PART II

Economic Considerations

9

Economic Incentives for Sustainable Community Management of Fishery Resources in the Mamirauá Sustainable Development Reserve, Amazonas, Brazil

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The increasing demand for and degradation of limited resources by the rising human population of the Amazon basin has precipitated a great deal of discussion about the sustainable use of its natural resources (Hall 1997; Ayres et al. 1999). For the most part the fisheries of the Amazon basin are underexploited, and fishing pressure is concentrated on only a few species (Bayley and Petrere 1989; Crampton and Viana 1999). Crampton et al. (this volume) provide a detailed account of the history and current status of floodplain fisheries in the Brazilian Amazon basin. Until the 1970s tambaqui (*Colossoma macropomum*) and pirarucu (*Arapaima gigas*) represented staple protein supplies in the Amazon basin. With the growth of commercial fishing fleets, these species began to show clear signs of overfishing and today are luxury food species (Petrere 1986; Costa 1992; Goulding, Smith, and Mahar 1996). In the last two decades the detritivorous curimatá (*Prochilodus nigricans*) and jaraquis (*Semaprochilodus* spp.) have become the staple food species. As yet, there is only anecdotal evidence for overfishing of these species (jaraqui sizes are decreasing in Manaus markets, V. Batista pers. comm.). The major challenge in Amazon fisheries management is to avert a situation in which one species after another is depleted.

This article describes the principal activities and results of an experimental community-based fisheries management initiative in the Reserva de Desenvolvimento Sustentável Mamirauá (Mamirauá Sustainable Development Reserve, or RDSM), a protected area of várzea floodplain in the Brazilian state of Amazonas. This reserve covers 1,124,000 hectares and is delimited by the rivers Solimões, Japurá, and Uatí-Paraná. The work reported here is centered on a smaller, 240,000-ha Focal Area, bordered by the Japurá and Solimões rivers and by a connection between them, the Paraná Aranapu (fig. 9.1). Resident and user communities in or near this reserve have exclusive access rights to fishing resources granted by its status as a conservation unit. In addition to providing strong economic incentives for the sus-

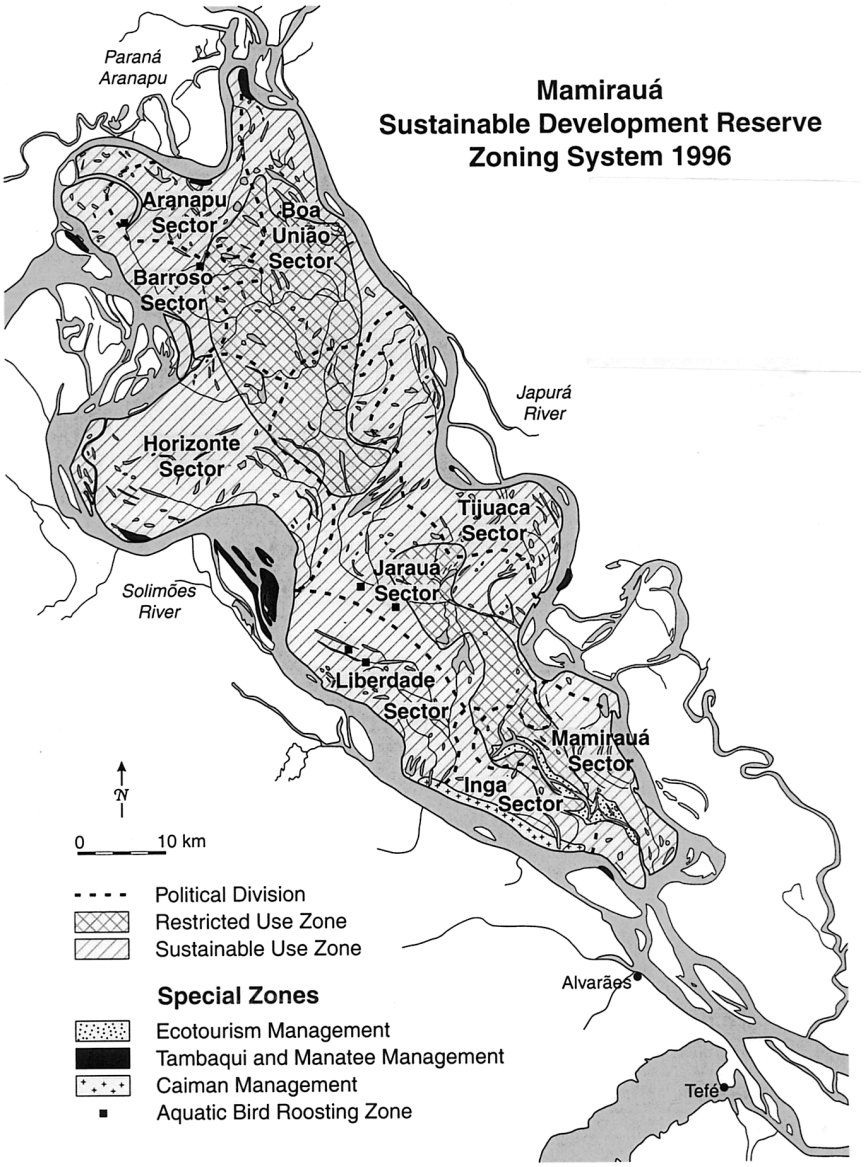

FIGURE 9.1 Organizational (political) sectors and Focal Area of the Mamirauá Sustainable Development Reserve.

tainable management of fisheries, the program described here supplied scientific and technical support in the definition of sustainable quotas. The program strove to improve the production efficiency of an existing fishery and to diversify its species base—both important strategies for reducing the pressure on key commercial stocks (Crampton and Viana 1999).

