

## Human body-mass index (weight in kg/stature in m<sup>2</sup>) as a useful proxy to assess the relation between income and wildlife consumption in poor rural societies

RICARDO GODOY<sup>1,\*</sup>, DAVID S. WILKIE<sup>2</sup>,  
VICTORIA REYES-GARCÍA<sup>1,3</sup>, WILLIAM R. LEONARD<sup>4</sup>,  
TOMÁS HUANCA<sup>1</sup>, THOMAS MCDADE<sup>4</sup>, VINCENT VADEZ<sup>1</sup> and  
SUSAN TANNER<sup>4</sup>

<sup>1</sup>Heller School for Social Policy and Management, MS 078, Brandeis University, Waltham, MA 02454-9110, USA; <sup>2</sup>Wildlife Conservation Society, 185th and Southern Blvd. Bronx, NY 10460, USA; <sup>3</sup>Institut de Ciència i Tecnologia Ambiental, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain; <sup>4</sup>Department of Anthropology, Northwestern University, Evanston, Ill 60208, USA; \*Author for correspondence (e-mail: rgodoy@brandeis.edu; phone: +1-781-736-2784; fax: +1-781-736-2774)

Received 22 April 2005; accepted in revised form 2 November 2005

**Key words:** Body-mass index, Bolivia, Bush meat, Price elasticities, Tropical forests, Tsimane', Wildlife, Income

**Abstract.** There is growing interest in assessing how income influences the consumption of wildlife in poor rural areas of developing nations. The interest stems from the possibility of using income to contribute to the conservation of wildlife. Though promising, efforts have been hampered by the difficulty of obtaining accurate measures of income. We propose using human body-mass index (BMI: weight in kilograms/physical stature in m<sup>2</sup>), an indicator of short-term nutritional status, as a proxy variable for monetary income to estimate income elasticities of wildlife consumption (income elasticity: percent change in wildlife consumption/one-percent change income). The advantages of BMI over monetary income include a positive association with monetary income, ease of measurement, and absence of zero values. The assessment procedure was tested among Tsimane' Amerindians, a society of foragers and farmers in the Bolivian Amazon. The population over 15 years of age (350 men and 322 women) in 13 villages was surveyed for five consecutive quarters (August 2002–November 2003). Income elasticities of wildlife consumption using BMI as a proxy for income ranged from  $-0.84$  to  $-1.20$ . The estimates suggest that wildlife is a food item whose consumption declines with increasing income. Estimates of income elasticity of wildlife consumption using conventional indices of monetary income are negative, but lower and indistinguishable from zero owing to classical measurement errors of monetary income. The use of BMI to estimate income elasticities of wildlife consumption is promising, but requires further validation in different settings.

### Introduction

There is growing interest in assessing how income influences the consumption of wildlife in developing nations (Godoy 2001; Wilkie and Godoy 2001; Apaza et al. 2002, 2003; Wilkie et al. 2005). The interest stems from the possibility of

using income to contribute to the conservation of wildlife. Case studies suggest that income growth can induce people to switch from consuming bush meat to consuming meat from domesticated animals (Wilkie and Godoy 2001; Apaza et al. 2002).

The idea that income growth might reduce pressure on wildlife requires empirical scrutiny, and may depend on whether wildlife is a normal or an inferior food (Wilkie et al. 2005). Normal goods are goods whose consumption increases as income rises (e.g., cars); inferior goods are goods whose consumption declines as income rises (e.g., kerosene). Studies measuring the association between income and wildlife consumption have produced mixed results. In a study with 1208 households in rural and urban Gabon, researchers found that a 1% increase in lifetime or permanent income (wealth) was associated with a 0.16% increase in the consumption of bush meat and with a 0.26% increase in the consumption of fish, suggesting that wildlife is a normal food item (Wilkie et al. 2005). In Bolivia, researchers surveyed 461 households in four lowland Amerindian societies and found that a 1% increase in yearly earnings from the sale of goods and wage labor was associated with a 0.20% decrease in wildlife consumption, suggesting that wildlife is an inferior food item (Godoy 2001; Wilkie and Godoy 2001). In yet another study in the Bolivian lowlands of 510 households of Tsimane' Amerindians in 59 villages, researchers found that earnings during the two weeks before the day of the interview bore no association with wildlife consumption (Apaza et al. 2002). These results suggest variability in the relation between income and wildlife consumption.

