Full Length Research Paper

Food security from cultivated *Dioscorea* yams: Is that what subsistence farmers want?

Timothy Harris

Royal Botanic Gardens, Kew, Richmond, TW9 3AE United Kingdom.
E-mail: t.harris@kew.org, Telephone: (+44) (0)20 83323121

Across Madagascar, wild endemic yam species are collected from open access areas and used as a food of last resort, at times when other crops fail. An alternative is to cultivate yams. A notable knowledge gap in using yam cultivation to enhance local food security is a paucity of data concerning demand for cultivated yams and whether people in the relevant communities prefer the wild yam species to the exotic cultivated yam species. Understanding these preferences contributes to addressing the issue of poor food security causing extinction pressure on specific native yams and helps to determine whether yam cultivation can reduce this. In this study, a revealed preference choice experiment approach found that subsistence farmers would rather obtain the cultivated but introduced species *Dioscorea alata* as a standby rather than the three wild species of yam that occur locally: *D.kimiae, D.arcutinervis* and *D.seriflora*. This study shows that a choice experiment can provide information about preferences in a subsistence setting and this study demonstrates how validity tests can be incorporated in to a choice experiment approach.

Key words: *Dioscorea,* Choice-experiment, Food-security, Madagascar, Ikongo, non-monetary, validity.

INTRODUCTION

Diversification of crops is an important aspect of improving food security (Bommarco et al., 2013; Lin, 2011). Food security is not just about ensuring that foods are available and affordable; it also includes ensuring that there is sufficient diet diversification and micronutrient availability (Tontisirin et al., 2002). Food security implies access by all people at all times to the food needed for a healthy life (von Braun et al., 1992). Diversification of crops also reduces vulnerability to pests and disease and to climatic variability (Altieri, 1999). This paper examines whether villagers prefer a cultivatable yam species that has recently started to be promoted as a crop that could increase food security or whether villagers prefer yam species that can be collected in open access forests.

Understanding consumers' preferences for alternative locally-grown subsistence crops is important in understanding whether an alternative subsistence crop will be accepted by the local population and hence how further crop diversification could be achieved (Faye et al., 2011).

Subsistence farming dominates in the majority of households in the Ikongo region of Madagascar, with few

households producing higher value products such as fruits, cash crops or other vegetables, isolating these households from fluctuations in the national economy (Ravelonjanhary, 2010). Remoteness and limited road access, particularly in this Ikongo Region, exacerbates this isolation and is a factor contributing to the dominance of subsistence farming. Remoteness and isolation result in areas being unable to trade surpluses or obtain agricultural inputs. Subsistence agriculture involves considerable uncertainty as yields can fluctuate considerably, with major effects on a household. Cash crops are grown for revenue while subsistence crops are grown purely for household food security. Since the vast majority of households are economically undiversified, they are also exposed to climatic variations (World Food Programme, 2011).

Subsistence farmers face a range of risks that have the potential to critically affect their food security (Scoones et al. 1996). Environmental risks include weather, pests and disease affecting their yield. The villages nearer to Madagascar's eastern coast are particularly at risk from the effects of cyclones and floods in the cyclone season

between November and April. Subsistence farmers in this Ikongo region, like subsistence farmers around the world, have limited capital to rebuild after disaster (World Food Programme, 2011). Diversification to incorporate a wider range of crops can mitigate against these risks that subsistence farmers face (Altieri, 1999).

In many parts of Madagascar, *Dioscorea* yam tubers are only eaten when staple crops such as rice fail or supplies have been exhausted. Madagascar has 40 species of native yams all of which are endemic. Thirty of these species are edible although some wild yams require more preparation to make them palatable than others. At least half of the edible species are endangered through forest loss and over exploitation (Wilkin, personal communication, 2011). Madagascar has predictable 'hungry seasons' between rice crops during which people switch from consuming rice to alternative foods. Yams are stored post-harvest in some parts of the world but not in this area of Madagascar. Inclusion of yams in the crops that are widely cultivated in a region may reduce the extinction pressures on native endemic yam species.

A yam cultivation project has recently started in the Ikongo region of Madagascar. The charity Feedback Madagascar is promoting cultivation of an introduced species of yam (*Dioscorea alata*) with the aim of improving food security for the local communities and reducing the degradation of forest habitats and the native yams that grow in them (Feedback Trust, 2011). The charity provides training for farmers to learn the cultivation methods that produce the highest yields. Understanding peoples' preferences for yams shows whether the cultivation project can be sustained into the future without additional inputs.

