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THE BENEFITS OF WILD CAUGHT ORNAMENTAL AQUATIC ORGANISMS IN THE PACAYA SAMIRIA NATIONAL RESERVE, PERU

INTRODUCTION

The global trade in ornamental aquatic species is a valuable and growing wildlife industry, believed to be worth billions of dollars annually (Roe, 2008; Smith *et al*., 2009). Aquarium fish and turtles are now among the most popular pets in the world (Lyons *et al*., 2013; Moreau and Coomes, 2007; Schlaepfer *et al*., 2005). Although captive breeding provides the largest source of ornamental aquatic species entering the trade, a significant proportion is still caught from the wild. The high demand for these species, coupled with their rising economic value, has spurred greater harvest rates, threatening the viability and sustainability of the industry (Cato and Brown, 2003; Chao *et al*., 2001; Vagelli and Erdmann, 2002; Lunn and Moreau, 2004). Consequently, much research is focused on the economic, social and ecological consequences of the trade in wild-caught species. In some cases, inadequate collection techniques have already caused significant habitat degradation and wildlife population declines (Chao, 1992; Crampton, 1999; van Dijk *et al*., 2000; Horne *et al*., 2012; Gerstner *et al*., 2006; Gibbons *et al*., 2000; Krishnakumar *et al*., 2009; Lyons *et al*., 2013; Madduppa *et al*., 2014; Moll and Moll, 2004; Shuman *et al*., 2005; Wabnitz, 2003). This puts populations under greater risk of extinction, limits the socio-economic contribution of natural resources and reduces genetic diversity (Kvist and Nebel, 2001). It is not surprising, therefore, that the collection of aquarium species is of particular concern to conservationists, as well as rural development professionals.

Despite this, it is believed that if well-managed the aquarium trade represents an alternative livelihood strategy that could counter problems of unsustainable wildlife harvests while addressing the needs of local people (Rhyne *et al*., 2012; Tlusty *et al*., 2008; Watson and Moreau, 2006). The benefits of this industry include employment opportunities for the local people, economic incentives for habitat preservation and reduced pressure on vulnerable species and habitats by providing a sustainable alternative to logging, hunting or exploiting reefs for building materials (Tlusty, 2002).

The Amazon basin is among the most important sources of wild-caught freshwater fishes and turtles in the global aquarium trade. The region supports exceptional aquatic biodiversity, with a total of 20 species of turtle and an estimate of up to 3000 fish species (Buhlmann *et al*., 2009; Henderson and Robertson, 1999). However, in a study conducted in the Peruvian Amazon, high fishing pressure was found to cause significant declines in the abundance, diversity and biomass of ornamental fish (Gerstner *et al*., 2006). On the other hand, in areas with medium fishing pressure no negative impacts were observed, suggesting it is possible to limit harvest rates to sustainable levels. While studies such as this have largely focused on the ecological dimensions of ornamental fisheries, very little attention has been paid to the role of the trade in the livelihood strategies of rural and indigenous people and the benefits they might accrue this trade (Béne, 2003; Wabnitz *et al*., 2003; Watson, 2000). Accordingly, management plans often fail to take into account the socio-economic and cultural needs of the local people, leading to conflict that ultimately undermines conservation efforts (Bodmer and Puertas, 2007; Pomeroy, 1991). An outright ban on the harvest of ornamental aquatic species would either remove an important source of income for thousands of people or more likely would be ineffective, as people turn to poaching and illegal trafficking. In light of the failings of such initiatives it is now generally agreed that a holistic, multi-disciplinary understanding of the aquarium

trade is imperative (Berkes *et al*., 2001; Chao and Prang, 1997; Jentoft, 2000; Moreau and Coomes, 2008).

This study provides a comprehensive description on the trade in ornamental aquatic species by the Kukama-Kukamilla people of the Pacaya-Samiria National Reserve (PSNR) in the Peruvian Amazon. Two important economic species that can be found in the reserve are the silver arowana (*Osteoglossum bicirrhosum*) and the yellow-spotted river turtle (*Podocnemis unifilis*). The silver arowana is a paternal mouth-brooding fish that has been exported from Peru since the 1950s and in recent years it has become increasingly popular in the international aquarium fish market. Turtles and their eggs are a major source of local income as well as protein. The population of yellow-spotted river turtles had declined in the reserve due to illegal egg extraction and overhunting. This study will focus on the ornamental value of these species. By exploring these specific but informative examples we aim to demonstrate the socio-economic and cultural benefits of the aquarium trade. Rather than posing a challenge to conservation, the trade in ornamental aquatic species is likely to represent a viable and sustainable livelihood activity for the Kukama-Kukamilla people of the PSNR. In the long term, this study is intended to provide a reference source to the industry, conservationists and development professionals on the means by which the trade may bring benefits to poor communities that depend on natural resources for their livelihoods.

METHODS

Study area

The aquarium trade in the Peruvian Amazon is centered on the city of Iquitos, the capital of the Department of Loreto. Iquitos is the largest urban area in the Peruvian Amazon, with over 400,000 inhabitants, and serves as the principal market for agricultural, fisheries, game and forest products extracted from the region (Kvist *et al*., 2001). There are 14 main exporters of aquarium species in Iquitos, but the trade is dominated by "M/F Tropical Fish" and "Aquatrade". The city of Requena is an important centre for the regional aquarium trade and acts as an intermediate market before the produce reaches Iquitos.

Some of this produce originates from the nearby PSNR. The reserve, established in the 1940s, is one of the largest in Peru and extends across an area of around 20,600 km^2. It is bordered by two tributaries of the Amazon River, the Ucayali and Marañón rivers, and encompasses the two major drainage basins of the Pacaya and Samiria rivers. The reserve is characterised by massive hydrological fluctuations occurring between the high- and low-water seasons. During the summer months of October to May, heavy rainfall in the foothills of the Andes increases the water level of the western Amazonian rivers and causes large-scale flooding. This flooding inundates around 90% of the reserve each year (Kvist *et al*., 2001). The water recedes again in the winter months between June and September due to reduced rainfall. This pattern produces a complex mosaic of different aquatic habitats. At high water, these include numerous oxbow lakes, floating vegetation meadows and flooded forests, known locally as "*varzeas*". There are two types of river in region: the larger, nutrient-rich whitewater rivers that carry sediment down from the Andes and the smaller, nutrient-poor blackwater tributaries that are stained by tannins they pick up during

flooding.

A total of 23,930 people live within the reserve in 106 distinct communities and another 68,117 people live in the 100 communities in its buffer zone, gaining access through the Pacaya and Samiria rivers (INRENA, 2000; 2008). The majority of the inhabitants are descended from the Tupí-Guraní speaking Kukama-Kukamilla people, mixed with more recent immigrants of indigenous and Caucasian origin (Gow, 2007; Puertas *et al*., 2000). 4 communities participated in this study: San Martín de Tipishca, Bolívar, Leoncio Prado and Bretaña (Fig. 1). These communities were chosen based on indications of exploitation and trading in ornamental aquatic species by residents.

