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Manioc Varietal Diversity and Distribution Constraint in Rural Amazonia

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Abstract

Social exchange networks play a critical role in the maintenance and distribution of crop diversity in smallholder farming communities throughout the world. The structure of such networks, however, can both support and constrain crop diversity and its distribution. This report examines varietal distribution of the staple crop manioc among rural households in three neighboring *caboclo* communities in Brazilian Amazonia. The results show that the centrality of households in exchange networks had no significant correlation with the number of manioc varieties maintained by households. However, household centrality did show a significant correlation with households' perceived knowledgeability in manioc cultivation as well as the total area of manioc under cultivation. Although households with the most knowledgeable and active producers play a central role in the distribution of planting materials and manioc varieties, they did not maintain higher varietal diversity than more peripheral households in this study. This demonstrates that in some cases social networks can support unsustainable behaviors or conditions, such as low crop diversity, and increase community vulnerability.

Keywords: crop diversity, manioc, social network analysis, Amazonia

Introduction

The Food and Agriculture Organization (FAO) reports that since the 1900s more than 75% of the world's genetic plant diversity has been lost (FAO 1999). This loss has resulted in large part from the rise of industrial agriculture and the adoption of high-yielding uniform crop varieties over genetically-diverse traditional crop varieties (Altieri 1999; Thrupp 2002). Of the remaining global crop diversity, a significant proportion is managed by rural smallholder farmers, especially in the developing areas of the world. Despite increased attention toward global crop diversity managed *in situ*, especially for staples like maize (Bellon and Brush 1994), potatoes (Brush et al. 1995; Zimmerer and Douches 1991), and rice (Vaughn and Chang 1992; Zhu et al. 2003), the management of crop diversity by rural smallholders requires greater investigation, especially in regards to the ways it is shaped by human social dynamics. Social exchange networks of seeds and planting materials can support crop diversity and its maintenance (Emperaire and Peroni 2007; Seboka and Deressa 1999; Subedi et al. 2003). However, the structure of exchange networks, influenced by kinship patterns (Deletre, McKey, and Hodkinson 2011) and the position of individuals related to agricultural expertise or socio-economic status in the community (McGuire 2008; Subedi et al. 2003), has important impact on the distribution of crop diversity. As this study will show, social exchange networks may even produce vulnerabilities for farming communities when the primary households relied on for sourcing materials maintain relatively few varieties.

Most rural communities of Brazilian Amazonia rely heavily on the root crop manioc, often cultivating dozens of unique varieties (e.g. Emperaire and Peroni 2007), selected for different rates of maturation (Elias, Rival, and McKey 2000), resistance to rot and disease (Heckler and Zent 2008; but, see also Wilson 2003), and agronomic performance in relation to climatic and soil conditions (Fraser 2010; Fraser et al. 2012). Many manioc varieties are also selected because of socio-economic considerations including aesthetic appeal (Heckler 2004), market demand, and consumptive purpose (Dufour 1993). Among some Amazonian indigenous groups, a high number of varieties cultivated by an individual or household can also reflect social prestige (Heckler 2004; Heckler and Zent 2008). Although not all Amazonian ethnic groups attribute the same socio-cultural value to manioc varietal diversity, manioc varieties are often widely exchanged among households in rural communities. The distribution of such varieties, however, is rarely uniform (Emperaire and Peroni 2007).

While past research on manioc varietal diversity has focused largely on indigenous groups of Amazonia, this study centers on rural smallholders of mixed-descent, oftentimes referred to as *caboclos*, who represent the majority of the rural Amazonian population. The social dynamics of exchange and the importance of manioc varietal diversity in *caboclo* communities can differ greatly from indigenous groups, including greater market influence and more common participation of both men and women in exchange (Lima, Steward, and Richers 2012). Our study uses social network metrics to investigate two primary research questions:

1. *Is the position of a household in manioc exchange networks positively correlated with the number of manioc varieties managed by the household?*
2. *Is the position of a household in manioc exchange networks positively correlated with the household's perceived knowledgeability of manioc agriculture?*

Methods

Household surveys and structured interviews were conducted at all 45 permanently occupied households in three communities surrounding Puruzinho Lake in the municipality of Borba, Amazonas, Brazil (Figure 1). Since members of these three communities are closely related through kin ties and live in close proximity, we have analyzed them together as a group. During the survey and interviews, adult household representatives present at the time of study were asked about the varieties of manioc they planted, the area of land they dedicated to manioc, and the characteristics they considered most important in manioc varietal selection. Since household representatives were selected based on availability during the time of visit, men were interviewed at 24 households, women were interviewed at 9 households, and couples were interviewed at 12 households. Informants were also asked with whom they had exchanged manioc cuttings in the 12 months prior to the interview. From these data, we created a one-mode relational matrix of households by households for manioc exchange.

