

# Oil industry, wild meat trade and roads: indirect effects of oil extraction activities in a protected area in north-eastern Ecuador

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## Keywords

Ecuador; wild meat market; oil industry; roads; Yasuní National Park; indigenous people; wildlife trade.

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## Abstract

Starting in 1994, a wholesale wild meat market developed in north-eastern Ecuador, involving Waorani and Kichwa people in the area of influence of a road built to facilitate oil extraction within Yasuní National Park. Between 2005 and 2007, we recorded the trade of 11 717 kg of wild meat in this market, with pacas *Cuniculus paca*, white-lipped peccaries *Tayassu pecari*, collared peccaries *Pecari tajacu* and woolly monkeys *Lagothrix poeppiggi* accounting for 80% of the total biomass. Almost half of the wild meat brought to the market was transported by dealers for resale at restaurants in Tena, a medium-sized town 234 km west of the market. Prices of wild meat were 1.3–2 times higher than the price of meat of domestic animals, suggesting that it is a different commodity and not a supplementary protein source in the urban areas where it is consumed. The actual price of transportation between the local communities and the market was a significant predictor of the amount of meat sold in Pompeya. Based on this relationship the Waorani hunters sold exceptionally larger amounts of wild meat than would be expected if they would not have the transportation subsidies provided by the oil companies. Although the scale of this wild meat wholesale market is still relatively small, its dynamic reflects the complex interactions that emerge as the overriding influence of oil companies or other private industries modify the culture and subsistence patterns of marginalized indigenous groups, increasing their potential impacts on wildlife and natural ecosystems.

## Introduction

Subsistence hunting is a critical element in the culture and livelihood systems of many indigenous groups throughout the Tropical region (Robinson & Redford, 1991). At the same time, as human populations grow and their social structures change, hunting has become a major threat to wildlife (Bennett *et al.*, 2002a,b), especially in areas where hunting is the only subsistence or economical activity available for impoverished and sensitive rural communities (Robinson & Bennett, 2002; de Merode, Homewood & Cowlshaw, 2004). Despite the magnitude of this threat, there is little understanding about the factors that control current changes in the patterns of wildlife use by rural communities, and most of our knowledge comes from studies that analyzed the influence of local changes in infrastructure, cash availability and market access on the purpose, frequency and intensity of hunting activities (Vickers, 1991; Wilkie & Godoy, 2001; Franzen, 2005). For example, previous studies in the Amazon basin suggest that wildlife-use patterns can exhibit plastic responses to environ-

mental and ecological conditions, and can be sustainable if human population sizes are small and traditional hunting technologies are maintained (Vickers, 1988, 1991). Conversely, there are also examples of direct changes in wildlife-use patterns that can happen as a result of increased access to roads and development of local markets (Vickers, 1991; Sierra, Rodriguez & Losos, 1999; Peres & Lake, 2003; Franzen, 2005). The extent to which these patterns can intensify with increasing economic pressure is still unclear.