Obtaining a reliable estimate of the relation between income and wildlife consumption in poor rural societies of developing nations requires an accurate measure of income. Researchers have found it hard to obtain such estimates primarily because people in such societies rarely work for wages or sell goods. Also, these societies exhibit much economic self-sufficiency; only a small share of goods produced enter the market and many of the goods produced lack a market price (Deaton 1997). In addition, poor people spend most of their time and resources obtaining food, rather than earning income from the formal labor market. Last, conventional measures of income are subject to well-known random measurement errors from faulty recall (Angrist and Krueger 1999).

Economists have shown that over time, anthropometric indicators of nutritional status such as physical stature correlate reliably with income (Fogel 1994; Steckel 1995, 2003; Strauss and Thomas 1998; Alderman et al. 2003). Given this, we propose a new approach to the measure of income in poor rural settings of developing nations that may give more accurate estimates of the association between income and wildlife consumption. We use body-mass index as a proxy for monetary income and as a way of estimating the income elasticity of wildlife consumption. An income elasticity of consumption refers to the percentage change in consumption of wildlife from a 1% change in income.

Body-mass index provides a reasonable proxy for income in poor rural societies of developing nations. First, in our sample body-mass index is

positively associated with monetary income. We regressed the logarithm of cash earnings from the last 2 weeks (dependent variable) against the logarithm of body-mass index (explanatory variable) controlling for age and sex, and found a positive coefficient or elasticity of +0.76 ( $p < 0.08$ ;  $n = 1,272$ ). Second, body-mass index requires measuring only physical stature and weight so it does not produce the large random measurement errors that surface when trying to obtain conventional estimates of monetary income. Last, body-mass index does not contain zeros, so it does not produce missing values that may reduce the sample size when using log transformed values in the analysis.

### **The measure of wildlife consumption and income in poor rural societies**

Human ecologists and conservation biologists have drawn on two methods to measure wildlife consumption in poor rural households of developing nations: threshold surveys (also known as weigh days) and interviewee recall (also known as recall surveys). In threshold surveys, researchers select a day at random and then record all goods brought into the household from dawn until dusk. As people bring wildlife into the household, researchers identify and weigh animals, note the sex of the animals, and assign a price or value to the animals or to the parts of the animals (Demmer et al. 2001, 2002; Godoy et al. 2000, 2002). The method yields accurate information on the amount and types of wildlife brought into the household, but requires considerable time because researchers must stay in the household of the participant for most of the day. When households lie close to each other, researchers can monitor wildlife brought into many households during a day at the same time, but when households are scattered, threshold surveys are exceedingly time consuming. Using this method, researchers gain accuracy at the expense of sample size. The second method, recall surveys of consumption, solve the problems with threshold survey and allow researchers to increase the sample size at low cost, but they introduce measurement errors from faulty recall (Fowler 2001).

When studying how income affects consumption, economists have found it useful to distinguish between current and permanent income (Friedman 1957). The former is typically defined as monetary earnings over the recent past (e.g., year) and the latter as earnings over a longer span (e.g., lifetime). In pre-industrial, poor rural societies, researchers have measured current income in two ways. Some have equated current income with monetary earnings from the sale of goods and from wage labor, as is done in industrial nations (Deaton 1997). The problem with this procedure is that many people do not earn monetary income. Other researchers equate current income with the value of consumption plus monetary earnings. The second measure is better because it eliminates zero values, but requires measuring consumption, which is difficult in rural settings as just shown when discussing the measure of wildlife consumption. Note that it is precisely the problems of measuring current

income with accuracy that drives us to seek an alternative, rather than to select between one of the two standard definitions of current income.