Informants were also asked to name those in their community they believed "worked best with manioc" (*trabalhava bem com mandioca*), or in other words, were most skilled and knowledgeable in manioc agriculture. More than one individual could be named. Household manioc "knowledegeability" was ranked by summing the number of times individuals in the household were cited by others.

UCINET (Borgatti, Everett, and Freeman 2002) was used to calculate centrality measures for these networks. Measures of centrality reflect the relative position of a node (household) within a network; many studies show a strong relationship between centrality and influence (Freeman 1977; Borgatti et al. 2007). For this study we used two centrality measures, degree and betweenness. Degree centrality for a household is the number of other households to which it is directly connected. Betweenness centrality is calculated by finding the shortest path between every pair of households with their betweenness measured as the number of short paths they are on (Scott 2000: 86). Degree centrality serves as a measure of network activity while betweenness is a measure of brokering.

Since these relationships are directional (i.e. households can borrow from one household and lend to another) distinctions can be made between in-degree and out-degree centrality. In this study, in-degree centrality is a measure of the number of households to which an individual household gave manioc cuttings while out-degree centrality measures the number of households from which an individual household received manioc cuttings. Measures of betweenness centrality were normalized to improve their distribution.

Results

Manioc Varietal Diversity and Selection

Of the 45 permanently-occupied households, 43 households cultivated manioc. All of these 43 households planted their manioc fields in the uplands (*terra firme*) including 14 households that resided on the floodplain (*várzea*). Some of the households that resided on the floodplain planted manioc in floodplain homegardens, but their primary manioc fields were planted in the uplands most often to avoid losses in the unpredictable floodplains.

Households studied in these three communities actively cultivated between 0 and 8 varieties of manioc with an average of 3.5 (±1.7) varieties per household (Figure 2). Knowledge of manioc varieties and their names varied greatly among household representatives as 6 of the 43 (14.0%) households interviewed could not name any of the varieties in their fields. This stands in sharp contrast to reports from other studies of

Amazonia, particularly among indigenous groups, where value and even prestige can be associated with knowledge of manioc varietal diversity (Heckler 2004; Heckler and Zent 2008). However, Heckler (2004) also reported that Piaroa respondents expressed concern that many in their communities no longer knew the names of the manioc varieties they planted (p. 248).

In all, residents reported 28 different varieties of manioc under active management (Table 2). The most common varieties were: Nova Olinda (planted by 32 households), Branquinha (22 households), and Jabuti (18 households). Seventeen varieties were cultivated by only one or two households, demonstrating that a small number of varieties dominated in the community while much of the varietal diversity was poorly distributed.

Farmers were asked about the most important characteristics they looked for in manioc varieties, and they were able to mention more than one. The most common response (24 households) was selection for varieties that produced the greatest root biomass ("*dá bem batata*"). The second most common response (22 households) was selection of varieties of bitter manioc that had deep yellow roots. This emphasizes the importance of regional aesthetic preference, which also related to regional market demand for yellow manioc flour. It is difficult to say whether or not yellow manioc flour has a distinctive taste, but it is nearly always favored over lighter colored varieties. Extension agents reported that some producers in Borba dyed their *farinha* yellow to make it more attractive to consumers and boost sales (Kawa 2011: 101).

Manioc Exchange Network

Twenty-six households (57.8%) acquired manioc cuttings from at least one other household around Puruzinho Lake during the year before interviews, while fifteen households (34%) did not. Four households (9%) acquired manioc cuttings strictly from households in communities outside the Puruzinho Lake region.