Foods collected from open access areas are important for food security, but over use has implications for species conservation (Ackermann, 2004). The FAO estimates that approximately one billion people use wild foods in their diet (Aberoumand, 2009) and thus they are important for food security. Forests are valuable areas for wild food collection and provide livelihoods and food for some 300 million people in the form of non-timber forest products. Food security and non-timber forest products are strongly interlinked in rural communities, especially for the most vulnerable groups (Belcher et al., 2005).

The wild yams of Madagascar are an example of an open access forest resource where exploitation is only limited by social norms which are themselves limited by taboos associated with gathering such a famine food. These wild yams could become depleted, and certain species become extinct, if overexploitation continues. Yams (*Dioscorea* tubers) are used as a food of last resort in a number of African countries (Coursey, 1967; Andresen, 2009). The tubers provide a starch-rich food. When cultivated, rather than growing the plants from seed, 'seed tubers' are exchanged and grown. Some

yams are also sold in Madagascar as a wayside snack. It remains to be seen whether, as yam cultivation becomes more widespread in Madagascar, introduced yams will be grown as a security crop or with a greater emphasis on providing staple nutrition or even cash revenue, as in other countries in West Africa.

The role of overexploitation in increasing the risk of extinction of certain wild foods has been particularly studied for medicinal plants and for timber extraction (Hawkins, 2008). Cultivation has on a number of occasions been proposed as at least part of a solution to over exploitation. As collection of subsistence foods from the wild is not well documented and their trade difficult to follow it is not surprising that the extinction risk posed from such collection is poorly understood and rarely discussed.

This study assesses which yam species is most highly valued by villagers in the Ikongo region of Madagascar, with a central aim to better understand preferences for wild and cultivated yams. Such information could be used to direct priorities in future yam cultivation projects. This study thus investigates whether villagers from a particular area prefer cultivated yams to a range of yams obtainable from open access forests. This study also investigates variables that correlate with respondents' preferences to understand the context of the results and to assess their validity.

MATERIALS AND METHODS

This paper applies the choice experiment method (Adamowicz et al., 1998) to estimate the private benefits farmers derive from three different species of wild yam and one species of cultivated yam that form components of villagers' diets especially in months when the villagers' household store of rice, the staple crop, is exhausted. The analysis is based on primary data collected in eight villages in the Ikongo region of central Madagascar.

In this study a choice experiment procedure was used to value different features of villager's diets with the overall objective of better understanding the potential role of yam cultivation on both food security and biodiversity conservation. Each choice experiment question required respondents to compare two hypothetical scenarios of receiving a variety of different food items in return for hypothetically providing a given quantity of rice as 'payment'. Choice experiments are structured, with each choice set containing different quantities of different attributes (Louviere et al., 2000). In this survey, each of the four different yam species was treated as a separate attribute. Checks were made on whether respondents could identify the yam species, but no further information was provided to respondents regarding the taste, nutrition, ease of collection or ease of preparation for the

Caption for Figure 1.

Maps showing the location of the eight villages surveyed in the Ikongo region of Madagascar and their proximity to the Ambositra-Vondrozo forest which includes habitat suitable for wild yams.
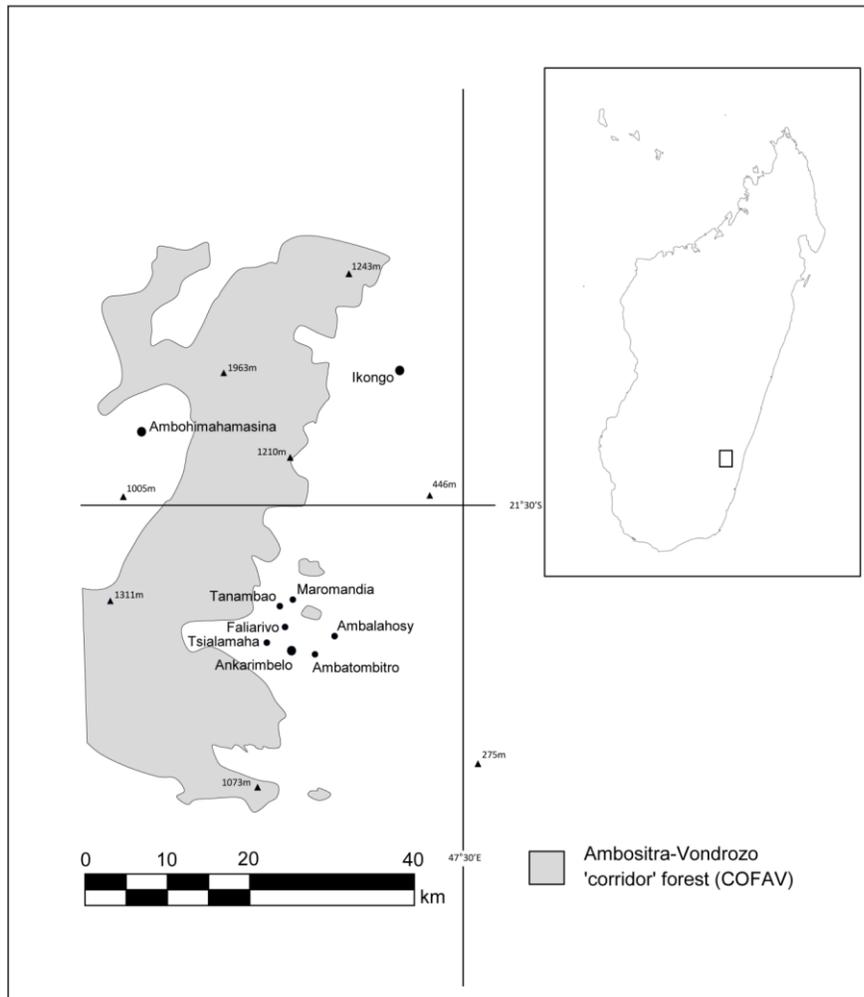
yams or any other food items. Each choice experiment question also had a third hypothetical scenario where the respondent could choose not to provide any 'payment' of rice and not receive any yams. Another food item also appeared as an attribute in the choice experiment scenarios.