The RDSM was created in 1990 by the state of Amazonas and is one of the largest areas of relatively intact várzea floodplains in the Brazilian Amazon. The lakes, channels, and seasonally flooded forests of this unique ecosystem offer fishes a rich supply of vegetation, detritus, seeds, fruits, and invertebrates (Junk, Bayley, and Sparks 1989). The immense productivity and size of this reserve probably means that the area is a regionally important nursery ground for commercial food species. Such resident species as pirarucu and tucunaré (*Cichla* spp.) pass their entire life cycle in the floodplain. Many species of migratory characiform fishes, such as the detritivorous jaraquis and curimatá, spend the first years of their lives in the várzea before migrating upstream to colonize other areas.

Crampton, Castello, and Viana (this volume) describe the human population of the RDSM. The principle economic activities of the area are fishing, agriculture, and timber extraction, which are undertaken seasonally and on a communal or familial basis. The average annual income of families in the reserve is around US$ 900, of which 53% is spent on the purchase of food and basic supplies. Fishing represents by far the most lucrative source of income in the reserve, forming 72% of the average domestic income (SCM 1996).

The management of natural resources in the RDSM is based upon an alliance between the local resident and user population and a multidisciplinary research and extension project carried out by the Instituto de Desenvolvimento Sustentável Mamirauá (Mamirauá Institute for Sustainable Development, or IDSM). The local people of the reserve are involved in making management decisions that reconcile sustainable economic development with the conservation of biodiversity (Howard et al. 1995; SCM 1996; Crampton, Castello, and Viana this volume). Because of their economic importance, fisheries resources represent a major focus of management initiatives in the reserve.

Research undertaken in the Mamirauá reserve and negotiations with local communities resulted in the development of a series of restrictive and advisory measures designed to regulate fishery resource use in the area. These measures are outlined in the reserve's management plan (SCM 1996) and summarized by Crampton, Castello, and Viana (this volume). In addition to restrictive measures, the reserve's management plan established a zoning system. This comprises a core no-use zone surrounded by a zone designated for sustainable resource use by the residents and user communities of the Reserve (fig. 9.1).

To promote the conservation of biodiversity, to stimulate the sustainable use of natural resources, and to improve the economic well being of the residents and users of the Reserve, the IDSM is undertaking several extension programs in partnership with the local communities. One of the most important programs, named *Novas Alternativas Econômicas* (novel economic alternatives), aims to promote alternative economic activities, diversify income sources, and enhance existing activities by either increasing production efficiency and/or by forging more lucrative marketing arrangements. This initiative involves the organization and empowerment of production groups, technical and administrative training, the construction and implementation of new infrastructure, and the development of systems to keep

track of the dynamic market conditions. The experimental fish commercialization initiative described in this article is a central component of this Novas Alternativas Econômicas program.

THE FISH COMMERCIALIZATION PROGRAM

In 1998 an experimental Programa de Comercialização de Pescado (Fish Commercialization Program, or PCP) was implemented in one of the nine organizational sectors of Focal Area of the reserve. The Jarauá Sector, which comprises around two hundred inhabitants in four communities, was selected for this experimental program for four reasons:

1. Its communities are located strategically at the entrance to the largest lake system in the Focal Area.
2. Fishing represents the main economic activity.
3. The communities have a relatively well organized social structure.
4. The communities have a history of cooperation with the IDSM throughout the installation of the reserve.

The program began with an economic viability study prepared by outside consultants. This study projected the scale of fisheries production in the area and proposed an operational structure and chronogram (Bostock 1998). It assisted with the early planning of the program but underestimated the time and infrastructure that would be required.

Several meetings and consultations with the participating communities were held at the onset of the program in order to define the logistic and administrative organization necessary to stage a new fisheries production program. Training courses in fish processing were also given in order to improve the quality of fish for marketing. Also, visiting instructors ran workshops on the structure and management of commercial associations and cooperatives. As far as possible, the traditional systems of fish production were maintained, or altered only so as to improve productivity without drastically altering the community organization.

There was, however, room for consensual experimentation. In the beginning one attempt was made to conduct communal pirarucu exploitation in which labor was divided among the participants into fishing, transporting, and processing, and the income then equally divided. This strategy was proposed because of the relatively small fishing quota allowed (see below) and the unequal distribution of fishing equipment (canoes, engines, ice chests, and tackle) among fishermen. Most fishermen and the supporting staff felt that a communal organization with division of labor was more appropriate for such conditions. However, this approach was unsuccessful for several reasons. Friction developed around the division of duties and unequal division of labor. More importantly, pirarucu fishing is traditionally organized on an individual or family level or by small teams composed mostly of relatives. In view of the failure of communal fishing arrangements, the organization of

pirarucu fishing expeditions reverted to individual or small group affairs organized by the fishermen themselves.

Following capture, fish are transported from the managed area to a processing base located at the Jarauá community. The base comprises a covered floating raft with a large icebox and water purifying system. This facility was built in partnership with the fishermen and serves as a base for eviscerating, cleaning, and chilling fish, as well as an administrative base for the fishing operations. The base allows up to 4 tons of fish and ice to be stored. When this limit is reached, the fish are transported to the nearby city of Tefé in a boat dedicated to this program and equipped with an ice hold. The fish are either sold in Tefé or sent to Manaus or other cities. The IDSM invested (at no cost to the fishermen) approximately US$ 15,000 capital funds into the construction of the floating fish processing base plus the purchase of the boat and some equipment and supplies (a scale, office supplies, ice chests, etc.). The participating fishermen contributed manual labor and wood for the base.