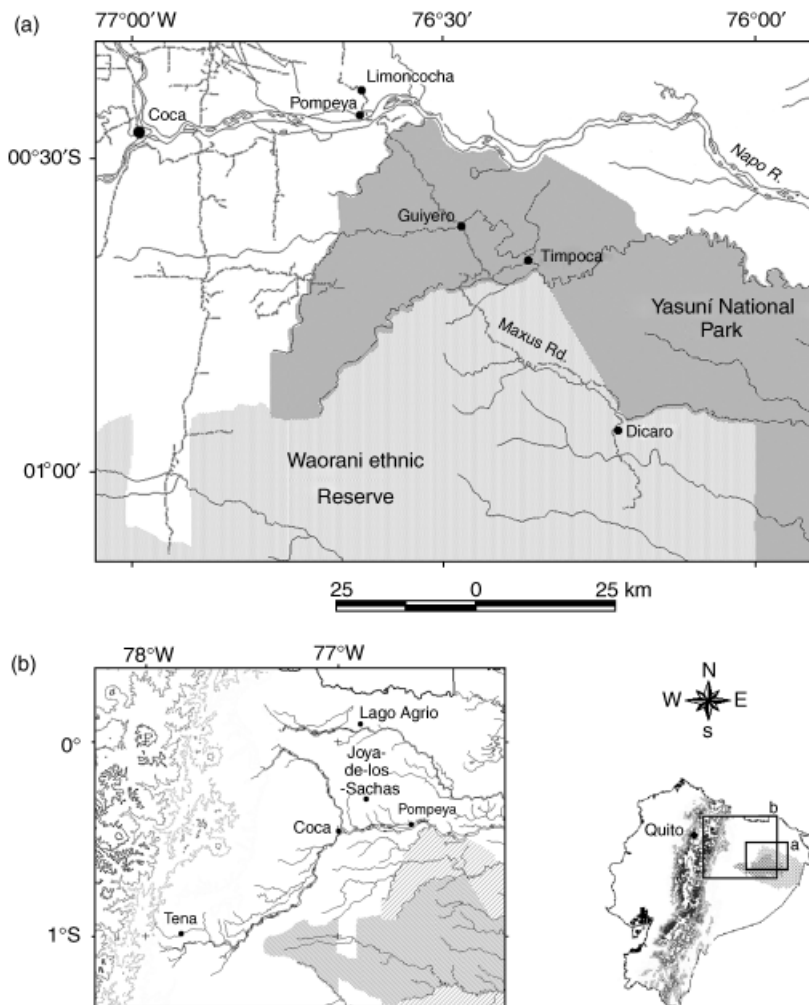
As the need for economical growth intensifies, developing countries are increasingly turning to aggressive exploitation of natural resources in order to supply their economical needs (e.g. Landes, 1998; Brechin *et al.*, 2002; Garrity *et al.*, 2002). In many cases, these patterns of exploitation conflict with the conservation of protected areas with high levels of biodiversity because intensive extraction is not always compatible with the maintenance of ecological integrity and ecosystem functionality (Wray & Alvarado, 1996; Canaday & Rivadeneira, 2001; Olsen, 2001; Fiori & Zalba, 2003; Zeng, Sui & Wu, 2005). In the Neotropical area, for example, oil and gas extraction activities sometimes occur

within protected areas or in their buffer zones. Moreover, in many cases these extractive initiatives also overlap with vulnerable indigenous territories where the absence or weakness of local governments, and the lack of economic alternatives often result in impacts that go well beyond the ecological or environmental modifications, to include drastic social changes that affect both the livelihoods of local groups, and the wildlife upon which they depend (Jobin, 2003; Villaverde *et al.*, 2005).

Among the socioeconomic impacts of large industrial activities within protected areas, one of the most important is the change in the subsistence patterns of local communities, especially those that could lead to overexploitation of wildlife (e.g. overhunting). These changes can occur not only because of the rapid development of cash economies, but also because of increased access to markets, and changes in the social values and perceptions of local people regarding their life standards (Sierra *et al.*, 1999; McLean & Parkinson, 2000). In many cases, these changes are amplified by patronizing relationships in which large companies buy their right to operate in the area by providing local communities with resources, money or infrastructure without considera-

tion of the social and ecological impact of these ‘compensation plans.’ We hypothesize that the nature of these relationships (i.e. economic subsidies, free food and transportation) can increase the pressure on wildlife populations, by facilitating the involvement of local people in trade activities, which demand a constant flow of cash, and wild products to be traded. Despite their potential impacts these changes have not been sufficiently characterized.

In the Ecuadorian Amazon, started in 1992, Maxus Ecuador Inc. constructed a road that penetrates more than 140 km in Yasuní National Park (YNP), in north-eastern Ecuador. Although the oil company strictly controls the access to this road, its presence produced dramatic changes in the distribution and subsistence systems of Waorani and Kichwa communities that live inside YNP and its buffer zone. Among these changes, one of the most important was the emergence of a wild meat market in the Kichwa community of Pompeya, some 5 km outside the boundary of the national park (Franzen, 2005, 2006; Fig. 1). This market is supplied with wild meat from Kichwa communities along the Napo River, and from Waorani communities that live along the Maxus road, and whose



**Figure 1** Map of the north-western portion of the Yasuní National Park in the Ecuadorian Amazon. The map shows the location of some of the main communities and towns involved in the wild meat trade chain that starts at the community of Pompeya.

transportation through the road is fully subsidized by oil companies. In this paper, we characterize the wild meat market of Pompeya, as an example of the complex interactions that emerge from the uncontrolled interactions between large economic interests in protected areas, the livelihoods of vulnerable indigenous groups and the conservation of wildlife in tropical developing countries.