The network of reported exchange of manioc varieties (Figure 3) consists of three separate components (a set of households connected directly or indirectly, and twelve isolates (households that did not give or receive manioc cuttings). The first component (C1) is composed of only two households in which a mother had given manioc cuttings to her adult son whose house was located on the same property. The second component (C2) comprised of three households reflects a similar situation in which another mother who served as the head of her household shared varieties with her adult sons who had their own homes in very close proximity. This "cluster" pattern of households linked by closely-related kin follows the same model reported in other areas of rural Brazilian Amazonia (Lima 1992). Finally, the third component (C3) consists of 29 different households making up the bulk of the network. In this largest component, two households clearly stood out with both the highest degree centrality and betweenness centrality in the network (Figure 3: Households A and B).

In-degree centrality did not correlate with household manioc varietal diversity (r= -.026; p=.876) nor did out-degree centrality (r=.252, p=.127). Betweenness centrality which requires a connected graph, was calculated for the main component in the network (C3), and showed no significant correlation with the number of manioc varieties either (r=.023; p=.890). We conclude that a household's position in the exchange network held no significant relationship to the number of varieties managed by the household.

Knowledge and Manioc Agriculture

Recall that households were asked to name the individuals who "worked best with manioc" (*trabalhava bem com mandioca*), or in other words, were most skilled and knowledgeable about manioc production. One household named by 25 different households (more than 50% of those surveyed), and both female and male head of the household were considered experts. This household had the highest degree and betweenness centrality in the network of exchange (Figure 3; household A). The second most knowledgeable household, named 10 times (specifically citing the female head of the household), and had the second highest degree and betweenness centrality in the exchange network (Figure 3; household B). Knowledge and in-degree centrality were found to be highly positively correlated (r=.765, p=.000), but out-degree centrality was not (r=-.239, p=.114). There was a significant positive correlation between betweenness centrality in the exchange network and knowledgeability as well (r=.557; p=.000). In other words, households that were perceived as having the most skilled and knowledgeable manioc farmers were the ones that people sought out when they were in need of manioc cuttings.

There was a significant correlation between the area of manioc planted by the household and the perceived knowledge of the household (r=.343; p=.023) as well as the in-degree centrality in the exchange network (r=.461; p.002). Yet there was no significant correlation between the score of manioc "knowledgeability" and the number of varieties managed by a household (r= -.074, p=.653). We conclude that unlike previously studied indigenous communities in which knowledge of manioc agriculture is usually reflected in a high varietal diversity, knowledgeable households in our study did not plant more varieties of manioc. However, these households did plant a larger area of manioc and played an important role in giving manioc cuttings to other households.

Discussion

In their research with the Makushi in Guyana, Elias, Rival, and McKey (2000) described families in terms of "sources" and "sinks," the former describing households that managed their cuttings efficiently and had enough to share with other community members while the latter suffered from shortages of cuttings and had to seek out others for planting materials. Source families were more respected within the community than sink families. In this study of *caboclo* communities, a similar tendency appears in which more centralized households in exchange not only donated cuttings to more households, but they were also viewed as the most knowledgeable manioc farmers. However, this demonstrates that in communities where the most knowledgeable or skilled producers maintain a low number of varieties, there is a constriction of the overall number of varieties managed, potentially leading to greater agricultural vulnerability.

The total number of manioc varieties as well as the mean number of varieties planted per household in this study are relatively low when compared to manioc diversity studies from other areas of the Amazonia. It seems that *caboclo* communities plant fewer varieties of manioc compared to Amazonian indigenous groups (c.f. Boster 1984; Carneiro 1983; Chernela 1986; Heckler and Zent 2008; Emperaire and Peroni 2007). Pinton (2003) makes the argument that these differences may relate to traditional knowledge, arguing that *caboclos* usually maintain less knowledge related to varietal diversity and its management than Amerindian groups (see also Emperaire, Pinton, and Second 1998). Socio-cultural factors influencing diversity may also explain this difference as high varietal diversity does not necessarily command status or prestige in contemporary *caboclo* communities. Salick, Cellinese, and Knapp (1997) made similar observations among the Amuesha, noting that while varietal diversity was seen as important historically within communities, productivity played the most important role in the contemporary varietal selection and maintenance. Market influences appear to also have an effect, as the primary criteria for selection in this study were productivity and varietal color, the latter reflecting a response to market demand for yellow manioc flour.