This survey in the Ikongo region investigates preferences for three wild species of yam that occur locally: *D. kimiae* Wikin (ovitareta), *D.arcutinervis* Hochr. (ovifaitra) and *D. seriflora* Jum. and H. Perrier (ovifotsy). In a previous study of the Ikongo area, (Ravelonjanhary, 2010) it was reported that villagers knew ovitareta and ovifaitra and confirmed that these local names corresponded to these species.

Study Area

The villages surveyed are 60km south-east of Fianarantsoa city, which is centrally placed in the highlands. Ambohimahamasina is 80km from the eastern coastline of Madagascar and is in the Haute Matsiatra region. The other seven villages are further east in the Ikongo district of the Vatovavy-Fitovinany region: Tanambao, Faliarivo, Tsialamaha, Maromandia, Ambalahosy, Ambatombitro and Ankarimbelo, designated as the local community centre. Between Ambohimahamasina and the villages of Ikongo district is an escarpment descending from 1000m near Ambohimahamasina to 800-400m altitude for the other

Table 1. The average weight of rice, the staple food crop, produced by a household varies fourteenfold across the eight villages visited.

	Maromandia	Tsialamaha	Tanambao	Faliarivo	Ambalahosy	Ambatombitro	Ankarimbelo	Ambohimahamasina (Sofanolo)
Involved in the yam project	NO	NO	NO	YES	YES	YES	NO	YES
Average number of yams cultivated per household this season	26	0	13	11	9	23	8	3
Average number of yams collected from forest per household this season	84	175	126	38	63	98	45	1
Average rice harvest per household	67kg	86kg	88kg	180kg	215kg	135kg	210kg	964kg
Average age of head of household	34yr	40yr	43yr	46yr	45yr	46yr	44yr	47yr
Proportion of households cultivating yams	25%	10%	34%	50%	24%	48%	24%	30%
Proportion of households cultivating yams but not collecting from forest this season	23%	0%	30%	30%	14%	21%	6%	30%
Proportion of households collecting yams from forest but not cultivating this season	61%	90%	58%	26%	54%	44%	50%	3%
Proportion of households collecting yams from forest *and* cultivating yams this season	2%	0%	4%	20%	10%	28%	18%	0%

villages studied. On this escarpment is the Ambositra-Vondrozo 'corridor' forest (COFAV), which has been included within a protected area since December 2006. It extends to Ambositra, 200km to the north. The ranges of the native wild yams considered in this survey extend into the Ambositra-Vondrozo forest. The whole study area is incorporated within the coordinates 21°55'S 47°08"E to 22°10'S 47°25'E (Figure 1).

While some cash crops, including coffee and vanilla, are grown by farmers within the study area, the region's main staple crop is rice. This staple crop of rice provides the majority of the nutritional intake for the local population (Ravelonjanhary, 2010). In addition to cultivation, villagers also collect animals and plants from open access forest areas (the forest is under some degree of protection as it falls within the COFAV protected area). 58% of respondents surveyed said that they collected yams from this forest area (**Table 1**). In order for the Feedback Madagascar yam cultivation project to be successful it is important to know which species of yam villagers most prefer.

