calakmul in southeastern Mexico. Two adaptive strategies were found, HSA and HCA. As suggested by Netting and others, household trajectories, land-use strategies, and management were affected by market participation. HCA households that emphasize production for the market did not conform to the expectations of Chayanov's model. The relationship between household trajectories and land use in HSA households that emphasize subsistence on the other hand did. While both types of households were affected by their developmental cycle, HCA utilized intensive production methods with high agricultural inputs regardless of household size, while HSA households increased production with increasing household size**,** and favored less intensive land-use forms. Practicing agriculture as a business or as a subsistence strategy, however, was not explained by access to the market but was a cultural choice taken by the migrant before he arrived to Calakmul. A choice that implied life ways changes that affected family trajectories and established distinctive human–environment interactions that lead to singular outcomes in regard to material livelihoods, the environment, and household impacts from different types of shocks to the system. The commercial households (HCA) maintained better living standards but were exposed to relatively high levels of risk from market and environmental perturbations and stresses. The relative impacts on the environment by either household type remain under investigation, although it is clear that HCA households placed greater stress on individual land parcels than did subsistence households.

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