The household with the highest varietal diversity in this study sheds further light on these trends. A lone elderly widow managed this household, cultivating a total of eight different manioc varieties. She was clearly very knowledgeable of manioc and its cultivation, and eagerly discussed at length the nuanced differences of local varieties, including their rates of maturation, the color of their roots and leaves, and the quality of the flour they produce. However, unlike the most commonly cited expert households, this woman produced manioc largely for her personal subsistence, and had little interest or land capacity for market production. Because she produced relatively little manioc, and was less concerned with market production, her role in varietal exchange was minimal. As a result, she distributed little of the varietal diversity she managed.

Limitations

As with any study of crop diversity it is possible that differences in overall diversity were related at least in part to the specific period of time when research was undertaken. Nearly all households commented on the extreme nature of the climate and its impacts on agriculture prior to data collection in 2009 (see Chen, Wilson, and Tapley 2010). Record floods led to a major drop in manioc production in Brazilian Amazonia and a locally reported shortage of manioc cuttings in the municipality of Borba. Although households in the communities around Puruzinho Lake do not typically plant in the floodplain, the potential to acquire cuttings and different manioc varieties from other communities that plant in the floodplain was greatly reduced. Moreover, many farmers in Puruzinho commented that a period of drought following the record floods led to manioc crop failure. Families that usually replanted fields with cuttings taken from older fields had to scramble to find cuttings elsewhere, potentially losing varieties that they had collected and adopted over time.

It must also be noted that an exhaustive catalogue of manioc varieties was not attained. Some respondents explained that they could cite the names of the varieties they knew best, but there were a few lesser known varieties in their fields that they could not recall. Also, while names of manioc varieties were solicited from all households, field visits were not conducted during interviews because manioc fields were located far from the majority of homes. Since interviews were conducted in the afternoons, it seemed inappropriate to ask respondents to trek back out to their fields during the hottest part of the day to identify manioc varieties.

Finally, while manioc remains the primary staple for the majority of rural families in the municipality of Borba, it seems that many households in past years have shifted the focus of their production to other market crops and opted to buy or trade for manioc flour. This strategy was re-evaluated by many farmers, however, as the flooding in 2009 and later drought led to major losses in manioc production and prices for manioc flour soared as a result. Some farmers who had adopted other market crops that were once more valuable in the market reverted to manioc production not only because prices improved, but also because it remained a critical part of the daily diet and they couldn't afford to pay for manioc flour at such elevated prices. As one elder resident and avid manioc farmer in

Puruzinho proclaimed, "Hunger for manioc flour is the worst thing ever." This underscores the importance of understanding manioc varietal diversity and its distribution in caboclo communities where crop diversity may be dwindling over time.

Conclusions

From these analyses, several important conclusions can be drawn:

1. The centrality of households in exchange networks had no significant relationship to the number of varieties maintained by individual households.
2. Knowledge of manioc agriculture was highly correlated with in-degree centrality and betweenness centrality in exchange networks, revealing that households with the most knowledgeable manioc farmers also maintained highly centralized positions in exchange networks.
3. These most centralized households typically planted a large area of manioc and played important roles in the sourcing of manioc cuttings, but did not manage the highest diversity of manioc varieties.

These findings raise an important question about the degree to which influential households in social exchange networks may have a broader impact on the overall crop diversity in rural communities and how such social structure can influence the distribution of varietal diversity over time. Policy interventions to encourage the adoption of greater crop diversity should not assume that those households central to exchange are necessarily those that maintain a great diversity of varieties. While centralized households in exchange networks can be targeted for the most efficient distribution of varieties, they may need to be convinced that the adoption of greater varietal diversity is in their best interest as well as that of their community. Such an approach may be a more effective way to encourage varietal diversity than untargeted interventions.

This study also demonstrates some of the ways in which social network analysis can be a useful tool for understanding the social distribution of crop diversity, and future studies examining the distribution of other crops in different areas of the world may benefit from this model. Future research could be improved by incorporating GIS into the analysis to further investigate the relationship between spatial distance and social networks. Also, longitudinal studies that collect data on patterns of exchange networks could be particularly useful for understanding how such networks may respond or adapt to changes over time, specifically in response to crises like flooding and drought. Furthermore, the comparison of networks of exchange among different social groups and ethnicities could provide useful information for understanding how specific social structures or social networks are more conducive to the long-term conservation of crop diversity than others.