Data Collection

The survey was carried out in person by the author assisted by enumerators employed by Feedback Madagascar, and was translated into and out of Malagasy. Enumerators undertook a preliminary survey of 30 households in Ambohimahamasina, to test the planned approach. The choice experiment and modified survey was then carried out in seven more villages in the Ikongo region.

The sampling units were households. A sampling frame of all the households associated with the seven selected villages was constructed using the contacts provided by local collaborators. Random sampling was used to select households from the sampling frame, stratified according

to village. The sample size was 300 households. Fifty households from each village were chosen at random (The two villages called Tsialamaha and Maromandia were combined due to their small size). A reward of one packet of crop seeds was given to each household that took part.

Within the whole of the Vatovavy-Fitovinanay region, 34% households cultivate rice in the first season and 59% households cultivate rice in the second season. In 71% of households in the Vatovavy-Fitovinanay region, the total yearly quantity of rice harvested is less than the total yearly quantity of rice consumed by the household, showing that households have periods when they need to source food from whatever markets are available or gather food from the wild. The World Food Programme finds that only 1.4% households in the Vatovavy-Fitovinanay region are food secure. Most households in this region show borderline food security (World Food Programme, 2011).

Half of the villages surveyed were involved in a yam cultivation project that promoted the best methods to achieve increased yam yields. In three out of the four villages where the yam cultivation project was not active, yams were being cultivated, although rarely using the techniques supported by the project.

The Choice Experiment Approach

The preferences of villagers determine the implicit values they attach to different yam species. As most yams are rarely traded for money, non-market valuation methods must be used to determine the value of the benefits obtained from each food. When agricultural markets are limited and when large proportions of food grown or gathered are consumed by the household rather than exchanged, the value placed on such food crops can be very different to the market price (Arslan and Taylor, 2009).

In the absence of an active cash economy, expression of the value of yams in this choice experiment was by the volume of rice at which people are indifferent between rice and yams. Value can be expressed in terms of Willingness To Pay (WTP) or Willingness To Accept (WTA). Willingness To Pay is elicited from a respondent when a hypothetical benefit is offered and the respondent is asked how much they would pay or the benefit. Willingness to Accept is elicited when the respondent is asked what price they would be willing to accept to give up something they already own (Mitchell and Carson, 1989). This study follows uses rice as a numeraire to elicit WTA bids, following the assessment of costs of setting up Mantadia National Park, Madagascar (Shyamsundar and Kramer, 1996).

Choice experiments have been used previously to provide non-market valuation of agrobiodiversity of small farms, non-use values of wetland ecosystems and the value of river health (Birol, 2006; Groom et al., 2010; Kragt and Bennett, 2009). Choice experiments have also been used to examine personal traits underlying environmental preferences (Soliño and Farizo, 2014) and have been used to understand consumers preferences for different foods (Gracia 2014). The choice experiment approach has a theoretical grounding in Lancaster's model of consumer choice (Lancaster, 1966) in which consumers are considered to derive satisfaction not from goods themselves but from the attributes that they provide. The full range of attributes that can be attached to each species of yam is not fully known and so in the choice experiment, the species of yam was regarded itself as the attribute. Lancaster's model of consumer choice has been built upon by Random Utility Theory (RUT). RUT gives a theoretical foundation to experiments that ask respondents to choose their most favoured option from a choice set (McFadden, 1974; Thurstone, 1927).

The Choice experiment procedure followed that of (Adamowicz et al., 1998). Information sheets illustrating the attributes that distinguish wild and cultivated yams were used to characterise the decision problem. One attribute of the choice experiment was a readily valued food item: a live chicken. Including this item, in addition to the rice that is hypothetically exchanged for the yam attributes, was intended to provide an indicator of validity for value estimates calculated. Each respondent received a booklet containing three choice sets. For each choice set, the respondent chose their most favoured situation.

The information survey recorded the variation in wealth, knowledge, household structure and existing yam consumption and cultivation in the study area.

Choice Sets

Attribute levels were chosen based on reported market prices for yams (Cameron, personal communication, 2012). The number of cups of rice hypothetically handed over by the respondent is an indirect measure of cost to the respondent and allows an estimate of WTP. The indirect measure of cost is preferred over a direct monetary attribute because tubers in this Ikongo region are consumed or exchanged without being traded. This measure and can readily be converted into actual monetary units by using recorded market prices of the quantity hypothetically proposed for exchange, in this case rice.