The most important feature of the PCP is the elimination of intermediaries (*atravessadores*) between the fishermen and the market. Intermediary purchasers travel around the interior buying fishes at prices way below the market values. Most of the transactions are based on an exchange of fish for household supplies, such as cooking oil, salt, sugar, and coffee, all of which are bartered at inflated prices. By removing intermediate purchasers and improving production quality of the fish products, the fishermen of the Jarauá Sector are able to achieve a far greater economic return with smaller landings of fishes. Fishing expenses are the responsibility of the fishermen, while commercialization expenses are discounted proportionally from the sales. The profits are then divided according to the amounts and species of fishes captured by different fishermen. For team efforts the leader is responsible for paying the others according to the arrangements made with his partners.

The original proposal of the PCP was for fishermen of the Jarauá Sector to avoid capturing species which are prohibited by IBAMA bans and to capture fish only above legal minimum sizes. The idea was to divert fishing pressure toward species without capture restrictions and toward those for which there is no evidence of current overfishing (Bostock 1998). However, from the onset it became clear that only a few species, including pirarucu and tambaqui, were capable of generating sufficient profits to make the PCP an economically viable operation.

THE PROBLEMS OF *PIRARUCU* AND *TAMBAQUI*

Pirarucu is the most economically important species of fish for the residents and users of the RDSM (Queiroz and Sardinha 1999). It made up around 40% of the total weight of fish landed for sale and local consumption in the early 1990s. In six communities between 1993 and 1995, an average annual catch of between 1.4 and 1.6 tons was registered. On the basis of this information, the annual capture of pirarucu in the Focal Area of the reserve was estimated to be in the order of 110 to 150

tons. The production of pirarucu occurs mostly during the low-water months of September to December. Queiroz and Sardinha (1999) showed that only 30% of the landed pirarucu were larger than the legal minimum total length (TL) of 1.5 m. This shortfall indicated that the species was being exploited beyond a maximum sustainable yield in some parts of the Reserve.

These studies led to the establishment of pirarucu fishing guidelines in the reserve's management plan (SCM 1996). The closed season and minimum capture size follow those established by federal legislation (IBAMA decrees 480/1991 and 8/1996). However, other guidelines imposed by IDSM were more restrictive. IBAMA decree 14-N/1993 established legal minimum sizes for the salted and sun-dried flanks (*mantas*) off pirarucu at 1 meter, effectively allowing the landing and commercialization of pirarucu well below 1.5 m TL. Instead, the Mamirauá management plan set limits of 1.15 m for salted and dried mantas and 1.25 m for fresh mantas. Given the economic importance of pirarucu, these restrictions on the commercialization of mantas were predictably unpopular with the reserve's residents and created some animosity towards the IDSM. Nonetheless, they were considered necessary to regulate pirarucu fishing, along with other measures proposed by reserve residents and users. These measures included a minimum gill net mesh size for pirarucu fishing (29 cm measured across opposed angles) and the prohibition of fishing soon after the water level starts to drop, extending until the floodplain lakes become isolated.

From 1996 onwards the IBAMA representation in Amazonas declared pirarucu stocks to be in a critical stage of overexploitation and established a two-year statewide ban on the capture and commercialization of this species. This ban was enacted by prohibiting fishing from June through November because a 1996 decree by the IBAMA head office in Brasília had already banned fishing from December through May every year throughout the Amazon basin (a period that roughly corresponds to the species reproductive season). So far this statewide suspension of pirarucu fishing has been renewed twice without interruption, and there are no indications that it will be lifted in the near future.

The ban ruled out the possibility of legal pirarucu fishing within the RDSM, in principle resulting in a potentially significant decline in income for the resident communities. Tambaqui fishing is still permitted by IBAMA, with a minimum landing size of 55 cm TL (IBAMA decree 8/1996) and a closed season, which lasts from three to four months and varies in exact dates from year to year (IBAMA decrees 6/1996 and 142/2001). The minimum size of 55 cm TL drastically complicates the capture of tambaqui in the reserve. Tambaqui spend the first five years or so of their life in floodplain lakes and forests and then, as adults (above around 55 cm TL) undertake upstream migrations along main whitewater river channels (Goulding 1979; Costa, Barthem, and Correa 1999). Only around 5% of the tambaquis in the floodplain lakes of the RDSM are larger than the legal minimum size of 55 cm TL (Costa, Barthem, and Correa 1999).

RESOLVING THE PROBLEM OF *PIRARUCU*

From the onset of the PCP the biggest difficulty was related to the restrictions placed on the species with highest commercial value. The participating fishermen made it clear that the initiative would not generate financial returns unless pirarucus were involved. A monitoring system was implemented in early 1998 with the objectives of evaluating local fish production and identifying alternative species for extraction. The first results made it clear that the fishermen were right. Without pirarucu and tambaqui the yields of other species when weighed against production expenses would not generate profits.