Few legislative controls are in place for the region's trade in ornamental species, but national legislation requires fishermen to be licensed, limits harvests through established quotas, calls on collectors to minimize mortality in transport and holding and bans the fishing of the fry of a number of species important for consumption. The extraction and sale of the silver arowana and the yellow-spotted river turtle from the PSNR cannot exceed quotas established by reserve authorities and is only permitted for management groups. These consist of inhabitants from local communities who are given the responsibility of conserving certain priority species through approved and sustainable management plans. Management groups are based at guard stations and a number of other settlements located along the Samiria and Pacaya rivers and each protects a designated sector within the reserve. When groups can demonstrate natural resource conservation they can obtain licenses from the park authorities to extract natural resources from the reserve. The yellow-spotted river turtle is additionally listed on Appendix II of the Convention on International Trade in Endangered Species (CITES), with export allowed only under permit from national authorities. Currently, the management groups from the Samiria River are in the process of applying for licenses and since the formalization of the trade have been unable to catch and sell silver arowana fry.

The harvest of turtles by the Kukama-Kukamilla people of the PSNR provides a potential model for resource use by other indigenous groups in other protected areas. Since the year 2000 the local communities have been involved in the regulated trade in yellow-spotted river turtles and increasingly the giant South American river turtle (*Podocnemis expansa*). Each year, turtle eggs are collected by management groups under the supervision of biologists and incubated in artificial beaches at the guard stations, where they are protected from predators and poachers. At least 50% of the hatchlings are then returned to the wild and the remainder is sold either directly to exporters in Iquitos or to intermediaries. Inviable eggs may also be used for subsistence purposes. Data gathered by biologists reveal significant increases in the turtle populations throughout the reserve, suggesting conservation efforts are working. However, as the turtles are relatively easy to breed in captivity, the long-term commercial viability of this trade cannot be guaranteed. It is therefore imperative that the benefits the local people receive from the trade are made clear in order to conserve this important livelihood strategy.

The harvest of silver arowana is not so heavily regulated, but the hope is that it will follow a similar pattern as the harvest and trade in turtles. Management groups help to conserve the silver arowana by patrolling the rivers and deterring poachers.

Licensed groups are then able to harvest and sell arowana fry. The adult males, which mouth-brood fry for up to two months, are caught and the fry still attached to the yolk sacs are harvested. For ornamental fisheries, the males are then released back into the wild; otherwise the male may be killed and sold. Each male may yield 70-200 fry, which are sold and exported to the aquarium trade.

Data collection

This study was carried out from November 2014 to May 2015. Export companies in Iquitos were contacted prior to field studies in order to obtain information on the sources of wild-caught ornamental aquatic species as well as estimates of the number of animals exported. During a preliminary visit to the guard stations along the Samiria River, management groups were interviewed on the harvest of silver arowana and turtles. The aim of this initial stage was to identify communities and management groups that are involved in the aquarium trade, encourage participation in the project and set up a series of interviews to be conducted during a future visit. 56 members of management groups from the Samiria (n = 30) and Pacaya (n = 26) rivers were interviewed using questionnaires. These included semi-structured and closed survey questions. A local key informant who was familiar with the study areas and the residents assisted with the interviews. Questions covered the following: personal data; livelihood activities; methods; yields; socio- economic value of activities; expenses; the importance of the trade in aquatic ornamental fisheries; assets and wealth; local perceptions and attitudes towards wildlife; laws and regulations on the trade.

Government sources are used to complement the field data. Arowana and yellow-spotted river turtle export figures compiled for the year 2012 and 2013 were obtained from the Ministry of Environment (Loreto).

Data analysis

The data were analysed to determine the socio-economic background of management group members, including gender, age, birthplace, ethnicity, family size and education level. The methods and purpose (subsistence and/or commerce) of livelihood activities were described. Distances travelled to fishing and hunting sites were recorded in hours travelled by motorized canoe ("*peque peque*"). The number of hours per day, the number of weeks a month and the number of months a year spent on each activity were recorded. Factors that limit livelihood activities were noted and listed in order to importance.

Estimates of the weekly yield from the main livelihood activities were recorded in kilograms and the percentage of this yield that was kept for consumption and the percentage sold was recorded. This was extrapolated to monthly yields and multiplied by the number of months the activity was carried out by each household to provide annual yields. These were then multiplied by the price per kilogram and the costs of each livelihood input (e.g. machetes, nets, boots) were subtracted from this value to give overall profit, which provided the subsistence and monetary values of each activity. Mean economic values of each livelihood were calculated by dividing the total economic value of livelihood activities by the number of households participating in the study. Likewise, hourly income provided by each

activity was obtained by diving the total economic value by estimates of the number of hours households spend on each activity. All values were converted from Peruvian Nuevos Soles to US dollars (US$) using the current conversion rate of x0.32. Comparisons were made using analysis of variance (ANOVA).

Descriptions of yields and income earned are as reported to us by interviewees and could not be directly verified. Nevertheless, recall bias is expected to be minimal as quantitative information asked was simple, activities are regular and arowana fry and turtles eggs are collected and sold in precise numbers and over a short time period (i.e. the breeding season).

RESULTS

Socio-economic background of interviewees

All interviewees were men, though several women are known to be members of management groups. Ages ranged from 22 to 70. The level of education also varied, with several (n = 10) interviewees completing secondary school. Household sizes ranged from 2 to 11 members, averaging 5 to 6, and consisted of husband and wife, children and other members of their immediate or extended family. The majority of interviewees were born in the communities of the PNSR but a few were from other communities located throughout the Peruvian Amazon, and some were even from large cities such as Requena and Lima. While most identified with the Kukama-Kukamilla ethnicity, one identified more closely with "*mestizo*" (mixed-race) and another with Quechan.

Livelihood activities

The Kukama-Kukamilla people still retain a largely traditional way of life and depend on a combination of fishing, hunting, gathering and small-scale agriculture. Other activities that provide food or a source of income include running a small grocery store (9% of interviewees), driving a "*mototaxi*" (rickshaw) (4%), rearing livestock (2%), carpentry (4%) and the sale of forest products such as palm fruits (4%).

Fishing, which in this case refers to the harvesting of food fishes, is the main livelihood activity, and is carried out by all households. The mean annual yield of fish produced by fishermen is 4,251 kg. Approximately 67% of this fish is sold and the rest is kept to feed the fishermen and their families. 63% of households (n = 35) supplement fishing with farming, some for purely subsistence purposes but others also sell a large proportion of the crops they produce. Agriculture provides farmers with an annual yield of 17,360 kg of crops, including maize, rice and plantain, of which 71% is sold and the rest is kept for consumption. Only about a third of households (n = 22) mentioned hunting as an important livelihood activity. According to those that do hunt, they do so for both consumption and to sell bushmeat at the urban markets. At most, 5 animals are killed during hunting trips (up to 50 kg), though some trips may be unsuccessful. This produces an average of 21 animals killed a year (135 kg). 57% of the biomass harvested is sold, the remainder kept for consumption. The paca (*Cuniculus paca*) is the most commonly harvested species (91% of hunters). Other game species include the peccaries (73%), the nine-banded armadillo (*Dayspus novemcinctus*) (23%), the razor-billed curassow (*Mitu*

tuberosa) (35%), the lowland tapir (*Tapirus terrestris*) (9%) and primates (18%).