A large number of unique scenarios can be constructed from the number of attributes and levels shown (**Table 2**). Rather than using a full factorial design, an orthogonalisation procedure was used to recover main effects in a fractional factorial design, consisting of 15

Table 2. Table of attributes

Attribute	Levels
Cups of rice(indirect measure of value)	20, 40
A chicken	0, 1
Tubers of ovifaitra (*Dioscorea arcutinervis*) from the forest	0, 2, 4, 8
Tubers of ovitareta (*Dioscorea kimiae*) from the forest	0, 2, 4, 8
Tubers of ovifotsy (*Dioscorea seriflora*) from the forest	0, 2, 4, 8
Tubers of ovibe (*Dioscorea alata*) grown in a garden	0, 2, 4, 8

pairwise comparisons of the scenarios. These were randomly blocked to five different versions, each with three choice experiment questions. Each choice experiment question contained two scenarios in which the respondent was expected to hypothetically give up a quantity of rice to hypothetically receive different quantities of the other food attributes.

Fractional designs systematically select subsets of attribute combinations from the complete factorial such that the effects of primary interest can be estimated under the assumption that some of the interactions between attributes are not significant. It was decided that testing the research questions would only require examination of main effects. (In factorial designs each level of each attribute is combined with every level of all other attributes. Limitations on sample size in any survey will mean that each respondent in a complete factorial experiment would have a high number of choice sets to complete, increasing opportunities for strategic responses.) A fractional factorial design of options orthogonal for main effects and consistent with an attribute based design strategy (Bunch et al., 1996) was generated by SPSS. Options were randomly paired together to form the choice sets. The choice sets were visually checked and were not thought to contain choice sets where an option overtly dominates another. Unlabelled generic alternatives were used to ensure that each option in the choice experiment was judged by the respondent on the basis of the attributes presented (Louviere et al., 2000).

The process of working through a series of choice sets can influence stated preferences such that the choice outcomes are dependent on the order in which a question is answered (Hutchinson et al., 2004; Bateman et al., 2008). The respondent may develop a response heuristic after answering a number of choice sets. As the respondent becomes aware of available combinations for goods and prices on offer, they may increase their rejection rate for combinations that are less favourable. (Scheufle and Bennett, 2010). The choice experiment only contained three choice sets per respondent, reducing opportunities for such learning effects.

According to Louviere (2000), each option in a choice experiment should be judged by the respondent on the basis of the attributes presented and so the options need to be unlabelled generic alternatives, as is the case in this survey.

Indirect Utility Function

In the Random Utility Theory approach, the utility of a choice is comprised of a deterministic component and an error component. Choices made between alternatives will be a function of the probability that the utility associated with a particular option (j) is higher than that associated with other alternatives. Assuming that the relationship between utility and characteristics is linear in the parameters and variables function, and that the error terms are identically and independently distributed with a Weibull distribution, the probability of any particular alternative j being chosen can be expressed in terms of a logistic distribution.

The vectors of coefficients β_1 to β_6 are attached to the vector attributes that influence utility.

Since social and economic characteristics are constant across choice occasions for any given household, these only enter as interaction terms with food attributes.

$$V_{ij} = \beta + \beta_1 \ln(Z_{rice}) + \beta_2 \ln(Z_{ovifaitra})$$
$$+ \beta_3 \ln(Z_{ovitareta}) + \beta_4 \ln(Z_{ovifotsy}) + \beta_5 \ln(Z_{ovibe}) + \beta_6 \ln(Z_{chicken})$$

where β refers to the ASC, which is specified to account for general willingness to pay for the food items offered in the choice experiment.

Alternative Specific Constant (ASC)

For each choice set, respondents chose between three options. The third option was a null option of not carrying out a hypothetical transaction: not giving up any rice and not receiving any other foods. All attribute levels are zero when this null option is chosen. The ASC variable is coded 1 for this option so that the reasons behind people choosing not to perform a hypothetical transaction can be assessed.

RESULTS

The data was initially analysed using a Conditional logit model. However, the model failed to meet the assumption of Independence of Irrelevant Alternatives (Arrow, 1950) and so the analysis was repeated using a Mixed Logit model (Hausman, 1984).

Do People Value Cultivated Yams more highly than Wild Yams?

The coefficients of a mixed logit model are the logarithm of the odds of an individual choosing an option containing the relevant food item. When p-values are less than 0.05, the null hypothesis of the respective coefficient being zero is rejected. Model 1 (**Table 3**) shows that people value ovibe more highly than any of the wild yams. The coefficients for the wild yams are not significantly different to zero, suggesting that villagers are indifferent to them whatever quantity is offered. Rice is used as the price numeraire. (Respondents were asked to hypothetically give up rice in order to receive quantities of the other foods). The results show the coefficient for rice is negative and significant, as would be expected for the price numeraire.