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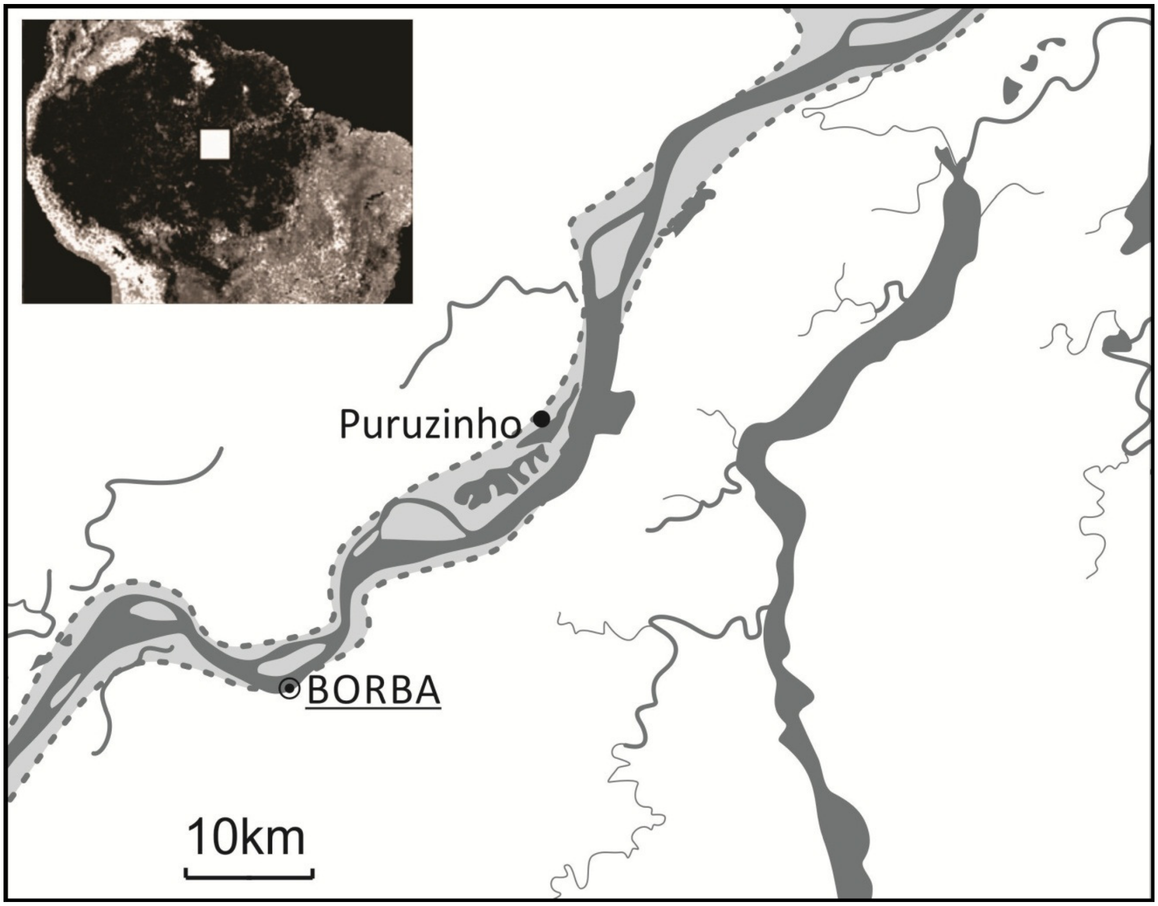

Figure 1. Map of the municipality of Borba and the Puruzinho Lake study area. (Credit: Victoria Frausin)