All households are involved in the trade in turtle hatchlings and those from the Pacaya River also harvest and trade in the silver arowana. Both species provide a significant source of protein in the villagers' diets as well. In fact, while conducting preliminary interviewees at the guard stations along the Samiria River we were served arowana for lunch. This is legal as long as fishermen are harvesting the fish for their own consumption. According to the local people, finding these resources is relatively easy, suggesting they occur in abundance throughout the reserve. The length of time interviewees have been involved in the trade range from 1 month to 15 years, depending on when they joined management groups. In 2013 a total of 186,549 turtle hatchlings were exported from the Pacaya and Samiria river basins (Fig. 2). Data for arowana exports from 2013 are lacking, but in 2012 71,511 arowana fry were exported from the Pacaya River basin. These exports are destined for Asian markets, especially China, Thailand and Japan. The USA and Canada are also big importers of aquarium species. A small proportion of the trade (<1%) is domestic.

Time spent on activities

The number of hours households dedicate to different activities varies (Fig. 3). The most time-consuming activity is hunting, which becomes very labour intensive during the high-water season when the terrestrial mammals are restricted to the non-inundated levees. Some hunters make trips deep into the forest as little as once a year, but trips usually last between 4 to 6 days. In contrast, fishing trips last an average of 3.55 hours. However, fishing is carried out much more frequently than hunting, with the more devoted fishermen fishing every day. It also occurs year round. The low water level traps fish in shallow lakes, channels and rivers, making them easy prey, while fish migrations into the flooded forests make fishing of some species profitable in the high-water season. The aquarium trade is restricted to the breeding season of the ornamental species, which occurs from October to December for arowana and July to November for turtles. Likewise, farming is only possible when the low water level exposes agricultural land. These activities require relatively little labour input. 7.28 and 10.94 hours are spent harvesting arowana fry and turtle eggs, respectively, for up to 7 days a week. Farmers work for an average of 4 hours a day, between 2 to 5 times a week.

Limiting factors

Various environmental and socio-economic factors limit the productivity of livelihood activities. The most frequently cited issue was the climate (59% of interviewees). The annual floods damage crops and erode agricultural fields during the high-water season. The high water level also makes the fishing of some species difficult, as they are sparsely distributed throughout the flooded forest. On the other hand, during the low-water season, the scarcity of animals limits hunting activities. The deterioration of materials and the lack of money to purchase items such as motors and shotguns is also a problem (27%). Caiman and piranhas are known to damage fishing materials and nets may be stolen by other fishermen who cannot afford their own. Several interviewees also expressed concern over the difficulties of acquiring licenses to harvest and export certain species from the reserve (7%). This is the main issue preventing residents from participating in the aquarium trade.

Socio-economic value of livelihood activities

The mean annual socio-economic value of livelihood activities for the Kukama-Kukamilla households in the PSNR management groups is US$ 7,917. Significant differences exist between the values of each livelihood activity, depending on the type of activity, the purpose of the activity and the study area ($F_{3,192} = 10.24$, $p < 0.0001$) (Table 1). Fishing is the most economic activity, followed by agriculture (Fig. 4). Thought not the major livelihood activity, ornamental aquatic species also have substantial value. The mean annual income gained from the trade in aquarium species equates to around 14% of the total socio-economic value of livelihood activities, and up to 19% of the income obtained from commercial activities. Hunting has additional value for some households. Other activities such as driving *mototaxis* or carpentry provide negligible sources of income in the study areas. Overall, the combined value of extractive activities exceeds that of agriculture (Fig. 5). The value of the monetary income generated by commercial activities exceeds the value of the subsistence economy (Fig. 6). Finally, substantial differences exist between study areas ($F_{1,45} = 18.71$, $p < 0.0001$) (Fig. 7). On average, households from the Pacaya study area are wealthier than those from the Samiria study area.

Table 1. Average annual socio-economic value of subsistence and commercial activities for households in management groups from the Pacaya and Samiria rivers.

Activity	Average economic value (US$)	
	Pacaya study area	Samiria study area
Subsistence		
Fishing	2,308	1,529
Agriculture	2,916	722
Hunting	11	72
Commerce		
Fishing	4,252	2,981
Agriculture	3,160	1,826
Aquarium trade	1,427	766
Hunting	43	81

Large differences exist when comparing the hourly income obtained from different livelihood activities ($F_{3,90} = 16.71$, $p < 0.0001$) (Fig. 8). Viewed in this way, the less profitable activities are hunting and fishing. Agriculture and the collection of aquatic ornamental species provided the highest hourly income, but because these activities are seasonal they provide small proportions of the total value of extraction.

Assets

Comparisons of goods owned by households, such as radios and televisions, provide further evidence that inhabitants of the Pacaya River basin are wealthier and thus possess greater assets than those from the Samiria River ($F_{1,40} = 8.39$, $p < 0.01$) (Fig. 9). The proportion of households that possess various items depends on the price of these items (Fig. 10). Nearly all households from the Pacaya River possess the basic, cheaper items such as tables, chairs and beds, whereas around half of households from the Samiria River possess these items. Perhaps surprisingly, not everyone who owns a bed has a mattress. In fact, less than half own a foam mattress, and even less sleep on a straw mattress. The most common form of cooker owned by the local people is a coal fire. A few people from the Pacaya River own solar-powered cookers, a relatively new and expensive commodity that they bought no more than a

month ago or were given as a gift. Less than half of the households surveyed own kitchen utensils such as pots and pans, possibly sharing amongst villagers, although most will likely have staple items such as plastic plates and a few forks. What is interesting is the general perception of the price of these items. For instance, interviewees claimed that foam and straw mattresses cost an average of US$ 56.77 and US$ 24.80, respectively. The costs of such items are likely being overestimated because a large proportion of the population cannot afford them. All of these household items can be reused over many years and therefore do not require ongoing expenditure; one interviewee claimed to have owned the same bed for 50 years.

Canoes represent one of the only means of transport from villages and as such they are extremely important assets. Unfortunately they are also relatively expensive. Nevertheless, without a canoe most livelihood activities, including hunting, fishing and agriculture, would be extremely difficult. Again, nearly all households from the Pacaya study area own this commodity, whereas less than half of households from the Samiria study area own a canoe. Because of the damage inflicted by pressures such as the weather, canoes have to be replaced frequently and so were no more than 2 years old. Less people own motorized canoes, which cost almost 4 times as much as regular canoes. Because of their high price, motorized canoes are not replaced as often. Those who possess carpentry skills may build their own canoes, and may also build to sell.