To obtain unbiased estimates of the effects of current income on wildlife consumption, researchers must overcome two additional hurdles besides the measurement issues just noted: reverse causality and omitted variables. Current income might affect wildlife consumption, but wildlife consumption might affect current income. For instance, participants with higher consumption of wildlife might be better nourished and so earn higher wages. Besides reflecting consumption of wildlife, BMI also reflects physical activity, health status, body physiology, and environmental factors. Second, consumption of wildlife and current income might both reflect the role of omitted third variables that operate at the level of the participant, household, or village. Later, we give examples and show how we deal with possible biases from omitted variables.

### **The estimation strategy**

Our task consisted of estimating the direct association between current income and wildlife consumption. We model the consumption of wildlife as a function of current and permanent income using the following linear approximation:

$$\ln Y_{ihvt=0} = \alpha + \beta \ln I_{ihvt-1}^t + \delta \ln I_{ihvt=0}^p + \zeta C_{ihvt=0} + \theta T_{t=0} + \lambda V_v + \varepsilon_{ihvt=0} \quad (1)$$

Table 1 contains definition and summary statistics of the variables in Equation (1). To deal with possible biases from reverse causality, we lagged body-mass index by a quarter and we exclude cash earnings and wages earned during the week before the day of the interview. To deal with possible biases from omitted variables, we followed two steps. First, we used a full set of dummy variables for villages ( $V$ ) to control for village fixed effects. Some villages may have more wildlife, which would affect both the nutritional status of participants and the amount of wildlife captured, so failure to control for community attributes might bias the estimated parameter of current income. We also used a full set of dummy variables for quarters to control for seasonal effects. Second, we estimate parameters using a person fixed-effect model to remove biases from individual variables that do not change over time that might affect both current income and wildlife consumption. We did not have instrumental variables for body-mass index or for cash earnings, so our estimates could contain biases. To ensure consistency in results, we use ordinary least squares (OLS), random effect, and person fixed-effect models.

### **Sample and variables**

Eight researchers surveyed and took anthropometric measures from 672 participants (322 women and 350 men) over 15 years of age in 13 villages along the Maniqui River during August 2002–November 2003. Researchers collected data from the same participant once each quarter during five-consecutive

Table 1. Definition and summary statistic of variables used in regression analysis.

Name	Definition	N	Mean	SD
<i>Dependent variable</i>				
Wildlife $\ln Y_{iht} = 0$	Kilograms of game, fish, and wild birds consumed in last week by household divided by adult equivalents; in regression estimate entered in logarithms. i, h, v, and t refer to person, household, village, and time.	3110	2.665	3.585
<i>Explanatory variables</i>				
BMI $\ln I'_{iht-1}$	Body-mass index; kilograms/m <sup>2</sup> ; in regression estimate entered in logarithms and lagged by a quarter	2603	23.156	2.554
Earnings $\ln I_{iht-1}$	Cash earnings from wage labor and from sale of goods two weeks ago; in <i>bolivianos</i> (1 US\$ = 7.45 <i>bolivianos</i> ). In regression estimate entered in logarithms. <i>I'</i> : current income	2943	29.173	101.167
Wages $\ln I'_{iht-1}$	Cash earnings from wage labor in last two months (excluding last 2 weeks); in <i>bolivianos</i> (1 US\$ = 7.45 <i>bolivianos</i> ). In regression estimate entered in logarithms. <i>I'</i> : current income	2943	55.554	275.04
Stature $\ln P'_{iht-0}$	Stature of participant in centimeters; in regression estimated entered in logarithms. <i>P'</i> : permanent income	2605	156.66	7.642
Age $C_{iht} = 0$	Age of participant in years during first quarter. <i>C</i> : control variable	672	33.352	15.732
Male $C_{iht} = 0$	Sex of participant; 1 = male; 0 = female. First quarter. <i>C</i> : control variable. The figure under mean refers to the share of participants who were men	672	52	
Size $C_{iht} = 0$	Household size measured with male-adult equivalents. First quarter. <i>C</i> : control variable	672	4.674	2.134

Name in italics under the first column correspond to the variables in Equation (1). For meaning of subscripts see definition of variable 'wildlife'.

quarters. We selected villages at different distances from the market town of San Borja to capture cross-sectional variance in income.