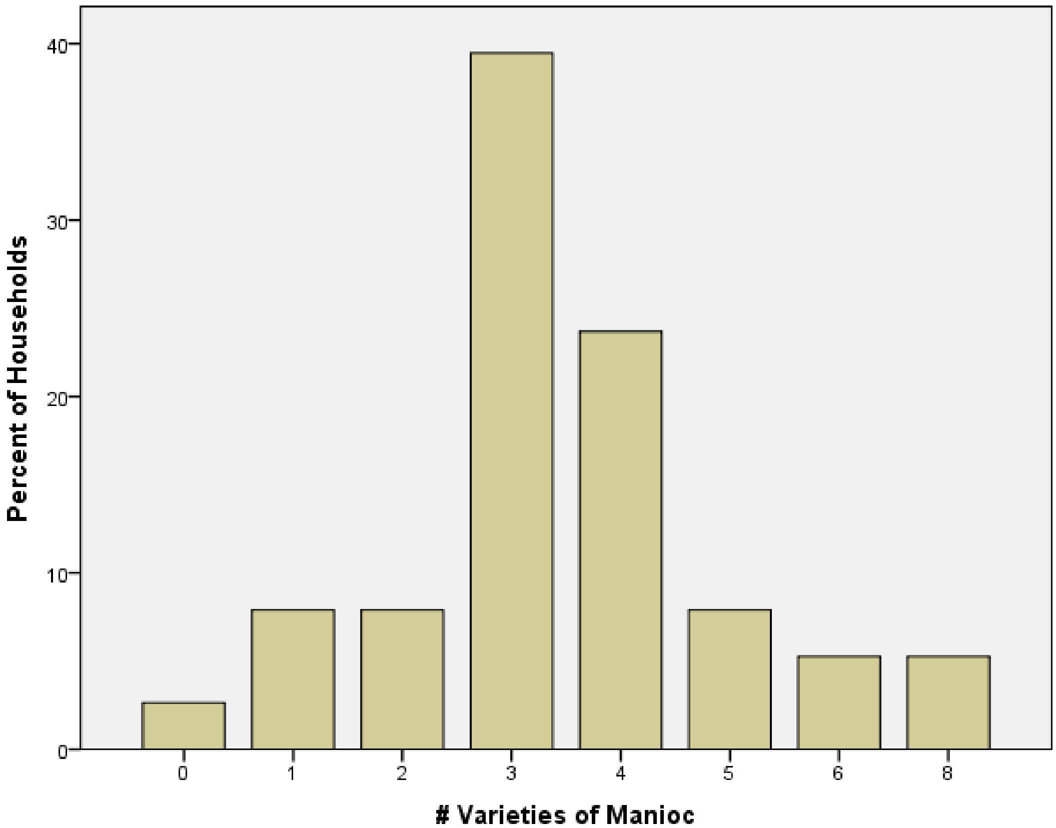

Figure 2. Distribution of the number of varieties of manioc per household in Puruzinho Lake region

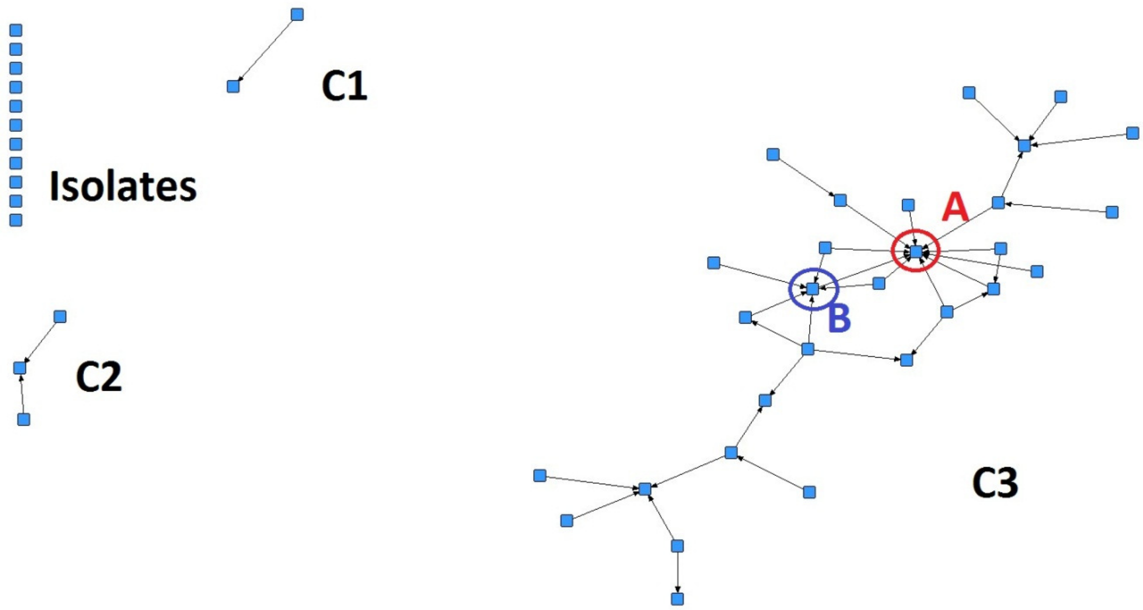

Figure 3. Puruzinho Lake network with households tied by manioc varietal acquisition. C1, C2, and C3 are the three components of the network. A and B are the households with the highest and second-highest in-degree centrality, respectively. Arrows point to households from which cuttings are acquired or taken on "loan."