Luxury items such as clocks, watches and bicycles are rare among the local people, but televisions, DVD players and radios/CD players are relatively common, considering the price. The few families who own these items may invite relatives, friends and neighbours to utilize them. These items are not particularly recent either, having been owned by some households for up to 12 years. The price likely means that these possessions cannot be replaced very often. Mobile phones have become increasingly common over the last year, as newly constructed cell towers are extending the range of phone and Internet connection. Less than half of households own their own personal generators, which is the most expensive item at US$ 242.84. Generators are used now and again to power lights and electrical equipment such as televisions, but the cost of fuel means that they are used infrequently.

Finally, only 3 interviewees claim to be landowners, most likely reflecting the high price (US$ 1,000 per ha), and have held this land for up to 25 years. Most land is transferred along kin lines as opposed to being bought.

Local perceptions

The laws and regulations of the PSNR appear to be somewhat confusing, as 27% of interviewees from the Samiria study area were unfamiliar with the regulations surrounding the harvest of wildlife. No unanimous cultural norms dictate the harvest of ornamental species. Surprisingly, less than half of interviewees (48%) saw the benefits of the silver arowana and only slightly more (59%) saw the yellow-spotted river turtle. In contrast, armored catfish (83%) and the gamitana (*Colossoma* spp.) (84%) are perceived as more valuable resources.

DISCUSSION

The trade in aquarium species in the Peruvian Amazon has grown over the years and it is now an important livelihood activity for poor communities, providing a significant source of income. As global demand increases, the harvest of wild-caught species is likely to increase with it. In light of this, conservationists and development professionals are concerned over the aquarium trade and the threat it poses to ornamental aquatic species and the socio-economic benefits they offer. Many major trading centers for aquarium species are located along waterways outside of protected areas, where they represent an essentially open-access resource and are at risk of overexploitation through "the tragedy of the commons". The complete harvesting of all arowana fry and turtle eggs encountered, as well as the killing of reproductive adults, is likely a common practice in the Amazon. Fishermen from the Río Tapiche, for instance, compete intensely for arowana on open-access fishing grounds and explain that if they do not kill adults when they are encountered, someone else will (Moreau and Coomes, 2006; 2008). Such unsustainable practices appear to be depleting supplies nearer to the urban markets of Iquitos and forcing the trade to expand to more remote areas. Similar trends indicating widespread population declines in many species has fuelled the spread of an "anti-fishing" message and contributed to the general public perception that the trade in wild-caught aquarium species is having negative environmental impacts.

Accordingly, conservationists are frequently calling for the farming of ornamental aquatic species and there is much interest in developing and advancing captive breeding methods. Already approximately 90% of freshwater aquarium fish are captive-bred (Pineda-Catalan *et al*., 2012; Whittington and Chong 2007). However, any management initiative must be based on a thorough understanding of the nature of the aquarium trade, the benefits local people receive from this trade and of the long-term ecological and socio-economic consequences for both the resource and the resource users. The collection and trade of wild-caught freshwater species remains one of the least understood components of the aquarium industry, as little quantitative data exist on the number and composition of species exported and of the health and resilience of natural populations (Moreau and Coomes, 2006, 2007; Collins *et al*., 2012; Raghaven *et al*., 2013).

This study did not explore the ecological impacts of the aquarium trade. However, the harvest of Amazonian ornamental aquatic species is extremely selective and benefits from almost no by-catch, which is a great source of mortality among marine species. Furthermore, many ornamental species are abundant, geographically widespread and reproduce rapidly. These characteristics make the aquarium industry one of the least environmentally damaging extractive activities in the region. Other activities such as mining or logging may be much more damaging. In removing the aquarium trade, local people might turn to these environmentally and socially unsustainable industries to replace the income lost. The aquarium trade therefore represents a sustainable livelihood activity that could take the pressure off more vulnerable species and habitats that might otherwise be overexploited or threatened. It also provides socio-economic incentives to preserve ornamental aquatic species and the habitats they depend on.

Sustainable use should thus be the guiding management principle. Similar conclusions are being drawn in other regions of the world where the aquarium trade represents an important livelihood activity (Bartley, 2000; Chao *et al*., 2001; Tlutsy,

2002; Watson, 2000). The more protectionist approach of placing an outright ban on the trade in wild-caught aquarium species would deny an important source of income to poor rural and indigenous communities and destabilize an export industry that is estimated to directly employ thousands of people and that provides important foreign earnings to developing countries. In the Amazon, thousands of people rely on the aquarium trade for at least some of their income, and for many it is their main livelihood activity (Kvist *et al*., 2001). Compared to other activities such as hunting or the sale of palm fruits, aquarium fisheries are relatively lucrative, as observed in this study. Even where households earn a relatively small proportion of their income from aquarium species, the earnings can be critical to buffer times of hardship. This is particularly important in the flooded forest ecosystems given the seasonality of livelihood activities. Many people collect aquarium species only as a complement to their primary income sources, often when agricultural lands are flooded and few other commercial activities are possible (Moreau and Coomes, 2007).

In the PSNR the aquarium trade provides the Kukama-Kukamilla people with a significant source of income. As the needs of indigenous people shift to ones defined by modern society, this income could cover the expenses of medicines and school materials. It might also allow families to buy luxury items in order to improve their standard of living, such as generators and motorized canoes. In recent years, more households have been purchasing these items, as well as electrical devices such as televisions and mobile phones. The continued socio-economic development of the local people through the aquarium trade would make these goods affordable to even more households. It could also provide households with enough additional income to invest in equipment and materials needed for fishing, hunting and agricultural activities and hence increase food security. The information gathered during this study provides insights into the role of the aquarium trade in poverty alleviation. The extra income that residents of the Pacaya study area obtain from the trade in arowana fry has likely contributed to their relative wealth compared with those from the Samiria study area and allowed them to acquire more assets.

The catch-and-release methods adopted by the Kukama-Kukamila people of the PSNR represent a potential model for sustainable harvesting and trading in aquarium species that could be applied to other indigenous populations in other protected areas. In return for their conservation efforts, management groups are allowed to exploit certain resources inside the reserve as well as prevent exploitation by outsiders. This means that only a small number of people are involved in the trade of aquarium species and that the pressure is spread over the entire reserve. It also means that aquarium species represent a defensible and renewable resource, providing an incentive for sustainable use. However, adequate enforcement of trade regulations is difficult due to the size of the reserve, corruption and financial limitations. Interviews revealed that not everyone from the Samiria study area was aware of the regulations surrounding the harvest and trade in wildlife and informal conversations with fishermen revealed that illegal harvesting of silver arowana is occurring. Nevertheless, sustainable practices are likely common, if not exclusive, as suggested by regular wildlife monitoring surveys that reveal significant population increases in many species throughout the reserve (Bodmer, unpublished data).