Interactions with the Alternative Specific Constant (ASC) term

41% of the choice sets received the null ASC response (29 % respondents gave the null response for all three choice sets shown to them). The lack of significance for the ASC term suggests a strong general willingness to pay for the foods offered in the choice experiment. (If the coefficient for ASC is significant and positive, this would imply a strong preference for the null option of not making a hypothetical transaction at all.) Interaction terms are introduced to investigate what affects general willingness to pay for the foods (Model 2, Table 3). There was a significant interaction term between yam identification skills and ASC . Those respondents who could identify the wild forest yams were less likely to refuse to make a hypothetical transaction.
 'YamID' was coded 1 if the respondent correctly identified images of a species of yam presented to them and coded 0 if they could not correctly identify the yam portrayed.

Does the Wealth of Different Villagers Correlate with how they value Different Species of Yams?

A range of variables were collected as indicators of

wealth. Due to poultry illness deaths affecting livestock ownership, yearly rice yield per household ('riceKg') was chosen as a wealth indicator. Interaction terms in Model 3, Table 3 suggest that more wealthy households are less likely to choose the null ASC option and are more likely to accept the hypothetical transaction.

Do People in Villages involved in the Yam Cultivation Project Value Cultivated and Wild Collected Yams Differently to People in Villages not yet involved in the Yam Cultivation Project?

Participation of a village in the yam cultivation project was coded 1 for 'Project'. (0 if cultivation project not present in village). Further interaction terms are added to the model (Model 4, Table 3).
  Lack of significance for the interaction term between yam project and ASC shows that being in a village involved in the yam project does not correlate with agreeing to the hypothetical exchange. Lack of significance for the interaction term between yam project and ovibe suggests that being in a village participating in the yam project does not significantly affect individuals' preferences for the different yam species.
  The experimental design had been structured so that villages involved in the yam project could be compared with those that are not. Once village participation in the project was shown not to affect preferences for yams, the effect of a household belonging to a particular village could be assessed (Model 5, Table 3). The interaction terms between Ambohimahamasina and ASC and Faliarivo and ASC are significant, suggesting that households in these villages were significantly more willing to undertake the hypothetical exchange than households in other villages. Tanambao was not involved in the yam project at the time of the survey.

Validity of Results

Stated preference methods only record what people say they would do, not actually what they do. Some of the variables collected are thus used to assess the choice experiment's validity. Following Mitchell and Carson, 1989, both Criterion and Convergent validity are addressed.

Criterion Validity

Inclusion of a chicken in the food options allows an assessment of criterion validity: whether the values produced by the stated preference method reflect actual market values. Local market surveys gave an average chi-

Table 3. Coefficients and p-values (italicised) for Mixed logit models. Values in bold are those for which the Null hypothesis of the coefficient being zero can be rejected at the 5% level. Model 5 was chosen as the source of coefficients used in assessing WTP.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Rice	**-0.108413**	**-0.116501**	**0.123085**	**--0.109607**	**-0.138181**	**-0.151970**	**-0.128649**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Ovifaitra	0.059322	0.079400	0.072861	0.064493	0.083407	0.078728	0.053367
	0.127	*0.058*	*0.138*	*0.101*	*0.110*	*0.211*	*0.288*
Ovitareta	0.042091	0.044118	0.048485	0.044382	0.038978	0.072802	0.048279
	0.230	*0.239*	*0.254*	*0.213*	*0.396*	*0.170*	*0.246*
Ovifotsy	0.044821	0.034509	0.068587	0.029492	0.0577463	0.055775	0.065117
	0.146	*0.302*	*0.073*	*0.342*	*0.167*	*0.245*	*0.098*
Ovibe	**0.199760**	**0.211339**	**0.222870**	**0.203155**	**0.219353**	**0.172296**	0.098173
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.038*	*0.229*
Chicken	**3.301184**	**3.764032**	**4.053629**	**3.508722**	**4.694855**	**5.193355**	**3.980366**
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
ASC	-0.954869	-1.150112	*-1.801943*	-0.700891	-1.844987	-1.623351	-1.454980
	0.156	*0.382*	*0.251*	*0.591*	*0.241*	*0.240*	*0.259*
Age×ASC		0.037216	**0.068055**	0.025704	0.056027	**0.063283**	0.0355237
		0.148	*0.036*	*0.488*	*0.044*	*0.032*	*0.129*
YamID×ASC		**-4.540188**	**-4.100789**	**-3.612853**	**-3.436917**	-2.123672	-2.307137
		0.001	*0.001*	*0.010*	*0.003*	*0.160*	*0.112*
riceKg×ASC			**-0.006576**		-0.000773	**-0.002438**	**0.001438**
			0.000		*0.377*	*0.028*	*0.037*
Project×ASC				-0.776755			0.167257
				0.460			*0.140*
Project×Ovibe				0.009190			0.051162
				0.893			*0.610*
Ambohimaham-asina×ASC					**-4.368464**	-0.034951	**-4.154196**
					0.010	*0.981*	*0.003*
Faliarivo×ASC					-1.594387	-0.539468	**-5.585380**
					0.067	*0.597*	*0.001*
Tanambao×Ovibe					**0.544988**	**0.470052**	**0.371599**
					0.005	*0.008*	*0.028*
radio×Ovibe						0.093687	0.101905
						0.333	*0.185*
No. of observations	2970	2934	2826	2934	2826	2826	2826
LR chi2	490.89	491.56	432.98	460.88	437.72	441.62	391.47
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