Both the female and the male head of the household were asked to identify all the game, fish, and birds brought into their household during the week before the day of the interview and, for each animal, to estimate the amount brought. If they did not know the weight of the whole animal, we assigned the animal a weight based on measures of typical animals that we collected during an earlier study (Apaza 2001; Perez 2001). We used the village selling price or barter rate of the animal to arrive at a monetary value for the animal. We divided the total value of wildlife consumption for the household by the number of adult-male equivalents (AME) in the household at the time of the survey to arrive at a consumption estimate for each AME. The formula for estimating AME was derived during an earlier study (Byron 2003). Based on the age and sex of participants, we computed a factor for each participant that captured their nutritional requirements expressed as a share of the nutritional requirements of an adult man.

To estimate current income we used both body-mass index and, for comparison, cash earnings. We followed the protocol of Lohman et al. and measured participants in light clothing without shoes or hats (Lohman et al. 1988). We recorded physical stature (standing height) to the nearest millimeter using a plastic tape measure and body weight to the nearest 0.20 kg using a Tanita Digital standing scale.

Earning refers to cash earned by the participant from wage labor and from the sale of goods 7–14 days before the day of the interview. Wages refers to earnings during the 2 months before the day of the interview, but excludes wages earned during the two weeks before the interview.

### **The people**

The latest Bolivian census puts the Tsimane' population at 8000 (Instituto Nacional de Estadística 2003). The Tsimane' live in small villages along river banks and logging roads. Subsistence centers on hunting, fishing, and slash-and-bum farming (Ellis 1996; Huanca 1999; Reyes-García 2001).

Tsimane' remained relatively isolated from contact with outsiders until the 1970s (Daillant 1994). In the 1970s the opening of roads brought loggers, ranchers, oil firms, and colonist farmers into or next to the Tsimane' territory. Contact with the outside world has centered on the sale of rice and forest goods and on work as unskilled laborers (Vadez et al. 2004). The most important market good Tsimane' buy or acquire is food (e.g., canned meat, oil) followed by clothing. Modern medicines and goods related to hygiene (e.g., soap) account for <7% of cash expenditures.

Despite contact with the outside world, the Tsimane' remain economically self sufficient and have low income. In the earlier study of 1999–2000 during which we measured the value of consumption, we found that mean annual

personal income from cash earnings and from the value of farm and forest goods reached US\$332, a third of the average income in Bolivia, which is one of the poorest nations in Latin America (Godoy et al. 2002). Goods bought from the market accounted for only 2.70% of the total value of household consumption.

Tsimane' adults obtain adequate amounts of energy and protein from farming and harvesting wild resources, and generally do not show evidence of acute nutritional stress. Nevertheless, the Tsimane' diet may not be adequate to fulfill the high nutrient demands of young children. Indeed, many of the staple foods (e.g., manioc, plantains) may not be sufficiently dense in energy, protein, or in key micronutrients to sustain the rapid growth rates that typically characterize infancy and early childhood. Low dietary quality combined with a high infection rate may contribute to the high rates of statural growth stunting seen among the Tsimane' (Foster et al. 2005; McDade et al. 2005; Tanner 2005). The average stature of a Tsimane' adult is two standard deviations below their same sex and age peers from the USA.

## Results

Table 2 contains the main regression results and Tables 3 and 4 contain the results of other regressions to ensure results of the main regressions were robust. The first row of Table 2 shows that income elasticities of wildlife consumption using body-mass index as a proxy for current income are negative, mostly statistically significant, and range from 0.84 to  $-1.20$ . A 1% increase in body-mass index during the previous quarter was associated with 0.84–1.20% lower consumption of wildlife in the next quarter.