## Materials and methods

This study was carried out in the northern portion of YNP in north-eastern Ecuador (00°26'41"S; 76°36'29"W; Fig. 1). This protected area is located on the western Amazon basin and has been recognized as part of a biodiversity hotspot (Mittermeier *et al.*, 1998), encompassing 982 000 ha of one of the most species diverse forests in the world (Pitman *et al.*, 2001; Valencia *et al.*, 2004). The study area has been classified as moist tropical forest (Sierra, 1999), dominated by large tracts of *terra firme* forest mixed with smaller extensions of *Mauritia flexuosa* swamps. There are still large expanses of continuous undisturbed vegetation in the eastern and southern portion of the Park, but its northern and western boundaries are surrounded by a constantly growing matrix of pastures, agricultural lands and secondary vegetation, especially along the Napo river and the Auca road (Zapata-Ríos *et al.*, 2006). Annual precipitation in the area ranges between 2860 and 3000 mm (MAE, 1999) and, during this study period, average daily temperature was 22.8 °C. The human population around and inside YNP is estimated at 45 000 people, with *c.* 2000 people living inside the protected area, and is mainly composed of Waorani and Kichwa people, living in small communities along the northern and western boundaries of the park. Additionally, a growing population of indigenous and non-indigenous colonists occupies its buffer zone toward the north and west (Villaverde *et al.*, 2005).

Between 1991 and 1994, Maxus Ecuador Inc. constructed a road penetrating more than a 140 km into YNP, to facilitate access to new oil fields discovered inside the protected area and in the Waorani Ethnic Reserve (Greenberg *et al.*, 2005; Fig. 1). Many Waorani people settled along the new road, and currently live clustered in three main communities (Guiyero, Dicaro and Timpoca) that emerged as a direct consequence of the creation of the road. Shortly after the construction of the Maxus road, a wild meat market developed in the community of Pompeya, on the northern shore of the Napo River, and right in front of the entrance of the Maxus road. The market is supplied with wild meat coming both from Waorani communities along the Maxus road, and from Kichwa communities along the Napo River (Franzen, 2005).

To characterize wild meat trade activities at the Pompeya market, between January 2005 and May 2007, we conducted systematic surveys of wild meat transactions during a minimum of 2 market days in each month (the Pompeya market only operates on Saturdays). The first 2 months were used to get acquainted with wild meat dealers at Pompeya and to refine our surveys methods. Although trade of wildlife or

wildlife products is illegal in Ecuador, the transactions at the Pompeya occur openly as there is no enforcement of existing laws. Although local authorities and park rangers know about the market, they lack the resources and political will to stop the illegal trade of wildlife in Pompeya, primarily to avoid conflicts with the local indigenous population. This lack of control meant that, after a few visits, the dealers were not reluctant of talking with us about their business. All transactions occur in the Napo river dock, or in an open area separating the dock from the market stalls. The dealers walk around this area looking for the hunters, which arrive at the market by river or dirt roads. By informally talking with the dealers or by simply witnessing the transactions, for each prey that was brought to the market we recorded the following information: species and common name, weight, state of the animal (smoked or fresh), ethnic group and community of origin of the hunter, price of the transaction and the town where the dealer intended to sell the wild meat. For fish, taxonomic identification was possible only to the generic level. In addition, we conducted surveys in local eateries and meatshops at Pompeya, Loreto, Tena, Lago Agrio and Puerto Francisco de Orellana (Coca), to record the prices of wild meat and domestic meat dishes. Using this information, we were able to estimate changes in the prices of wild meat as it moved along the market chain from producer to consumer.

Ordinary least square regression was used to assess the relationship between the amounts of wild meat sold at Pompeya and the current costs of transportation between the market and the different communities that supply this trade chain. For this analysis, we used actual costs of boat or bus rides in the region as an explanatory variable to be related to the amount of wild meat brought to the market by hunters of different communities.

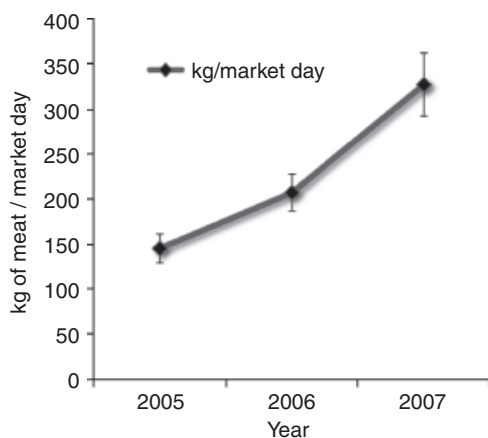
## Results

### Market description

We recorded information during 60 market days in Pompeya from March 2005 to May 2007. The Pompeya wild meat market operates exclusively on Saturdays, and functions mostly as a transit point where dealers get wild meat to be sold in other towns. Most of the transactions occurred between 06:30 and 11:30 h. The hunters or fishermen coming to the market arrive to Pompeya on boats or by roads, and approach the dock on the Napo River where they carry out the transactions usually with little bargaining. The traders store the meat or fish in boxes filled with ice and, by midday, when no more hunters arrive, they leave on their trucks or in public buses and travel for between one and seven hours to sell the fish and wild meat in towns located between 34 and 234 km from Pompeya. For any single market day, we identified a minimum of two and a maximum of five traders, but only three of them were present in the majority of the market days that we recorded. The group of sellers is much more heterogeneous and difficult to characterize, but most of them are Waorani or Kichwa Indians.