The IBAMA decrees banning pirarucu since 1996 do allow for the controlled capture and commercialization of the species provided that they derive from bone fide managed fisheries. The PCP therefore proposed a system of managed pirarucu extraction involving a rotation system in thirty-one of the eighty lakes in the sustainable use zone of the Jarauá Sector. This proposal, requesting an initial quota of 3 tons of pirarucu for the late 1999 season, was submitted to IBAMA-Amazonas and accepted in June 1999. The quota was based on a previously published estimate of pirarucu production in várzeas of the Peruvian Amazon at around 0.3 kg/ha/year (Bayley et al. 1992). The Jarauá Sector comprises 56,300 ha of floodplain lakes and forests, allowing a crude production estimate of around 15 tons/year of pirarucu in the sector (assuming that the area is under low-fishing pressure). Considering an average weight of 40 to 50 kg for a 1.55 m pirarucu, this production corresponds to an annual harvest of 375 fish. The quota was set at a conservative one-third of this number in order to err on the side of caution during the beginning of this program and to review the results thereafter.

The first year's quota of 3 tons was significantly below the previous levels of pirarucu fishing in the Jarauá Sector. Monitoring data in the peak production months of September to December 1998 showed a total landing of around 600 pirarucu (12 tons of mantas), of which at least 95% were below the legal minimum length of 1.5 m. We later learned from the fishermen themselves that the number was actually higher, maybe around eighteen to twenty tons of mantas, because the fishermen smuggled part of the production. Of course, due to the continuing IBAMA ban on pirarucu fishing, all these fish were illegally captured, including those above the minimum size. Even though the 3-ton quota was well below previous harvesting levels, the fishermen of the Jarauá Sector were satisfied to reduce production and to follow all of the RDSM fisheries guidelines in return for being able to sell IBAMA certified legal pirarucu and to avoid intermediary purchasers.

In the PCP's second year (late 2000 season), a new tool became available to monitor pirarucu stocks. This tool was a direct counting method conducted as a collaboration between local pirarucu fishermen and a researcher from IDSM (Castello in press). Pirarucu are obligatory air breathers and betray their presence to fishermen when they rise to gulp air from the surface. Using a combination of

auditory and visual cues, experienced fishermen are able to distinguish between several fish surfacing at the same time and are able even to estimate the approximate size of the fish. These abilities, when used in the context of quantitative methods, yield replicable information about pirarucu numbers in floodplain lakes. This direct count methodology was compared to independent estimates of pirarucu population sizes from mark-release-recapture studies in floodplain lakes (at low water) and proved to be very accurate for fish larger than 1 m TL (Castello in press). Once the accuracy of this method had been established, it was then employed to monitor pirarucu stocks and to calculate sustainable landing quotas in the Jarauá Sector.

POLITICAL INTEGRATION OF THE PCP IN THE JARAUÁ SECTOR

Each organizational sector of the RDSM operates as a separate entity with its own local coordinator responsible for organizing bimonthly meetings. These meetings provide a forum to discuss and resolve community-related issues and disputes. This organizational structure is modeled on the rural community projects of the Catholic Church. Working at the sector instead of community level helped to distribute the benefits of the PCP to more people and also to increase the number of people trained to undertake duties for the PCP. In the beginning management was set up in an informal manner and consisted of a technical coordinator (held by an IDSM technician) and a community coordinator (elected by the participating fishermen). A formal terms-of-agreement document was drafted in which the fishermen agreed to support the PCP work by maintaining the infrastructure (boat and floating fish processing base), guarding the lakes selected for rotation, and enforcing the rotation system. The final, formal, organizational structure and the necessary delegations of responsibility were left for the fishermen to develop.

As the discussions evolved, the communities opted to register the PCP as part of a formal production association (Associação de Produtores do Setor Jarauá), marketing not just fish but also agricultural produce and artisanal products, such as pottery and basketwork. A decision was made to extend the PCP infrastructure to the storage and transport of agricultural and artisanal products. The formation of a production association also allowed the formal inclusion of women. The presence of women was significant from the administrative point of view because it increased the possibility of finding people with skills to assume such tasks as record keeping and accounting. Most fishermen are illiterate, whereas literacy rates are higher among women. By the time the production association was formally registered in July 2001, the associates had already assumed most of the administrative and technical duties originally assumed by extension workers and community assistants from IDSM. Several women were elected to administrative posts, among them secretary and accountant. Currently, technicians from IDSM support the association mainly by establishing contacts with fish buyers outside Tefé (because of communication difficulties from the RDSM).

The legal registration of the production association permits marketing outside the state of Amazonas. In 2001 a contract was signed to supply a chain of restaurants in Brasilia with a major part of the annual pirarucu quota at an excellent price of 8.00 Brazilian Reais (R$) per kilo (exchange rate in 2001 was approximately $US 1 = R$ 2.3–2.7). The restaurant chain in turn was able to provide its customers with environmentally friendly pirarucu purchased legally and derived from managed fisheries in an area protected for biodiversity conservation.

ECONOMIC, SOCIAL, AND ECOLOGICAL RESULTS

The results of the PCP's first three years of operation have proven very satisfactory from the economic, social, and ecological points of view (table 9.1). In 1999 most of the harvested pirarucu were sold in Tefé. For the first batch of fish brought from the RDSM to Tefé in 1999, the possibility of sending the fish by passenger boat for sale in Manaus was investigated. However, the sale price would not have justified the expenses (freight costs and expenses for somebody to accompany the produce to its final destination). At that time it was impossible to find a buyer in Manaus who was willing to pay a premium for legally commercialized pirarucu. The trade in illegal pirarucu has continued more or less unabated throughout Amazonas state despite the IBAMA 1996 ban on commercialization. IBAMA enforcement of this ban has completely failed and most traders are not in the least bit worried about breaking the law.