Table 2 suggests that the use of different econometric models produced similar results. The exemption was the individual fixed-effect model (column E). Although the elasticity estimate of  $-1.27$  ( $p < 0.15$ ) with the individual fixed-effect model fell toward the upper range of the other estimates (range  $-0.84$  to  $-1.20$ ), it was statistically insignificant at the 90% confidence level or higher. We found small differences in elasticity estimates when using OLS and random-effect models, but elasticities became smaller (less negative) after controlling for village fixed effects or after adding a full set of village dummy variables. For instance, the elasticity estimate using OLS without dummy variables for village was  $-1.20$  ( $p < 0.001$ ) (column A), but changed to  $-0.84$  ( $p < 0.002$ ) after including a full set of dummy variables for villages (column B).

We next compared the elasticity estimates using body-mass index as a proxy for current income (row 1, Table 2) with the elasticity estimates using conventional measures of monetary income (rows 2–3, Table 2). In the second row, we used earnings from 7 to 14 days ago, and in the third row, we used wages earned during the last 2 months (excluding wage earnings from the last 2 weeks). Most of the coefficients in rows 2–3 are negative, but only one is statistically significant at the 90% confidence level. The use of recent cash

Table 2. Estimates of income elasticity of consumption of wildlife among Tsimane' Amerindian adults (15 years of age and older): Main regressions.

Proxy for current income	OLS		Random effect		Fixed Effect
	A	B	C	D	E
1. Lagged BMI; <i>n</i> = 1601	-1.205*** (0.257)	-0.841*** (0.269)	-1.182*** (0.269)	-0.841*** (0.266)	-1.277 (0.886)
2. Earnings <i>n</i> = 713	-0.001 (0.040)	-0.029 (0.039)	0.014 (0.036)	-0.006 (0.036)	0.044 (0.052)
3. Wages <i>n</i> = 397	-0.030 (0.046)	-0.072* (0.043)	-0.018 (0.047)	-0.054 (0.046)	-0.033 (0.099)
Village dummies	No	Yes	No	Yes	Yes

Notes for Tables 2–4: Standard errors are in parenthesis. \*, \*\*, and \*\*\* Significant at 90, 95, and 99% confidence level. Controls variables not shown include: (a) logarithm of stature, (b) age, (c) sex, (d) household size, and (e) full set of dummy variables for quarters. All regressions run with clustering by participant and constant (not shown). FE is person-fixed effect model.

earnings produced small elasticity estimates that range from  $-0.02$  to slightly above zero (row 2, Table 2). Using wage earnings during the last 2 months (row 3) produced more negative elasticities. The elasticities range from  $-0.01$  to  $-0.07$ , but in only one case were results statistically significant at the 90% confidence level or above.

In Table 3 were-estimated the main regressions of Table 2 excluding pregnant and lactating women since pregnancy and lactation change body-mass index and might influence wildlife consumption. Excluding pregnant and lactating women changed the coefficients slightly, but in no case did the new estimates differ much from the estimates of the main regressions. Removal of pregnant and lactating women made the income elasticity of wildlife consumption using body-mass index more negative than in the baseline scenario (row 1, Table 2), but results remained statistically significant at the 90% confidence level or above (row 3, Table 3). For instance, in the OLS model with a full set of village dummy variables (column B), the elasticity was  $-0.84$  in the baseline scenario (row 1, Table 2) and changed to  $-0.94$  after excluding pregnant and lactating women (row 3, Table 3).

In Table 4 we added another explanatory variable to the main regression that is the consumption of domesticated animals (pork, ducks, fresh and sun-dried beef, and chicken) per AME for the week before the day of the interview. We wanted to assess whether the association between BMI and wildlife consumption remained after controlling for the consumption of other sources of animal protein. The results of Table 4 agree with the results of the main regression.