## Species and quantities of wild meat sold at the Pompeya market

During this study we recorded a total of 1644 transactions, involving 11 717 kg of wild meat and fish. The estimated biomass of wild meat traded in Pompeya showed a marked increasing trend, from 145 kg of wild meat per market day in 2005, to 327 kg day<sup>-1</sup> in 2007 (Fig. 2); based on these figures, the 95% confidence interval for the yearly biomass of wild meat and fish sold in Pompeya is 10 516 ± 361 kg year<sup>-1</sup>, with mammals roughly representing 65% of the transactions and almost 70% of the biomass sold at the market (Table 1). Fish were second in importance, accounting for 30% of the transactions and biomass sold. Birds and reptiles were rarely sold and, together, they accounted for <2% of the biomass sold at the market. At least 47 species were recorded at the Pompeya market, including 18 mammals, nine birds, four reptiles and at least 16 morphospecies of fish (this group was identified only to the genus level). Among the mammals, the species more frequently sold were the white-lipped peccary *Tayassu pecari* and the paca *Cuniculus paca*, which accounted, respectively, for 37 and 28% of all the animals recorded at Pompeya; these species, together with the collared peccary *Pecari tajacu* and the woolly monkey *Lagothrix poeppigii* accounted for 80% of all individual mammals sold (Table 2). As fish is often sold in Pompeya



**Figure 2** Temporal trend (2005–2007) of the trade of wild meat (fish, mammals, birds and reptiles) in the market of Pompeya in the northern border of the Yasuní National Park, in the Ecuadorian Amazon. Mean ± standard deviation.

**Table 1** Number of transactions and biomass (kg) of wildlife and fish sold between March 2005 and May 2007 at a wild meat market at Pompeya, in the northern border of Yasuní National Park (Ecuadorian Amazon)

	Class				Total
	Mammals	Fish	Birds	Reptiles	
# transactions	1062 (64.6%)	477 (29.0%)	49 (3.0%)	56 (3.4%)	1644 (100%)
Biomass (kg)	8053.4 (68.7%)	3523.7 (30.1%)	73.9 (0.6%)	66.5 (0.6%)	11 717.5 (100%)

For mammals, birds and reptiles each record represents an individual animal, while for fish each record represents an individual transaction that could involve one individual or several tens of individuals for smaller species that are sold by weight. Percentages of the total number of records or biomass are shown in parentheses.

in multi-species batches, we could not ascertain the taxonomic identity of almost half of the individual fish brought to the market. Among the fish that we could identify, *Prochilodus* spp. (bocachico), and *Pseudoplatystoma* sp. (bagre pintadillo) were the most commonly sold species in the market, accounting for 27 and 17% of the total fish biomass recorded at the market, respectively.

## Place of origin of the hunters and destination of the animals sold at the market

During the study period, roughly half of the biomass of wild meat sold in Pompeya was brought by Kichwa hunters, while the other half was traded by Waorani hunters; however, the group of animals sold by hunters of each ethnic group was strikingly different (Table 3). While 97% of the meat sold by the Waorani came from mammals, the Kichwa traded a relatively more diverse group of species in which fish and mammals were equally important, each accounting for roughly half of the biomass sold. Non-indigenous colonists were minor players in the market, and the small amount of wildlife they traded (5% of the total biomass) was largely dominated by fish (88%).

Roughly 4100 kg or 35% of the total animal biomass sold at Pompeya came from three Waorani communities (Guiyero, Timpoca and Dicaro) located 32, 54 and 94 km away from Pompeya, along the Maxus road. The second most important source of fish and wild meat to the market was the community of Pompeya itself and the nearby area of Limoncocha, which contributed 2723.3 kg or 23.3% of the total biomass. The remaining 50% of the biomass was brought to Pompeya from communities as far as 100 km away along the Napo River.