In 1999 400 kg of pirarucu from the PCP were sold to a food processing company in Manaus at R$ 4.00/kg. The rest was sold in Tefé via an intermediary who agreed to pay the going rate for Manaus (R$ 3.00–3.40/kg). The food processing company in Manaus placed another order, but by the time it was received, the an-

TABLE 9.1 Production Statistics for the First Three Years of Operation of the Fisheries Commercialization Program of the Jarauá Sector, Mamirauá Sustainable Development Reserve

	1999	2000	2001
Number of participating fishermen	42	46	67
Number of species commercialized	7	13	12
Total production (tons)	6.2	9.9	15.0
Pirarucu production (tons)	3.0	3.5	5.3
Average sale price for pirarucu (R$/kg)	3.85	6.00	7.96
Total sales (R$)	16,903	29,209	56,687
Mean income per fisherman (R$)	402	635	846

Note: Data refer only to the three-month production season of late September through early December (including trimester incomes). Exchange rates for US$1 are approximately: 1999 (R$1.6–2.0), 2000 (R$1.7–2.3), 2001 (R$2.3–2.7).

TABLE 9.2 Total Capture (TC, in kg) and Average Sale Price (ASP, in R$) for the Fish Species Commercialized by PCP from 1999 through 2001

		1999		2000		2001	
SPECIES	SCIENTIFIC NAME	TC (kg)	ASP (R$)	TC (kg)	ASP (R$)	TC (kg)	ASP (R$)
Pirarucu	*Arapaima gigas*	3000.0	3.60	3377.0	6.00	5285.0	7.96
Aruanã	*Osteoglossum bicirrhosum*	—	—	1042.0	0.22	4380.0	0.46
Tambaqui	*Colossoma macropomum*	2166.6	2.34	2524.0	2.07	2921.00	2.87
Pirapitinga	*Piaractus brachypomus*	—	—	—	—	40.0	1.00
Caparari	*Pseudoplatystoma tigrinum*	73.4	1.89	754.8	1.92	401.0	2.33
Surubim	*Pseudoplatystoma fasciatum*	—	—	30.5	1.46	5.0	0.60
Dourada	*Brachyplatystoma flavicans*	—	—	217.5	1.39	96.0	2.15
Filhote	*Brachyplatystoma filamentosum*	—	—	219.0	1.44	551.5	2.43
Pirarara	*Phractocephalus hemiliopterus*	—	—	116.0	0.71	211.0	0.56
Pacamum	*Paulicea lutkeni*	—	—	21.0	0.85	—	—
Pescada	*Plagiocion squamosissimus*	11.5	0.85	—	—	2.0	0.80
Tucunaré	*Cichla monoculus*	879.0	0.92	1188.5	0.93	565.0	2.19
Acará-açu	*Astronotus ocellatus*	84.0	1.00	230.5	0.52	586.0	0.64
Acará-branco	*Chaetobranchus flavescens*	—	—	84.5	0.69	—	—

nual quota of 3 tons had already been reached. The next year, with a renewal of IBAMA authorization for PCP pirarucu landings, the same company purchased the entire PCP quota of pirarucu at R$ 6.00/kg. The other species captured in 1999 and 2000 were sold mostly in Tefé. The complete list of fish species exploited by PCP is presented in table 9.2.

Socioeconomic monitoring in one of the communities of the Jarauá Sector, São Raimundo do Jarauá, showed that, despite the restrictions in fishing (all fishes were captured in accordance with minimum size regulations and closed seasons established by law and by the Mamirauá Management Plan) and despite the overall reduction in pirarucu landings, there was no attendant reduction in annual family incomes. On the contrary, average family incomes increased from around R$ 1,900 in 1995 to R$ 2,700 in 1998/1999 and to R$ 4,100 in 2000. Using as a reference point a *cesta básica* (a standardized shopping basket of household supplies used by Brazilian social scientists for economic surveys), the buying power of São Raimundo do Jarauá doubled from 1995 to 2000 (table 9.3). Unfortunately, due to the way the data were collected, it was not possible to calculate the proportion of the annual wage derived from fishing. However, we believe that the contribution of fishing was significant because no other major revenue-generating activity was introduced in Jarauá during this period.

All fish commercialized by the PCP were above the legal minimum size limits

TABLE 9.3 Mean Annual Family Incomes from a Socioeconomic Monitoring Survey at the Community of São Raimundo do Jarauá

	1994–95	1998–99	2000
Number of families	16	20	19
Mean annual family income (R$)	1,939	2,721	4,142
Cost of a *cesta básica* (R$)	43.68	44.14	46.98
Buying power (number of *cestas básicas*)	44	61	88

Source: Edila Moura

TABLE 9.4 Mean Total Lengths (TL) for Species Exploited by the PCP for Which Size Limits Have Been Established by IBAMA

SPECIES (MINIMUM TL)	1999	2000	2001
	Mean ± SD (n)	Mean ± SD (n)	Mean ± SD (n)
Pirarucu (150 cm)	162.9 ± 21.5 (126)	157.8 ± 10.3 (143)	165.8 ± 13.4 (188)
Tambaqui (55 cm)	61.3 ± 5.1 (455)	59.2 ± 4.0 (610)	63.4 ± 4.6 (582)
Caparari (80 cm)	89.5 ± 8.4 (12)	86.5 ± 6.8 (147)	88.0 ± 8.4 (69)
Surubim (80 cm)	—	86.0 ± 9.4 (6)	85.8 ± 7.0 (5)
Aruanã (44 cm)	—	—	68.1 ± 4.9 (495)
Tucunaré (25 cm)	—	—	36.4 ± 3.0 (134)

Note: TLs for pirarucu were estimated from lengths of filleted flanks.

established by IBAMA (table 9.4). These sizes contrast with the situation immediately before the PCP project began when 95% of landed pirarucu from the Jarauá sector were below the legal size limit (fig. 9.2). There was also an encouraging increase in the diversity of commercialized species (table 9.1), indicating that fishermen were beginning to divert fishing efforts toward previously underexploited species (table 9.2).