(LR chi2 is the Likelihood Ratio Chi-Square test that at least one of the coefficients is not equal to zero. Prob>chi2 is the probability of getting such an LR statistic as extreme as this, or more so, if all the regression coefficients in the model were in fact zero. The low value of Prov>chi2 shows that at least one of the coefficients is not equal to zero.)

chicken price of 6600Ar. The average price for a cup of rice was 390Ar.

The marginal willingness to pay for an attribute measures the change in price that compensates a change in a given attribute while all other attributes are held constant (Vermeulen et al., 2008). When the trade-off is made with respect to the price of a good, the marginal rate of substitution is the marginal willingness to pay. The marginal rate of substitution can be found using the coefficients generated from the Mixed Logit Model (Table 3).

Willingness to Pay for one chicken

The trade off between the attribute (x_m) and the price (p):

$$dU = \beta_m dx + \beta_p dp = 0$$

Willingness to pay is computed as minus the ratio of the coefficients for attribute m and the price:

$$WTP = \frac{dp}{dx_m} = -\frac{\beta_m}{\beta_p}$$

β_m is the coefficient for the attribute while β_p is the coefficient for the price.

Table 4. Valuation of *D.alata* tubers by different methods.

Valuation method	A yam tuber is worth:	Monetary valuation of one tuber assuming that at the time a cup of rice was worth 390Ar
Choice experiment (WTP)	1.67 cups of rice	619Ar
Open ended bid (WTA)	2.23 cups of rice	870Ar

In this survey, the price attribute was the number of cups of rice respondents were willing to hypothetically give up in order to hypothetically receive given amounts of different food items.

From model 5, table 3 it can be seen that the chicken coefficient (β_m) is 4.694855 while the price coefficient (β_p) is -0.138181.

$$WTP = \frac{4.694855}{0.138181} = 33.97$$

The choice experiment suggests that, on average, villagers are willing to exchange 34 cups of rice for a chicken. If a cup of rice is worth 390Ar, this implies a chicken is worth 13260Ar. This is twice the actual market value of a chicken. The valuation given by the choice experiment is considered to include an element of consumer surplus and so the degree to which criterion validity is supported is unclear.

Convergent Validity

Convergent validity is implied when two different valuation methods give the same value to a good. The survey included a contingent valuation asking for an open ended bid for willingness to accept compensation in order for people to give away yams that they hypothetically own. 3.6% of respondents refused to provide a bid for any of the three yams considered in this validity test. Respondents were asked how much rice they would want in exchange for giving away ten tubers of ovifaitra and also how much rice they would want in exchange for giving away ten tubers of cultivated ovibe.

The coefficients from a regression showing how yam type influenced WTA bid amount indicate the marginal willingness to accept compensation for giving away ten yam tubers of the relevant species. The WTA for cultivated ovibe was higher than for any other type of yam.

Respondents from households collecting yams from the forest made significantly higher bids than households not collecting yams from the forest. Interaction terms in a regression showing effects of villager heterogeneity on WTA bid amount were not significant and so do not provide information as to why cultivated ovibe was so significantly more highly valued.

Comparison between Valuation of Ovibe by Open Ended Bid and by Choice Experiment

In order to assess validity, marginal WTP as assessed by the choice experiment is compared with marginal WTA as assessed by the open ended bid (See Table 4).

The high similarity in the value estimates given by both methods suggests strong convergent validity. Similarity between WTA and WTP suggests that rice and yams are reasonable substitutes (Hanemann (1991)).