The actual costs of transportation between the communities and the Pompeya market was a significant predictor of the biomass of wild meat sold by hunters of different settlements ( $r^2 = 0.51$ ;  $P = 0.015$ ; Fig. 3). In this relationship, the Waorani hunters of the Maxus road whose transportation costs are considerably reduced by the oil companies' subsidies are responsible for one-third of the total biomass of wild meat sold in Pompeya. However, if the Waorani would have to pay the actual costs of transportation in the area, according to this relationship they would be expected to sell virtually no meat in Pompeya, due to the very high costs of fleeing a truck and the absence of periodic public transportation along the road.

**Table 2** Number of animals and biomass (kg) of species of mammals, birds and reptiles sold between March 2005 and May 2007 at a wild meat market at Pompeya, near the north-western border of Yasuni National Park, Ecuadorian Amazon

Class	Species	# of records	% of records	Biomass (kg)	% of biomass
Mammals	<i>Tayassu pecari</i>	391	36.9	3855.5	47.9
	<i>Cuniculus paca</i>	301	28.4	1656.3	20.6
	<i>Pecari tajacu</i>	97	9.2	586.5	7.3
	<i>Lagothrix poeppigii</i>	61	5.8	342.1	4.2
	<i>Dasybus novemcinctus</i>	50	4.7	224.7	2.8
	<i>Mazama americana</i>	49	4.6	402.2	5.0
	<i>Dasyprocta fuliginosa</i>	40	3.8	136.4	1.7
	<i>Tapirus terrestris</i>	14	1.3	251.1	3.1
	<i>Ateles belzebuth</i>	9	0.8	38.9	0.5
	<i>Hydrochaerus hydrochaeris</i>	8	0.8	61.4	0.8
	<i>Mazama gouazoubira</i>	3	0.3	15.0	0.2
	<i>Saimiri sciureus</i>	3	0.3	0.5	0.0
	<i>Callithrix pygmaea</i>	2	0.2	0.0	0.0
	<i>Cebus albifrons</i>	2	0.2	1.4	0.0
	<i>Alouatta seniculus</i>	1	0.1	2.3	0.0
	<i>Callicebus discolor</i>	1	0.1	0.0	0.0
<i>Saguinus tripartitus</i>	1	0.1	0.0	0.0	
Unspecified		26.0	2.5	475.5	5.9
Total		1059	100.0	8049.8	100.0
Birds	<i>Mitu salvini</i>	27	55.1	56.2	76.0
	<i>Penelope jacquacu</i>	9	18.4	9.3	12.6
	<i>Pipile pipile</i>	5	10.2	3.9	5.3
	<i>Crypturellus</i> sp.	2	4.1	1.6	2.1
	<i>Tinamus major</i>	2	4.1	1.8	2.4
	<i>Ara ararauna</i>	1	2.0	0.0	0.0
	<i>Ortalis guttata</i>	1	2.0	0.5	0.6
	<i>Pteroglossus castanotis</i>	1	2.0	0.0	0.0
	<i>Tinamus</i> sp.	1	2.0	0.7	0.9
	Total		49	100.0	73.9
Reptiles	<i>Podocnemis unifilis</i>	38	66.7	13.6	20.5
	<i>Chelonoidis denticulata</i>	10	17.5	0.0	0.0
	<i>Caiman crocodilus</i>	7	12.3	41.3	62.2
	<i>Melanosuchus niger</i>	2	3.5	11.5	17.3
	Total		57	100.0	66.5

According to the interviews with the dealers, 69.8% of the biomass bought at Pompeya was to be sold at markets and restaurants at four towns: Tena (44.7%), Lago Agrio (8.8%), Sacha (8.6%) and Coca (7.7%); interestingly, the town of Tena lies roughly 234 km away from the Pompeya market.

### Prices of wild meat at the Pompeya market

During the study period, the market activity generated a total income of US\$21 090. Kichwa hunters received 50.2% of this income, while Waorani and Colonist hunters received 44.5 and 5.3%, respectively. Excluding pacas, the prices of the wild meat and fish sold at Pompeya were very homogeneous across species, averaging US\$2.11 ± 0.52 kg<sup>-1</sup>, (Table 4). Paca's meat, on the other hand, was sold at a consistently higher price than that of other species (US\$3.34 ± 0.74 kg<sup>-1</sup>; Table 4). Wild meat price variation was also very small across months, with a coefficient of variation of 14%, and was not related to the total amount of

meat sold in any given month (Pearson's correlation coefficient = -0.03).