We tested for a non-linear relation between wildlife consumption and body-mass index by adding a quadratic term for BMI or for monetary income. We found that the coefficient for the quadratic term was statistically insignificant, suggesting that the link between wildlife consumption and current income

*Table 3.* Estimates of income elasticity of consumption of wildlife among Tsimane' Amerindian adults (15 years of age and older): Excluding pregnant and lactating women.

Proxy for current income	OLS		Random effect		Fixed Effect
	A	B	C	D	E
1. Lagged BMI; <i>n</i> = 1099	-1.405*** (0.307)	-0.941*** (0.344)	-1.364*** (0.312)	-0.928*** (0.316)	-0.960 (1.351)
2. Earnings <i>n</i> = 598	-0.019 (0.042)	-0.042 (0.041)	-0.004 (0.039)	-0.021 (0.039)	0.033 (0.056)
3. Wages <i>n</i> = 376	-0.011 (0.046)	-0.064 (0.044)	-0.002 (0.048)	-0.046 (0.047)	-0.034 (0.099)
Village dummies	No	Yes	No	Yes	Yes

*Table 4.* Estimates of income elasticity of consumption of wildlife among Tsimane' Amerindian adults (15 years of age and older): Controlling for consumption of meat from domesticated animals.

Proxy for current income	OLS		Random effect		Fixed Effect
	A	B	C	D	E
1. Lagged BMI; <i>n</i> = 1601	-1.202*** (0.258)	-0.832*** (0.270)	-1.173*** (0.269)	-0.828*** (0.266)	-1.043 (0.881)
2. Earnings <i>n</i> = 713	-0.002 (0.040)	-0.030 (0.039)	0.015 (0.036)	-0.006 (0.036)	0.048 (0.052)
3. Wages <i>n</i> = 397	-0.029 (0.046)	-0.072 (0.043)	-0.018 (0.047)	-0.054 (0.046)	-0.034 (0.098)
Village dummies	No	Yes	No	Yes	Yes

(whether measured with money or with BMI) is linear and negative rather than parabolic.

One final point deserves brief mention. The use of monetary earnings to measure income elasticities of wildlife consumption produced almost no significant effects; however, the sign of the coefficients of elasticities with monetary earnings were generally negative. This is expected since earnings and body-mass index correlated positively.

## Conclusions

The use of body-mass index as a proxy for current income suggests that wildlife was an inferior food item; consumption declined with increasing current income. A 1% increase in body-mass index during the previous quarter was associated with a 0.84–1.20% reduction in wildlife consumption during the next quarter. Previous studies using conventional measures of monetary

income have produced smaller elasticities as discussed in the introduction. For example, in an earlier study with 461 participants from four lowland Amerindian populations, we found that a 1% increase in yearly income from the sale of goods and from wage labor was associated with only a 0.20% reduction in wildlife consumption, considerably lower than the estimate using BMI as a proxy for current income (Wilkie and Godoy 2001; Godoy 2001). Previous studies may have produced smaller income elasticities of consumption owing to random measurement errors that surface when trying to obtain direct estimates of monetary income. We found that estimates of income elasticities of consumption using monetary earnings produced negative values but weak results; results were statistically insignificant as we might expect with random measurement errors. Using either body-mass index or monetary income as proxies for current income suggests that wildlife consumption declines as current income rises, but results were stronger when using body-mass index rather than money to proxy for current income. The use of BMI to estimate income elasticities of wildlife consumption is promising, but requires further validation in different settings.

### **Acknowledgements**

Grants from the programs of Cultural and Biological Anthropology of the National Science Foundation (0078801, 0134225, 0200767, 9731240, 9904318, and 0322380) paid for this research. Thanks go to Lilian Apaza, Esther Conde, Johnny Dávila, Homero Rivas, Lourdes Parada, Bernabé Nate, Paulino Pache, Evaristo Tayo, Santiago Cari, José Cari, Manuel Roca, Daniel Pache, Javier Pache, and Vicente Cuata for help collecting the information and for logistical support. Special thanks to Lilian Apaza and Eddy Pérez for supplying us with data on the weight and dimensions of wild animals. An earlier version of the paper was presented at a seminar in the Institute for Tropical Ecosystems Studies, University of Puerto Rico in Rio Piedras. Last, thanks go to the anonymous reviewers of *Biodiversity and Conservation*.