Stock assessments in the sustainable use zone of the Jarauá Sector showed a 300% increase in the number of pirarucu between 1999 and 2001 (table 9.5). These assessments utilized the direct count methods described earlier (Castello in press) and discriminated between juvenile fish (1 to 1.5 m TL) and adult fish (1.5 m TL). The number of adult pirarucu counted in the 1999 stock census was used to calculate the quota submitted to IBAMA-Amazonas for the subsequent low-water season of 2000. The requested quota represented the removal of approximately 30% of the number of adults counted. This percentage corresponded to a total of 3 tons of mantas, or around 120 adult fish (assuming a mean capture size of 1.55 m, 40 to 50 kg of total weight per fish, and 20 to 25 kg of saleable meat per fish). A stock census

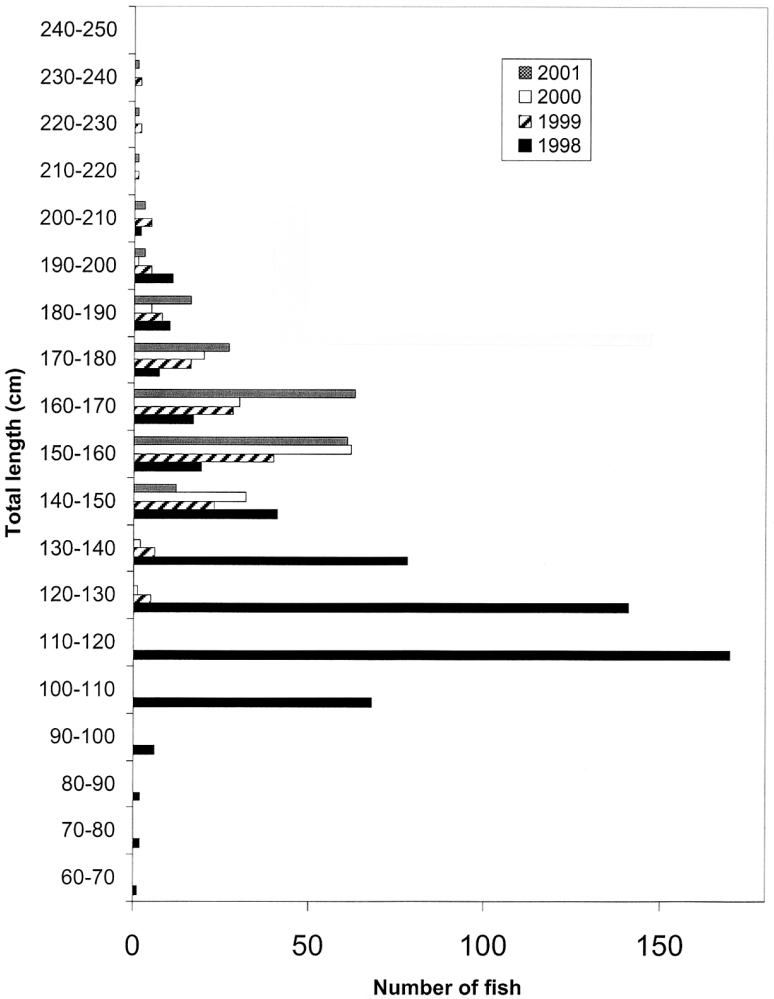

FIGURE 9.2 Histogram of size classes for pirarucu captured by communities in the Jarauá Sector of the Mamirauá Sustainable Development Reserve in the low water periods (September through December) of 1998–2001.

(based on the same methodology) in the low-water season of 2000 was used to plan the quota for the subsequent harvest in 2001. For 2001 a quota of 8 tons, corresponding to around 300 fishes, was submitted to IBAMA.

Before the 2001 season began, the fishermen proposed to relax the lake rotation system rules in favor of choosing lakes on a year-to-year basis. Fishing and access conditions to any given lake vary considerably from year to year, making it difficult to stick to a rigid schedule. In fact, some lakes are almost impossible to enter during very dry low-water periods. Such was the rate of increase of pirarucu stocks in

TABLE 9.5 Estimates of the Number of Pirarucu in Floodplain Lakes of the Jarauá Sector of the Mamirauá Sustainable Development Reserve from 1999 to 2001

YEAR	JUVENILES (1–1.5 M)	ADULTS (> 1.5 M)	TOTAL
1999	2,149	358	2,507
2000	2,984	994	3,978
2001	5,901	1,441	7,342

Note: Data from censuses involving a new direct counting technique (see text).

the sector that the fishermen thought it might be possible to capture the established quotas by fishing in the floodplain channels alone and without ever needing to enter the lakes. IBAMA agreed with the changes in management but unjustifiably refused to allow an increase in the pirarucu quota to the 8 tons requested for the 2001 low-water season; the quota was based upon the pirarucu stock assessment method. Instead, only 5 tons was granted. This tonnage corresponded to around 200 adult pirarucu.

In contrast to previous years, the IBAMA harvesting permit for 2001 established not only a quota for the total weight of mantas but also a limit to the total number of fish that could be landed. This alteration in the proceedings resulted in considerable changes in the way in which fishing was organized in 2001. On the basis of the numbers of fish, the pirarucu quota became more concrete and manageable. It began to be treated as a share and split among the associates according to specific rules. Also, each shareholder tried to make the best use of his share.