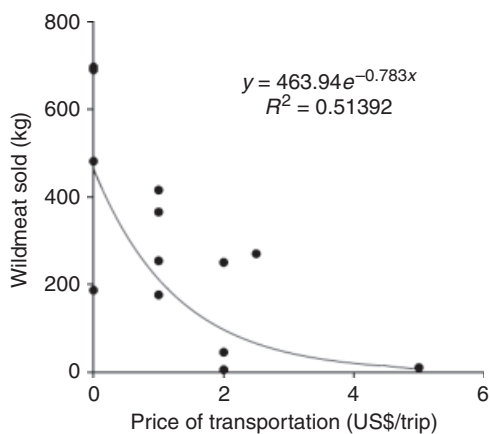
The average price of paca meat remained consistently higher than that of other wildlife species along the market chain from Pompeya to the meatshops in Coca (Fig. 4). At this town, the price of meat of paca and of other wildlife species had, respectively, increased by 60 and 57%, compared with the prices at the Pompeya market. The price of wildlife meat in Coca was 1.3–2 times higher than the average price of domestic animal meat (Fig. 4).

### Discussion

The Pompeya wild meat market, at the doors of YNP in north-western Ecuador, has become a preminent feature of this region's complex biotic and socio-economic environment. While the magnitude of the wildlife trade occurring at Pompeya is still limited, its emergence and continuous growth are symptomatic of the dramatic changes that the area is experiencing under the influence of the oil industry

**Table 3** Biomass (kg) and relative contribution (% of total biomass) of wildlife and fish sold by three ethnic groups between March 2005 and May 2007, at a wild meat market at Pompeya, in the northern border of Yasuní National Park (Ecuadorian Amazonia)

	Waorani		Kichwa		Colonist	
	Biomass (kg)	% of biomass	Biomass (kg)	% of biomass	Biomass (kg)	% of biomass
Mammals	4050.9	97.8	2318.2	50.1	57.0	11.8
Birds	48.5	1.2	14.9	0.3	–	–
Reptiles	16.4	0.4	27.3	0.6	–	–
Fish	24.3	0.6	2262.3	48.9	425.0	88.2
Total	4140.1	100.0	4622.7	100.0	482.0	100.0

**Figure 3** Regression model relating the amount of wild meat sold in the Pompeya market (north-eastern Ecuador) and the actual cost of transportation (boat or bus ride fares) between the Pompeya and several indigenous communities in the region (Fig. 1) (Biomass =  $463.94 \times e^{-0.783(\text{cost})}$ ;  $R^2 = 0.51$ ;  $P = 0.015$ ).

and the absence of effective management and control strategies. In the following paragraphs, we will discuss some of the general patterns found on this market, as well as the peculiarities that emerge in its functioning as a result of the influence of the oil industry in the region.

In terms of volume, the Pompeya wild meat market is a relatively small operation; the estimated annual yield of this market ( $10\,516 \pm 361 \text{ kg year}^{-1}$ ) is considerably smaller than estimates for well-established wild meat urban markets in other areas such as Iquitos, Perú with  $72\,972 \text{ kg year}^{-1}$  (Bodmer & Lozano, 2001), Malabo, Equatorial Guinea with  $111\,880 \text{ kg year}^{-1}$  (Juste *et al.*, 1995) and Sekondi-Takoradi, Ghana with  $190\,308 \text{ kg year}^{-1}$  (Cowlshaw, Mendelson & Rowcliffe, 2005). In terms of species sold, however, the Pompeya market is similar to other Neotropical rain forest locations in which pacas, peccaries and monkeys are preferred prey of traditional hunters, which usually end-up in markets if wild meat trade is an option in the area (Mena *et al.*, 2000; Bodmer & Lozano, 2001; Mena & Cueva, 2001; Zapata-Ríos, 2001). The species sold at Pompeya also reflect traditional differences in wildlife use by the Kichwa and Waorani Indians of north-eastern Ecuador; the almost complete absence of fish among the animals sold by the Waorani reflects the pattern that has been observed in

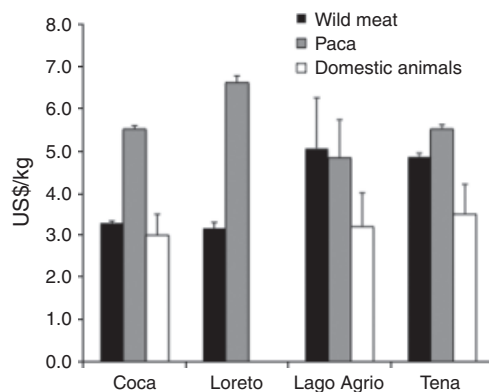
previous studies about this group's hunting practices (Mena *et al.*, 2000; Franzen, 2005). Their ancestral occupation of the inter-river ridges and upland forest in the Yasuní region, determined their almost total dependence on terrestrial and arboreal mammals, and particularly on woolly monkeys, which are among the most frequent prey in their households (Sierra *et al.*, 1999; Mena *et al.*, 2000; Franzen, 2005). The much higher representation of fish among the animals sold by the Kichwa reflects their traditional and current occupation of river-side ecosystems. The limited information on current wildlife use practices by the Kichwa do not show a strong dependence on fish (Mena & Cueva, 2001; Zapata-Ríos, 2001). However, the information gathered at Pompeya in this study, and data collected in Kichwa communities near YNP (E. Suárez *et al.*, unpubl. data), suggest that this pattern reflects a common bias toward terrestrial mammals introduced in previous studies, rather than a poor representation of fish on the diet of the Kichwa in this area.