Providing management groups from the Samiria River with licenses to export arowana legally should be considered a priority. Not only will this provide socio-

economic benefits for residents, it will also remove some of the difficulties of controlling the trade and ensure that fishermen have a long-term vested interest in the survival of this species, thus promoting sustainability. Finally, when the local people receive benefits from the sustainable harvest of aquarium species, they are unlikely to turn to mining or logging that would otherwise destroy the flooded forest ecosystem (Dowd and Tlusty, 2000).

The high educational level of the Kukama-Kukamilla people has likely facilitated the development of sustainable extractive activities. The implication is that where unsustainable resource use occurs, the forest and its products are valued to the point that they provide short-term returns (O'Brien and Kinnaird, 2000; Zapato-Ríos *et al*., 2009), yet during this study it became clear that the local people recognize wildlife as a finite resource and understand that hunting and fishing can have negative effects on this resource in the long-term. This has allowed NGOs to teach residents of the PSNR how to enhance the sustainability of these activities through outreach programmes. The turtle conservation programme perhaps best demonstrates the important role that the education can play in conservation. As part of an educational activity for children, school groups sometimes observe or help management groups releasing hatchlings. In other areas where ornamental fishing occurs, entire communities are illiterate with no secondary education (Madduppa *et al*., 2014). Low education levels and poverty are often associated with environmental degradation, so that where overexploitation occurs, the socio-economic development of the local people suffers, which then leads to further degradation through a positive feedback system (Sobhee, 2004).

The aquarium trade needs to guarantee a relatively stable income in order to ensure the continuation of sustainable practices. Not obtaining support due to scepticism from the local people has been recognised as a fundamental barrier to incentive-based conservation as they may turn to livelihood activities that are environmentally unsustainable but that they believe to be more economically valuable (Spiteri and Nepal, 2006). The Kukama-Kukamilla people attributed relatively little value in the silver arowana and yellow-spotted river turtle, despite the fact that they clearly offer significant socio-economic benefits. This likely reflects a combination of factors, including the difficulties of acquiring licenses and the long history of conflict between the local people and reserve authorities (Bodmer and Puertas, 2007). One mechanism that is being proposed in order to add value to the yellow-spotted river turtle is certification. This will emphasize the social and ecological benefits of sustainable harvesting of ornamental aquatic species; mainly that it represents an important livelihood for poor communities and discourages environmentally damaging alternatives. It will provide further economic incentives for sustainable resource use by allowing local people to sell turtle hatchlings at a premium. The certification programme may be the means by which rural and indigenous people are able to maintain a position in aquarium trade, which is increasingly being sourced by captive-bred populations. The turtle certification programme is currently being implemented in the PSNR, and a similar programme is being recommended for ornamental fish (Tlusty *et al*., 2006; Watson, 2005).

CONCLUSION

A well-managed and responsible aquarium industry can create sustainable livelihood opportunities for thousands of rural and indigenous people. However, there is a pressing need to gain a better understanding of the trade in wild-caught species, including the health of populations, the number of animals being harvested and exported and the ecological impacts of the trade. Data are also lacking on the value of wild-caught aquarium species for local people. The information described in this study complements a growing body of evidence for the socio-economic value of ornamental aquatic species by exploring the benefits that poor Amazonian communities obtain from the trade in two important species. This will help create awareness for the role that the trade can play in poverty alleviation as well as conservation and will provide a model for a responsible and sustainable wild-caught aquarium industry.

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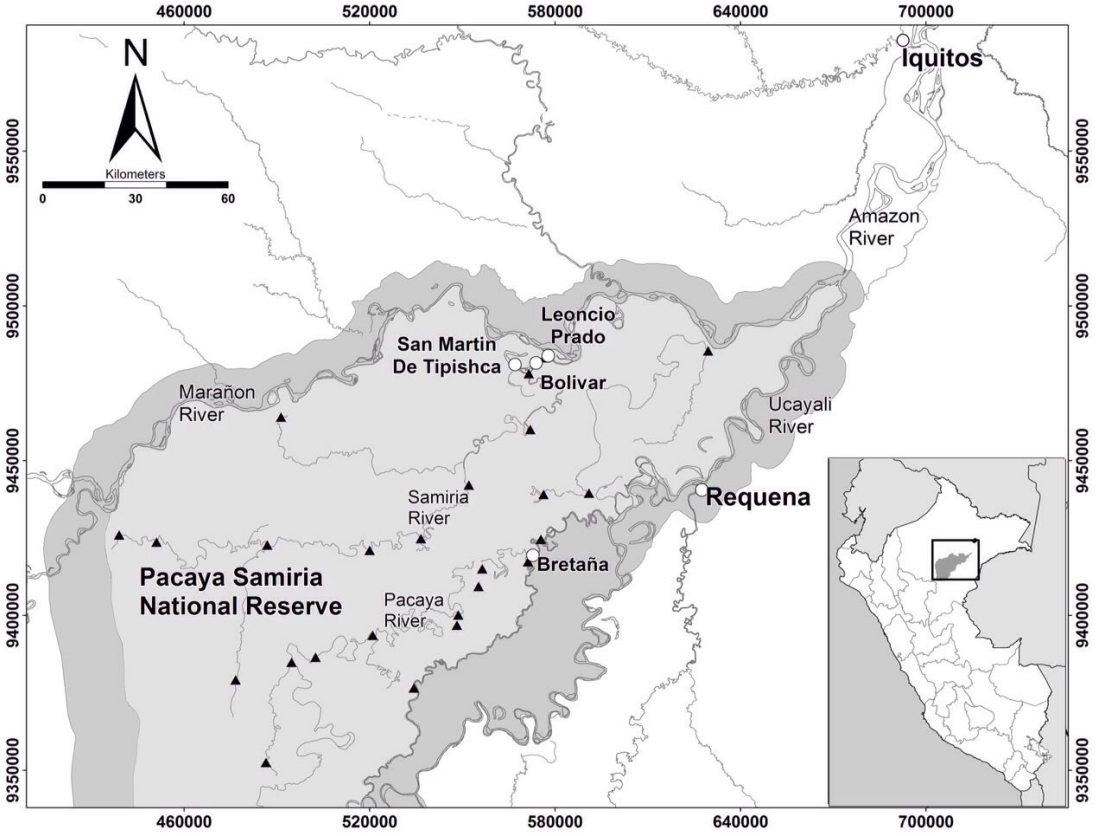


Figure 1. The Pacaya-Samiria National Reserve in the northeastern Peruvian Amazon, showing the locations of the 4 Kukama-Kukamilla communities (o) and the guard stations (▲).