Table 1. Household data for Puruzinho Lake households in relation to manioc varietal diversity, knowledgeability, and centrality in exchange networks

I.D.	Comm.	Age	Sex	#Var. Manioc	Knowledge score	Exchange Out Degree	Exchange In Degree	Between-ness
72	2	50	F	5	2	0	0	.00
5	1	55	M	?	0	1	0	.00
59	2	22	F	3	0	0	0	.00
63	2	35/?	M/F	3	0	0	0	.00
80	1	50	M	4	2	0	0	.00
34	2	35	M	2	0	1	2	.11
37	3	45	M	6	2	0	2	1.48
24	2	43	M	3	9	0	0	.00
87	2	31	M	3	0	1	0	.00
62	2	26	M	3	1	0	0	.00
116	3	34/29	M/F	3	0	0	2	15.54
35	1	81	F	8	0	1	1	.00
7	1	62	F	1	0	0	0	.00
89	3	48	F	3	2	0	1	.00
61	2	33	M	4	0	1	0	.00
78	1	22	M	4	0	1	0	.00
60	2	29	M	?	0	1	0	.00
16	2	50/52	M/F	3	0	1	0	.00
75	2	27/?	F/M	4	0	3	0	1.96
76	2	46	M	3	2	1	1	2.85
20	1	49	M	4	0	2	0	.00
27	2	27	F	2	0	1	0	.00
1	1	35	M/F	4	0	1	0	.00
74	1	26	M	?	0	1	0	.00
88	3	34/29	M/F	?	0	1	0	.00
22	3	27/24	M/F	6	0	2	0	2.85
6	1	38	M/F	4	0	1	0	.00
8	1	40	M	1	0	0	0	.00
17	3	31	M	3	0	0	4	10.68
26	2	30/?	M/F	5	0	0	4	8.25
70	2	42	M	4	0	2	0	.00
25	3	33	M	3	0	2	1	14.48
90	3	37	M	3	0	0	0	.00
115	1	40/35	M/F	8	0	2	1	12.58
91	2	48	M	?	0	1	0	.00
23	3	62	M	5	4	0	1	.00
64	2	18	F	3	1	1	0	.00
77	1	43	M	?	0	2	0	.00
65	2	76	M	4	1	1	0	.00
28	1	77	M	0	0	0	0	.00
36	1	53/40	M/F	2	10	1	5	18.45
71	2	30/54	M/F	1	3	0	2	.11
79	2	41	M	3	25	0	9	25.32
9	1	32	M	3	0	4	0	17.39

73	1	26	M	0	0	0	0	.00

Table 2. Varieties of bitter and sweet manioc managed by households on Puruzinho Lake

Local varietal name	Sweet/bitter	# Households	% Households
Amarelinha	bitter	8	17.7
Arrepiada	bitter	1	2.2
Aruari	bitter	4	8.9
Azulona	bitter	1	2.2
Batatinha	bitter	1	2.2
Branquinha	bitter	22	48.9
Cacaia	bitter	4	8.9
Flechinha	bitter	1	2.2
Folha fina	bitter	1	2.2
Geralda	bitter	3	6.7
Giovana	bitter	1	2.2
Guia_roxa	bitter	5	11.1
Hermosa	bitter	1	2.2
Jabuti	bitter	18	40.0
Jabuti de ouro	bitter	8	17.7
Japonesa	bitter	2	4.4
Macaxeira pele vermelha	sweet	5	11.1
Macaxeira manteiga	sweet	2	4.4
Macaxeira pao	sweet	1	2.2
Mandioca branca	bitter	1	2.2
Maniva do Bodeco	bitter	1	2.2
Nova Olinda	bitter	32	71.1
Paraiso	bitter	7	15.6
Pirarucu de ouro	bitter	2	4.4
Pirarucu de prata	bitter	1	2.2
“Sem nome” (Nameless)	bitter	1	2.2
Tartaruga	bitter	3	6.7
4 Mes	bitter	1	2.2