Regarding the clear growth that we recorded in the trade of wildmeat in Pompeya, this pattern may be due to a number of different reasons including: (1) an increase in population size; (2) improved hunting and fishing technology; (3) loss of local jobs or income sources from other activities; (4) a higher and unsaturated demand of wild meat. Although we do not have direct information to assess conclusively these options, we have not observed recent and drastic socio-economic changes in the region that could support the first three alternatives. On the contrary, the intense competition that we commonly observe between middlemen buying wild meat at Pompeya suggests that their demand is still unsatisfied, creating room for additional growth of this market. Clearly, this topic deserves further attention and will be crucial in terms of designing appropriate policy and management measures to curve the negative impacts of this illegal market.

The price of wild meat of different species in Pompeya was extremely uniform, averaging  $\text{US}\$2.11 \text{ kg}^{-1}$  throughout the study period. The only exception was the price of pacas, which was consistently higher not only at Pompeya, but throughout the trade chain. Pacas are well known as preferred game species throughout the Neotropics, and it is not surprising that this is a frequently sold and highly valued species in Pompeya. What is noteworthy, however, is the extreme homogeneity of the prices of the rest of the species, even across animals of different taxonomic classes. This observation suggests that with the exception of pacas, the

**Table 4** Average prices (US\$ kg<sup>-1</sup>) of fish, wild meat and pacas *Cuniculus paca* sold between March 2005 and May 2007 at a wild meat market in Pompeya, near Yasuní National Park, in north-eastern Ecuador

	Price (US\$ kg <sup>-1</sup> )				
	Mammals	Birds	Reptiles	Fish	Pacas
Mean	2.12	2.22	1.86	2.17	3.34
Standard deviation	0.92	0.36	0.96	0.41	0.74
<i>n</i>	715	45	10	184	293

**Figure 4** Prices (US\$ kg<sup>-1</sup>, mean and standard deviation) of meat of pacas *Cuniculus paca*, of other wildlife species, and of domestic meat at different towns in the area of influence of the wild meat trade chain in the northern portion of the Yasuní National Park.

meat of the other species sold at Pompeya area is a substitutable good in which one species is just as valued as another (Wilkie & Godoy, 2001). The potential reasons for this are difficult to discern, especially because other game species that tend to be highly appreciated (i.e. peccaries) were sold at prices basically identical to those of smaller species such as armadillos *Dasypros novemcinctus* and agoutis *Dasyprocta fuliginosa*.

The prices of wild meat were extremely constant not only across species, but also throughout the 27 months of this study (coefficient of variation 14%), and were independent of the total amount of wild meat that was brought to the market in any given day (Pearson correlation coefficient  $-0.03$ ). Hence, it is difficult to assess what could be the main factors determining the prices of wild meat at Pompeya, or in the towns where it is ultimately consumed. What is clear, however, is that wild meat is considered as a special dish in the towns where it was ultimately sold, for which people are willing to pay prices that are considerably higher than those of domestic meat. This observation is supported by the fact that almost half of the animal biomass brought to the market was ultimately sold in the town of Tena, 234 km away from Pompeya; the long distance to Pompeya and the time needed to do this trip in the local public transportation ( $\sim 16$ -h round trip) suggest that the profits are high enough as to justify these long displacements by the dealers. In this sense, our results coincide with other studies (Milner-Gulland, Bennett & Group, 2003; Wilkie *et al.*, 2005) which

have shown that wild meat can be a different commodity in urban centers where it is consumed preferentially as a treat, or because of assumed medicinal or nutritional properties. This pattern deserves further attention, especially regarding the socio-economic factors that allow the maintenance of the high prices of wild meat in the region. Informal interviews and observations in at least eight eateries in Lago Agrio and Tena, conducted during a parallel study suggest that the presence of well-paid oil company workers and local people that no longer have access to hunting areas, or time to engage in this activity, are at least part of the reason for the high prices of wild meat in the Yasuní region (E. Suárez *et al.*, in prep.).