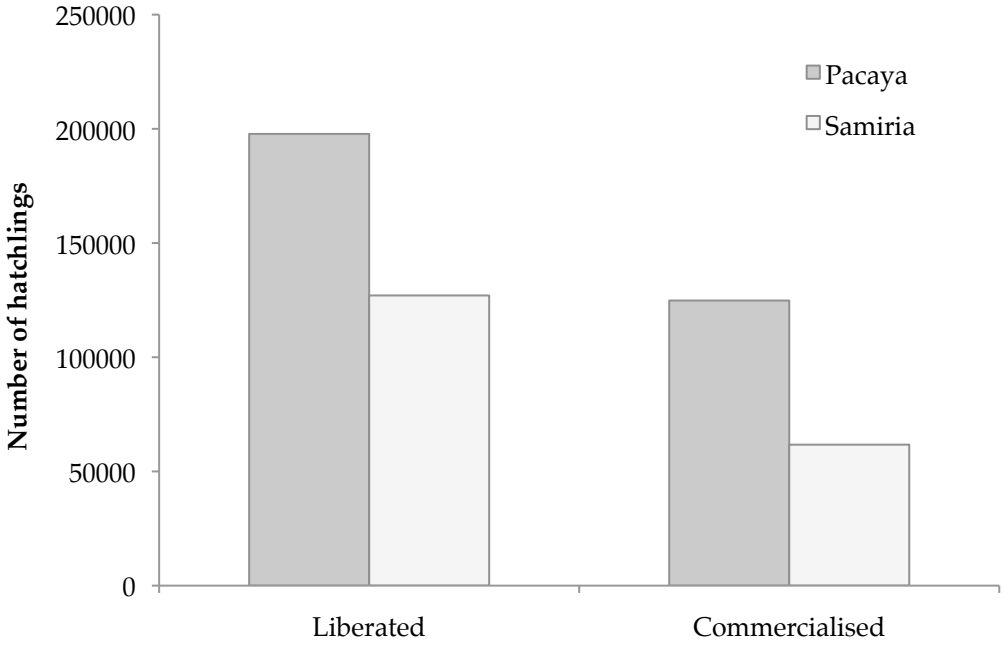


Figure 2. The number of yellow-spotted river turtle hatchlings liberated in the PSNR and the number commercialised by management groups of the Pacaya and Samiria rivers in 2013.

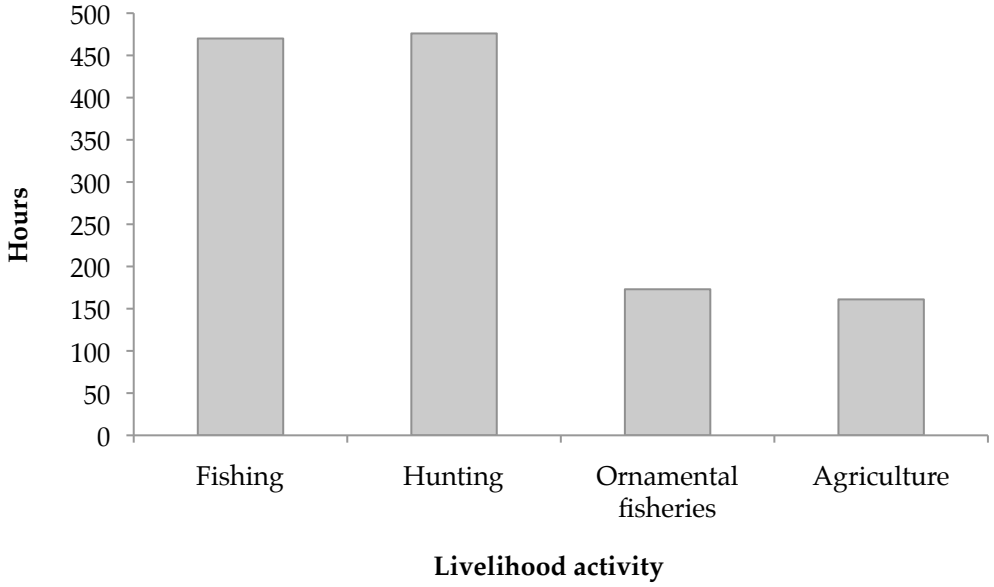


Figure 3. Mean number of hours households participating in the management groups of the PSNR spend on the main categories of livelihood activities over the course of a year.

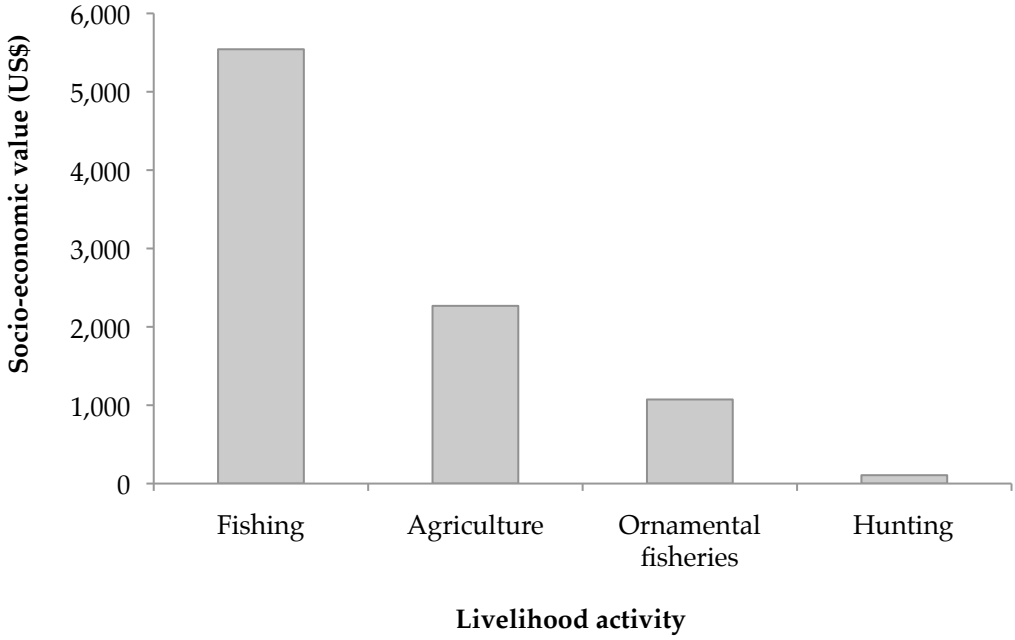


Figure 4. Mean annual socio-economic value ($US) of different livelihood activities for households participating in the management groups of the PSNR.