### **References**

- Alderman H., Hoddinott J. and Kinsey B. 2003. Long-term Consequences of Early Childhood Malnutrition. Washington, D.C., IFPRI, Food Consumption and Nutrition Division Working Paper 68.
- Angrist J.D. and Krueger A.B. 1999. Empirical strategies in labor economics. In: Ashenfelter O. and Card D. (eds), *Handbook of Labor Economics*. Elsevier Science, Amsterdam, pp. 1277–1366.
- Apaza L. 2001. Uso de mamíferos entre los Tsimane'. B.S. Thesis, Department of Biology, Universidad Mayor de San Andrés, La Paz, Bolivia.
- Apaza L., Godoy R.A., Wilkie D.S., Byron E., Huanca T., Leonard W.R., Pérez E., Vadez V. and Reyes-García V. 2003. Markets and the use of wild animals for traditional medicine: a case study among the Tsimane' Amerindians of the Bolivian rain forest. *J. Ethnobiol.* 23: 47–64.

- Apaza L., Wilkie D.S., Byron E., Huanca T., Leonard W.R., Perez E., Reyes-García V., Vadez V. and Godoy R.A. 2002. Role of meat prices in household consumption of bushmeat among the Tsimane' Amerindians of Bolivia. *Onyx* 36: 382–388.
- Byron E. 2003. Markets and health: the impact of markets on the nutritional status, morbidity, and diet of the Tsimane' Amerindians of lowland Bolivia. Ph.D. Thesis, Department of Anthropology, University of Florida, Gainesville, Florida.
- Daillant I. 1994. Sens dessus-dissous. Organisation sociale et spatiale des Chimanes d'Amazonie bolivienne. Laboratoire d'ethnologie et de Sociologie Comparative, Université de Paris, Paris.
- Deaton A. 1997. *The Analysis of Household Surveys: A Micro-econometric Approach to Development Policy*. Johns Hopkins University Press, Baltimore, Maryland.
- Demmer J., Godoy R., Wilkie D., Overman H., et.al 2002. Do levels of income explain differences in game abundance? An empirical test in two Honduran villages Biodivers. *Conserv.* 11: 1845–1868.
- Demmer J. and Overman H. 2001. Indigenous People Conserving the Rain Forest? The Effect of Wealth and Markets on the Economic Behavior of Tawahka Amerindians in Honduras. TROPENBOS, Amsterdam.
- Ellis R. 1996. A taste for movement: an exploration of the social ethics of the Tsimanes of lowland Bolivia. Ph.D. Thesis, Department of Anthropology, St. Andrews University, Scotland.
- Fogel R.W. 1994. Economic growth, population theory, and physiology: the bearing of long-term processes on the making of economic policy. *Am. Econ. Rev.* 84: 369–394.
- Foster Z., Byron E., Reyes-García V., Huanca T., Vadez V., Apaza L., Pérez E., Tanner S., Gutierrez Y., Sandstrom B., Yakhedts A., Osborn C., Godoy R. and Leonard W.R. 2005. Physical growth and nutritional status of Tsimane' Amerindian children of lowland Bolivia. *Am. J. Phys. Anthropol.* 126: 343–51.
- Fowler F.J. Jr. 2001. *Survey Research Methods*. Sage Publications, Newbury Park, California.
- Friedman M. 1957. *A Theory of the Consumption Function*. Princeton University Press, Princeton, New Jersey.
- Godoy R.A. 2001. *Indians, Markets, and Rain Forests: Theory, Methods, Analysis*. Columbia University Press, New York.
- Godoy R.A. and Lubowski R.N. 1992. Guidelines for economic valuation of non-timber tropical-forest products. *Curr. Anthropol.* 33: 423–433.
- Godoy R.A., Wilkie D.S., Overman H., Demmer J., Cubas A., McSweeney K. and Brokaw N. 2000. Valuation of consumption and sale of forest goods from a Central American rain forest. *Nature* 406: 62–63.
- Godoy R.A., Karlan D.S., Rabindran S. and Huanca T. 2004. Do modern forms of human capital matter in primitive economies? Comparative evidence from Bolivia. *Econ. Educ. Rev.* 24: 45–53.
- Godoy R.A., Overman H., Demmer J., Apaza L., Byron E., Huanca T., Leonard W., Pérez E., Reyes-García V., Vadez V., Wilkie D., McSweeney K., Cubas A. and Brokaw N. 2002. Local financial benefits of rain forests: comparative evidence from Amerindian society in Bolivia and Honduras. *Ecol. Econ.* 40: 397–409.
- Huanca T. 1999. Tsimane' indigenous knowledge, swidden fallow management, and conservation. Ph.D. Thesis, Department of Anthropology, University of Florida, Gainesville, Florida.
- Instituto Nacional de Estadística. 2003. *Bolivia: Características sociodemográficas de la población indígena*. INE, La Paz.
- Komlos J. 1994. *Stature, Living Standards, and Economic Development*. The University of Chicago Press, Chicago.
- Lohman T.G., Roche A.F. and Martorell R. 1988. *Anthropometric Standardization Reference Manual (Abridged Edition)*. Human Kinetics Publishers, Windsor, Ontario.
- McDade T.W., Leonard W.R., Burhop J., Reyes-García V., Vadez V., Huanca T. and Godoy R.A. 2005. Predictors of C-reactive protein in Tsimane' 2–15 year-olds in lowland Bolivia. *Am. J. Phys. Anthropol.* In press.
- Pérez E. 2001. Uso de la ictiofauna por dos comunidades Tsimane': San Antonio y Yaranda (T.I. Tsimane', Depto. Beni) bajo diferente influencia del mercado. B.S. Thesis, Department of Biology, Universidad Mayor de San Andrés, La Paz, Bolivia.