In 1999, the first pirarucu fishing season, no criteria were established by the PCP members for the distribution of pirarucu quotas. Those fishermen who benefited most were the best equipped (in terms of canoes, ice boxes, and tackle) and those with cash to finance fishing trips. In 2000 the PCP members decided to divide equitably the total pirarucu quota among the four communities, taking into account the number of fishermen in each community. In 2001, with the production association already legally registered, criteria were established by the directors to distribute the fish to associates according to their relative contribution to the different aspects of management required to sustain the fishery. These contributions included participation in lake-vigilance excursions, respecting the fishing rules (such as minimum sizes and closed seasons), and participating in meetings. The production association leaders viewed these criteria as a way to increase the number of people involved in fisheries management. During an open meeting the distribution of the quota (in numbers of pirarucus instead of weight) was then established at between zero and three fish per associate.

This new system of quota distribution was well received by the associates and is

expected to be maintained for the future. The results from 2001 demonstrate that each fisherman made the best of the quota he received by selecting and culling larger fishes that would give a better financial return. The average pirarucu yielded 28.2 kg of mantas in 2001, as compared with 23.8 kg in 1999 and 24.5 kg in 2000. The average size of captured pirarucu reached 1.6 m in 2001 (fig. 9.2), its highest level since the onset of the PCP.

FINAL CONSIDERATIONS

In just three years of operation, the Fish Commercialization Program of the Jarauá Sector has proven to be a viable model for the management of várzea fisheries. During this time many operational problems were identified and resolved. One of the greatest sources of difficulties was the complex infrastructure and the maintenance of a boat. For example, the Port Authority requires specific training for boat crews, including at least one skipper and one mechanic. Four fishermen volunteered to take the required courses offered by the navy and gained the necessary diplomas and documents. Another problem was that the administrative affairs of the PCP require the dedicated full-time attention of at least two people. The association consequently provided two salaried positions for two organizers and paid a salary from R$ 150 to 250 per month (depending upon the number of active fishermen since each contributed with a share of R$ 5 to make up the salary). In the end a small number of people assumed multiple tasks, including administration, boat piloting, and participating in sales trips. In the future more people are expected to become involved and the workload to be spread more comfortably.

Administrative delays at IBAMA proved to be one of the greatest sources of difficulties in the development of the Jarauá PCP. Large amounts of complex paperwork attended almost every stage of the proceedings and the resulting permits and documents were sometimes issued late. In 2001, for example, IBAMA permits for capture and commercialization of pirarucu arrived at the end of October, already two months into the low-water fishing season. This delay left only one month for the fishing quotas to be met, in contrast to the two to three months of the previous two years. The short fishing season made it impossible for the association to meet the quota, and only 188 of the 200 authorized pirarucu were caught.

The most important contribution of this experimental Fisheries Commercialization Program is that it proves the feasibility of exploiting high-value species at good prices while at the same time allowing stocks to increase through a program of combined management, vigilance, and monitoring. The community-based production association was able to manage its own affairs with initial—and thereafter occasional—technical assistance from the outside, demonstrating that communities can incorporate new systems and build upon them.

The general model developed in Jarauá may be a powerful tool for the management and conservation of fishery resources in other parts of the Amazon basin. The direct counting method for assessing pirarucu stocks was also considered to be vital

to the success of this program. This tool represents the integration of traditional knowledge with scientific methodology, and helped tremendously with the introduction of fisheries management principles to the communities. This method is already being successfully taught to fishermen from other areas of the Amazon basin, such as the Santarém region in the Brazilian state of Pará, the Pacaya-Samiria National Reserve in Peru and Guyana. In fact, it is currently under consideration by the Guyanese government as a tool in the country's strategy to promote the recovery and sustainable use of the pirarucu stocks.

The positive results of the PCP in the Jarauá Sector have attracted much interest from fishermen in other sectors of the Mamirauá Reserve and of the adjacent 2.3 million-ha Amanã Sustainable Development Reserve. Several communities of these other areas have requested technical assistance to develop similar programs. Nonetheless, the PCP system in the Jarauá Sector was expensive to set up and took a long time to be implemented by and integrated with the communities. We conclude that the ideal solution would be to implement similar but less complex, low-cost systems adapted to local ecological and socioeconomic conditions. These initiatives could, for example, rely on hiring boats for the transport of fish rather than investing in the purchase and maintenance of vessels. Replicating simplified and less expensive systems based upon the Jarauá model of fisheries production and management would allow more communities to benefit in a shorter time frame.

In 2001 a simpler fisheries production program was initiated in the Tijuaca Sector of the Mamirauá Reserve. The initial results were promising, but delays in the liberation of IBAMA capture and commercialization permits for pirarucu meant that in its first year of operation the Tijuaca PCP only had time to land 40 of a total quota of 120 pirarucus before the season closed. In 2002 two other simplified programs will be launched, one targeting the Fishermens Association of the nearby town of Maraã (around 160 members) and the other assisting the seven communities in the Coraci Sector of the Amanã Reserve (benefiting around 400 people). Both projects have been submitted to IBAMA and are currently being appraised.

Since 2001 IBAMA-Amazonas streamlined its internal procedures. The permits for the Jarauá sectors (500 pirarucus or approximately 15 tons of mantas) and Tijuaca (120 pirarucus or approximately 3 tons of mantas), with the full quotas requested by the fishermen through the stock assessment method, were issued in late June 2002. We expect that the results for Maraã and Coraci projects (120 pirarucus each) will be out well before the beginning of the fishing season, allowing time for the fishermen to plan ahead for their first pirarucu management experience.