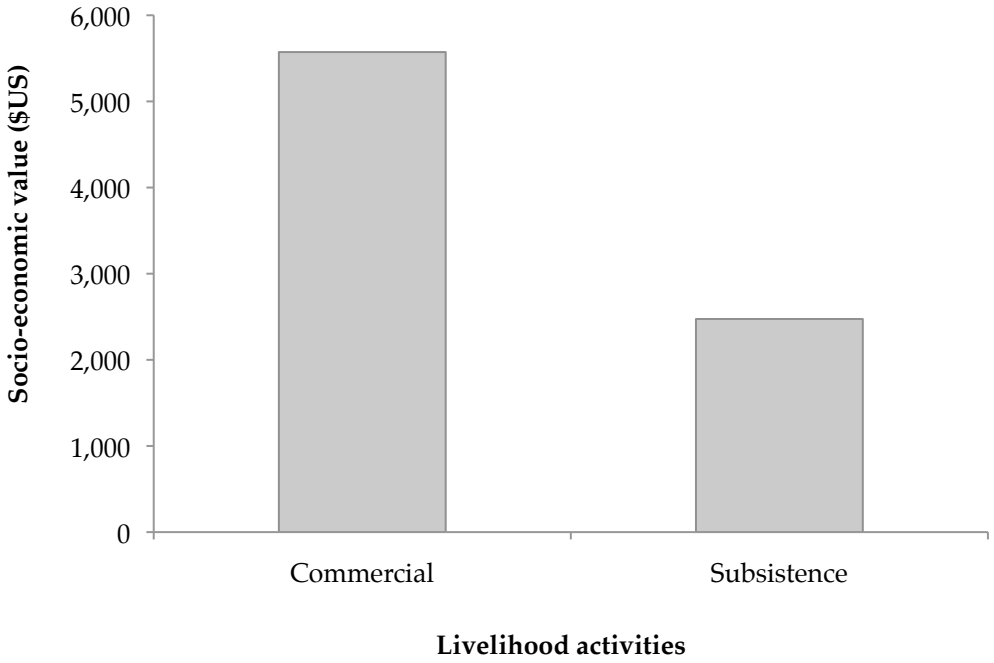


Figure 5. Mean annual socio-economic value ($US) of extractive and non-extractive activities realized by households participating in the management groups of the PSNR.

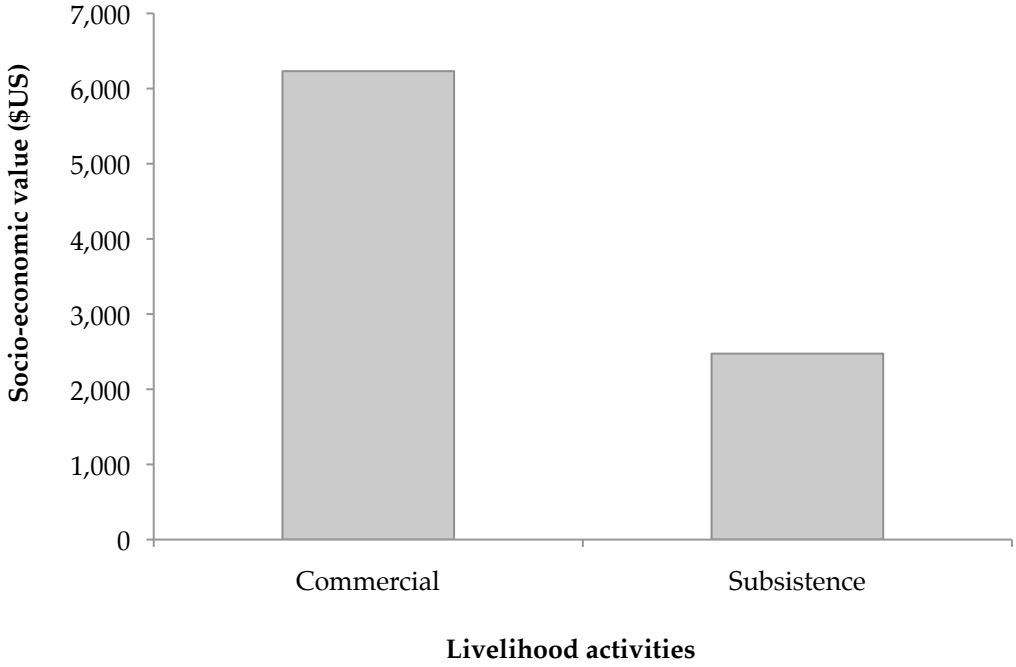


Figure 6. Mean annual socio-economic value ($US) of commercial and subsistence activities carried out by households participating in the management groups of the PSNR.

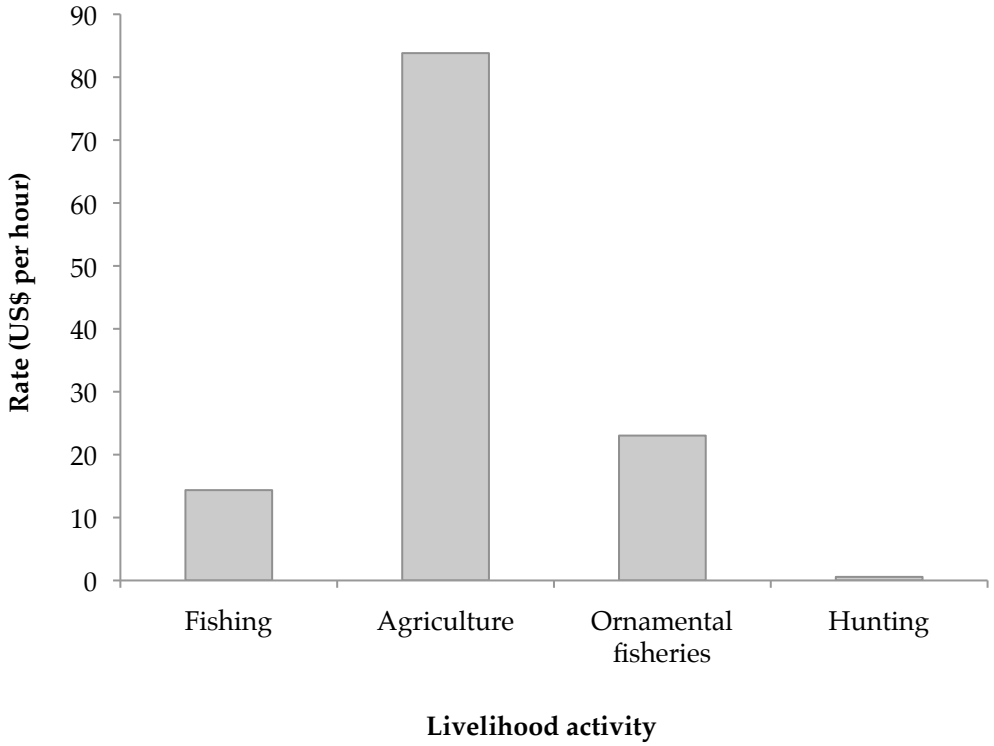
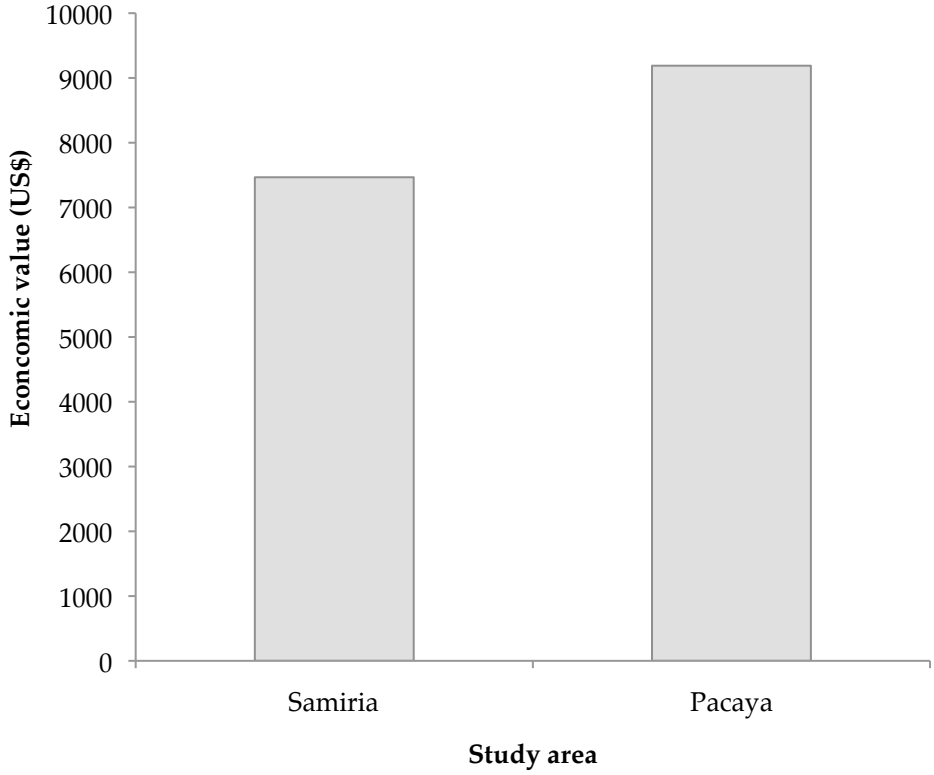