The WTP for yam tubers has implications for the conservation of the wild yam species. A high WTP for wild yam species might have indicated that wild yam species are a strong determinant of the value of the whole forest but would have suggested that wild species are strongly preferred to cultivated yams, making finding a suitable substitute for wild yams difficult. The choice experiment estimates a WTP of zero for wild yam species, suggesting a low demand for these species outside critical situations when there is no alternative foods source and showing that cultivated yams could be an appropriate substitute as long as the per-unit cost of cultivation does not exceed the WTP estimated for cultivated yam.

DISCUSSION

This study shows that, in a hypothetical exchange, villagers in this Ikongo region of Madagascar would rather receive cultivated yam tubers than the three local native yam tubers available in open access forest. Not all respondents were willing to make the hypothetical exchange but people who gave the correct local name of a yam when presented with its image were less likely to refuse to make a hypothetical exchange. Respondents from more wealthy households were less likely to refuse to make a hypothetical transaction than respondents from poorer household. Villagers responded to the use of rice as a price numeraire as is expected according to theory; all things being equal, respondents prefer a low price to a high one.

The survey was structured such that half the respondents lived in villages where an NGO was promoting yam cultivation and half the respondents had not experienced the NGO's promotion of yam cultivation.

This survey found that living in a village involved in the yam project did not significantly affect the respondent's preferences for the different yam species. It is noteworthy that Tanimbao village shows a stronger preference than any other village for ovibe despite it not being involved with the yam cultivation project at the time of this survey. This suggests that information regarding the cultivation of yams had spread beyond the villages participating in the project.

The high quantity of yams collected from the forest despite the low preference expressed for them (on average, respondents collected 79 yams from the forest per year while only cultivating 11) indicates that forest yams are being used as a last resort food resource in the event of food shortages.

The relative preferences for different yam species are markedly different to those recorded in Brickaville, Madagascar in an earlier survey. The Brickaville study used taste tests rather than choice experiments and found that *D. seriflora* is appreciated as a delicacy and has become scarce around Brickaville. *D.esculenta* was preferred to wild *D. serifolra* but *D.seriflora* was preferred to *D.alata* (Jeannoda et al. 2007). This may indicate that Ikongo respondents have less experience of these wild yams than people in the Brickaville area or the historic knowledge of using yams collected from open access forest may have been lost. The choice experiment method described here could be applied in Brickaville and other communities that harvest these yam species from wet tropical forest.

Environmental Valuation studies such as this one, that seek to record the preferences of respondents, produce results that are specific to the location. The results are also specific to the particular attributes considered by respondents, in this case, particular yam species. However, there are principles that may reasonably be applied over a wider area and in other contexts. This survey suggests that despite the remoteness of the villages concerned, information regarding *D.alata* and its cultivation and use as a food had spread beyond the villages specifically targeted in the yam cultivation programme. This study suggests that the spread of information before or during a development or conservation intervention can affect the preferences of people seemingly distantly connected to the site of intervention.

LIMITATIONS

Choice experiment methods assume commensurability such that multiple attributes of single items can always be traded off against each other. Studies (Blume et al. 1991) are increasingly showing that, rather than weighing up a range of attributes, individuals create rules or heuristics

for themselves. Future analysis of preferences for wild yams or other non-timber products may benefit from more detailed research into the decision heuristics made by the people who collect and then sell the products extracted from the wild. Use of the travel cost method (Clawson and Knetsch, 1966) after actual observation of the time spent on collection activities may be a more robust method of valuing the rarer wild species. This survey investigated the demand for different yams from different sources but did not investigate the respective costs of gathering yams or cultivating yams.

During interviews, some Ikongo respondents indicated that collection of wild yams from the forest was shameful due to the clear implication that that household had not grown enough rice. The hypothetical choice experiment could be providing an improbable scenario if one food option is only ever considered when another is not available and no trade-off is really made.

Despite these limitations, this study provides limited evidence that, as long as open access forest habitats are still valued, yam cultivation could conceivably reduce demand for wild yam species, potentially aiding wild yam conservation. While wild plants form a significant proportion of global food consumption, a variety of social and ecological drivers are acting to reduce use of foods collected from open access areas (Bharucha and Pretty, 2010).

Demand for cultivated yam quantified by this survey gives a limited amount of information regarding building a commercial market for yams.

CONCLUSION

Villagers in this Ikongo region of Madagascar would rather receive cultivated yam tubers than the three local native yam tubers available in open access forest. This finding was found in every village, irrespective of whether the village was involved in the yam cultivation project or not.

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