Our data do not allow a proper estimation of the sustainability of the hunting supplying the Pompeya market, because the precise catchment area is not known. However, recent studies in the area of the Maxus road have shown significant decreases in the population of some of the most hunted species (Franzen, 2006). To which extent this is only a local phenomenon, or a larger impact for the YNP remains to be studied, and will be critical in terms of the management of this protected area.

### Influence of the oil industry

Despite its continuous growth (Fig. 2), the Pompeya market is still a relatively small operation compared with wild meat markets in other tropical areas. However, its dynamic offers a striking example of the complex interactions that can occur in regions where the conservation of wildlife in protected areas overlaps with the territories of marginalized indigenous groups, and large infrastructure projects or economic activities (e.g. oil and gas exploitation). In the case of the Pompeya market, the influence of the oil industry in the emergence and subsequent development of the wild meat market can be divided between two sources: (1) the effects of road construction; (2) the effects of the oil companies policies as they shape their interactions with indigenous local communities.

In the first case, the construction of the Maxus road and of other oil extraction infrastructure in the YNP and the Waorani Ethnic Reserve, motivated several clans of Waorani people to abandon their semi-nomadic life styles, creating permanent settlements along the road. This change in their use of the territory and the availability of the commodities sold in the market determined a sharp change in the subsistence schemes of the Waorani as they had increased access to fire arms and other hunting supplies sold in

Pompeya. As a result, the Waorani increased their hunting efficiency, had access to a much larger hunting area, and were abruptly incorporated into a market economy (Lu, 1999; Sierra *et al.*, 1999). At the same time, the demand of wild meat by dealers coming to the emerging Pompeya market, stimulated the change in the original purpose of the Waorani hunting from a subsistence activity, to a more commercially oriented endeavor (Franzen, 2005).

The second type of influences relates to the introduction of large amounts of money in the region by the oil companies, and to their policy of subsidizing the transportation of the Waorani people along the road. On one hand, the large oil companies that entered the area hired Waorani and Kichwa people, usually paying salaries that were comparatively higher than the local wages. Additionally, large amounts of money also entered the region in the form of economic compensations provided by the oil companies to the local communities as a pay-off for the use of their territories. This rapid incorporation of the cash economy and the growth of the commercial activities in Pompeya, placed an extra value in the trade of wild meat, as an easy way to generate additional income. On the other hand, the oil companies provided (and still provide) free and continuous transportation for the Waorani people along the entire length of the road.

The transportation subsidy provided by the oil companies has had three important consequences: first, it gives access to a much larger hunting area along the road; second, it facilitates the transportation of the hunted animals and third, it considerably reduces the costs that the Waorani hunters would incur in order to bring the wild meat to the market. As a result, while a traditional hunter would have been limited to hunt in the immediate surroundings of his community, and would have never killed more than two or three animals in any single day (Mena *et al.*, 2000), unable to carry more, the current Waorani hunter can move freely and rapidly along the road, exploiting a larger area and killing as many animals as possible, as long as he can carry them to the edge of the road, where he will have free transportation to his community or to the Pompeya market. All together, these interactions result in a significant intensification of the hunting by local people, the change of the main purpose of the hunting from subsistence to trade and a significant increase of the impact of this practice on wildlife communities.

The type of interactions described in this paper will become more frequent in Neotropical developing countries, as the development of large infrastructure projects and energy production initiatives increases and overlaps with protected areas and indigenous territories. As a result, additional conflicts can be expected as protected areas and indigenous lands become common spaces where large economic initiatives develop under scenarios of ineffective control systems, weak enforcement of indigenous rights and paternalistic interactions between large industries and local communities. In this context, effective conservation of wildlife will require not only the improvement of the control systems and local participation frameworks in conservation

units, but also the development of honest cooperation schemes between the private industry, local people and the administration of protected areas. In particular, it is essential that, as decision makers, managers and land owners accept that in many cases protected areas or indigenous lands will be certainly affected by the activities of large extractive or infrastructure initiatives, we all move away from the assumption that controlling the direct impacts of these initiatives through a careful use of state-of-the-art technology, will be enough to curve their worst effects on local cultures and wildlife. New governance systems are needed to face these threats, emphasizing local participation, responsible interaction policies by the oil companies, respect for the local cultures and a strict avoidance of paternalistic practices toward local indigenous groups, as fundamental conditions to allow a less damaging intervention of the extractive industries in the sensitive lands where protected areas and indigenous groups coexist throughout the tropical regions.

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