- Reyes-García V. 2001. Indigenous people, ethnobotanical knowledge, and market economy: a case study of the Tsimane' Amerindians in lowland Bolivia. Ph.D. Thesis, Department of Anthropology, University of Florida, Gainesville, Florida.
- Steckel R.H. 1995. Stature and the standard of living. *J. Econ. Lit.* 33: 1903–1940.
- Steckel R.H. 2003. What can be learned from skeletons that might interest economists, historians, and other social scientists? *Am. Econ. Rev. Papers Proc.* 93: 213–220.
- Strauss J. and Thomas D. 1998. Health, nutrition, and economic development. *J. Econ. Lit.* 36: 766–817.
- Tanner S. 2005. A population in transition: health, culture change, and intestinal parasitism among the Tsimane' of lowland Bolivia. Ph.D. Thesis, Department of Anthropology, University of Michigan, Ann Arbor, Michigan.
- Vadez V., Reyes-García V., Godoy R.A., Apaza L., Byron E., Huanca T., Leonard W.R., Wilkie D. and Perez E. 2004. Does integration to the market threaten agricultural diversity? Panel and cross-sectional evidence from a horticultural-foraging society in the Bolivian Amazon. *Hum. Ecol.* 32: 635–646.
- Wilkie D.S. and Godoy R.A. 2001. Income and price elasticities of bushmeat demand in lowland Amerindian societies. *Conserv. Biol.* 15: 1–9.
- Wilkie D.S., Starkey M., Abernethy K., Nstame Effa E., Telfer P. and Godoy R.A. 2005. Role of prices and wealth in consumer demand for bushmeat in Gabon, Central Africa. *Conserv. Biol.* 19: 1–7.