Figure 7. Mean hourly rate (US$) of the main categories of livelihood activities carried out by households participating in the management groups of the PSNR.



ıe Samiria and Pacaya management groups.

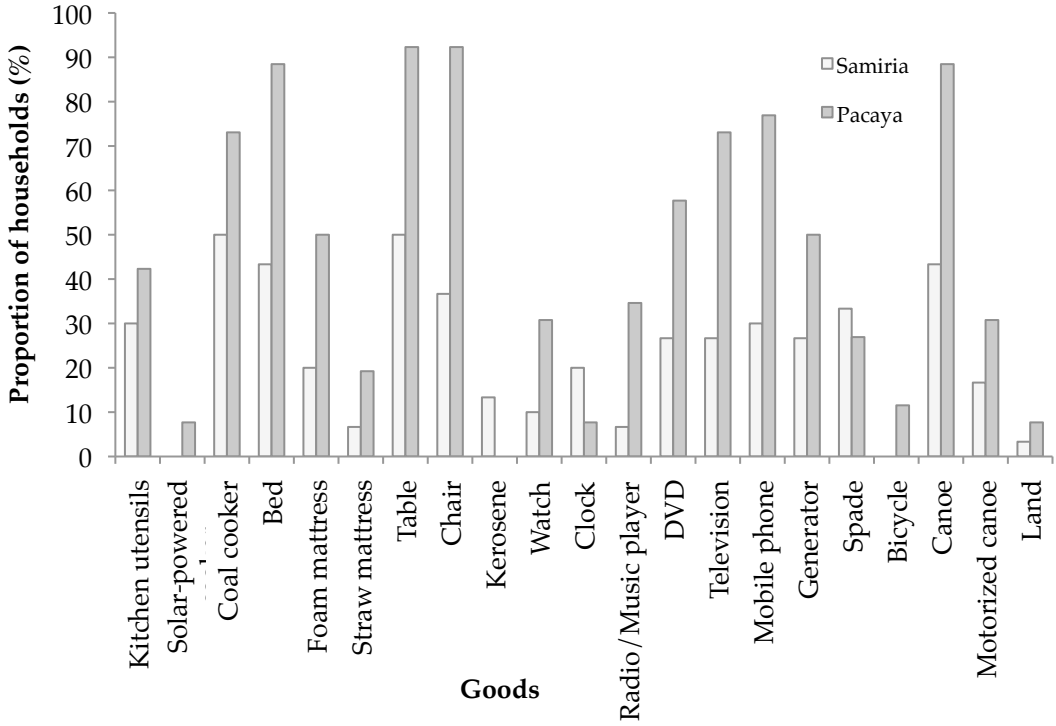


Figure 9. Proportion of households (%) from the management groups of the Samiria and Pacaya rivers that possess various goods.

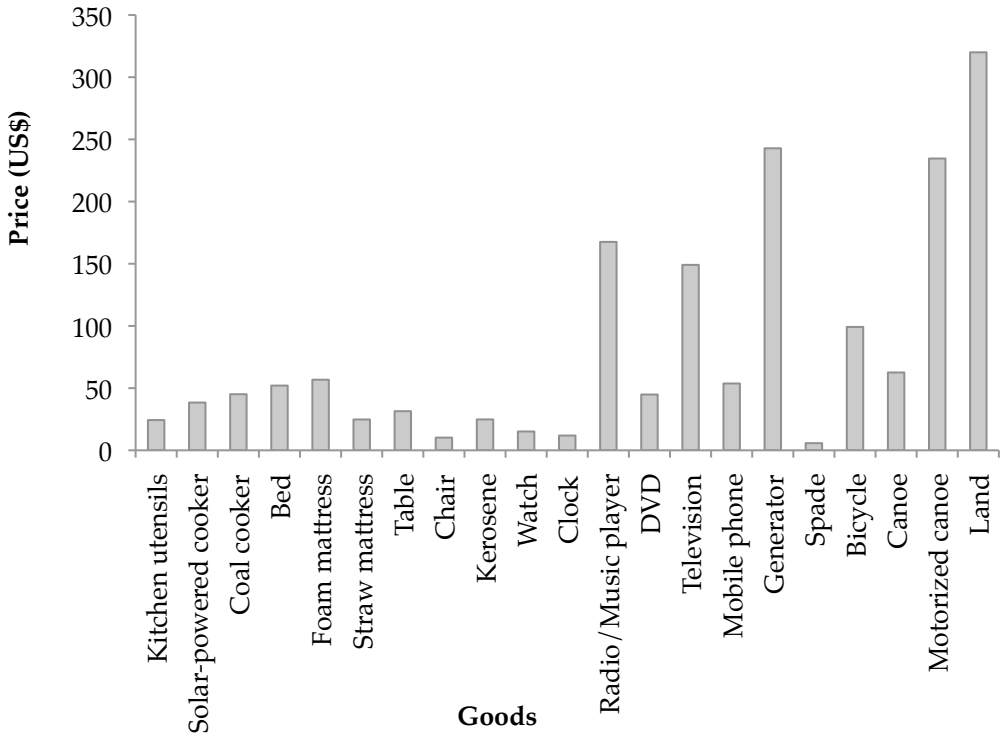


Figure 10. Mean price (US$) of various goods owned by households participating in the management groups of the PSNR.