The Jarauá fisheries management system, which began in 1999 with merely 3 tons of pirarucu, is now ready to harvest 15 tons of legally caught and sized fish. On the basis of ongoing monitoring of pirarucu stocks, we expect that the total production of the four ongoing systems will double next year. This significant increase is expected because only a fraction of the full potential of the Maraã and Coraci systems will be harvested this year. On the basis of the direct counting method, the fishermen from Maraã, for example, could start harvesting 400 fish in the first year.

However, they preferred to begin on a smaller scale and review the situation afterwards. In the case of Coraci the first quota was based on a stock assessment survey using the direct count method in a representative subset of the available lakes made two years ago. After this survey, and in the expectation of having a pirarucu management system for this area, the fishermen decided to completely ban fishing for commercialization purposes. They wanted pirarucu stocks to recover and to start harvesting them in a different, sustainable manner. In a four to five year time frame and with the addition of new community fisheries management systems, we expect that the total production of wild pirarucu in the Mamirauá and Amanã reserves will reach 100 to 150 tons per year.

Today, the Mamirauá Institute is working on the development of a large-scale model for the implementation of this new generation of simplified community-based fisheries management programs around the várzeas of the Brazilian Amazon. Simplicity, technical practicability, and the ability to mould new initiatives around preexisting local conditions are fundamental principles for the successful planning and implementation of such initiatives. The role of technicians will be mostly limited to training fishermen in procedures for stock assessment (for pirarucu and other species), methods for setting quotas, basic management principles, fish processing techniques, and association management. The commercialization of the harvests, and the day-to-day running of production associations will be the responsibility of the associates themselves. Due to communication difficulties, communities at great distances from markets are placed at a considerable disadvantage in establishing commercial contacts. These cases would probably need the intervention of technicians from such organizations as IDSM. Likewise, the technical reports required from community fisheries programs by IBAMA would probably need to be compiled by experienced fisheries technicians for most communities.

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10

Community Ownership and Live Shearing of Vicuñas in Peru

EVALUATING MANAGEMENT STRATEGIES AND THEIR SUSTAINABILITY

CATHERINE T. SAHLEY, JORGE TORRES VARGAS, AND JESÚS SÁNCHEZ VALDIVIA

In 1994, after years of being listed under Appendix I of the CITES convention, vicuña (*Vicugna vicugna*: Camelidae) populations in Peru were reclassified as an Appendix II species. Under this classification Peru obtained permission to export fiber from animals captured in their wild state, partially shorn, and then released. In 1995 the Peruvian government passed Law # 26496, "System of regulation of property, commercialization and sanctions for the hunting of vicuñas, guanacos, and their hybrids." The purpose of the law was to give Andean *campesinos* a direct interest in the conservation of the vicuña and to motivate them to participate in conservation efforts. This law includes the following components:

1. It gives usufruct rights of vicuñas to communities if such animals are found within community boundaries and also the rights to a portion of profits from the sale of vicuña fiber
2. It gives the communities the responsibility of management and "rational" use of the vicuña
3. It enacts legal penalties for poaching that range from two to twenty-five years imprisonment, depending on the gravity of the crime committed (El Peruano, July 11, 1995).

This law represents a new focus for conservation efforts of the vicuña in Peru. *Campesino* communities are legally recognized entities, which by and large, are made up of Andean indigenous peoples. As of 1998, 5,666 campesino communities were legally registered, and 3,956 have legal title to their land (Velasquez 2001). With the granting of exclusive usufruct and management rights to communities, the vicuña has in effect ceased to be a totally public resource. The capture, live-shearing, and release program (called the *chaku* in Quechua) offers many possibilities for the sustainable utilization of the vicuña in Peru and other South American

countries. However, many aspects of the current management program need to be carefully evaluated, and an urgent need exists for studies that generate information on the biological and economic costs and benefits of the program.

In the present article we review the most common management systems that are being utilized in Peru and examine the results of the program in terms of fiber harvests and economic gain. We also present data obtained for the communities of Tambo Cañahuas, and Toccra in Arequipa, Peru, with the objective of highlighting some of the current limitations of the management program. Finally, we present some conclusions and recommendations regarding the implementation of the live-shearing program in Peru.

BACKGROUND

PRESENT MANAGEMENT PLANS

Several management plans proposed by the government are currently being implemented. The first is the capture, live-shearing, and release program of free-ranging vicuñas; a program that has been approved by CITES. Once a year, each community implements the capture/live-shearing/release activity that should occur between May and November. The actual scheduling of the chaku varies greatly among communities and is influenced by a variety of factors, such as community activities that may or may not conflict with optimal capture dates, logistic constraints regarding the availability of appropriate capture equipment, and the organizational capacity of each community.

The primary method utilized for the live capture and shearing of vicuñas is the use of a temporary capture corral made of fishnetting 2 m in height. Community members hide behind bushes or in trenches and run behind the vicuñas carrying a colorfully flagged rope once the vicuñas have entered the capture zone. The vicuñas try to escape but are hampered by the funnel-shaped capture area. Finally, if the roundup is successful, the vicuñas are herded into a smaller mesh-shaped corral from which they cannot escape. They are then captured by hand, shorn (either with scissors or electric shears), and released.

The second plan, which is being pursued aggressively by the state and its extension workers, is the capture of vicuñas in the wild, followed by their subsequent transfer to corrals that are generally 500-1000 ha in size. The size of corrals varies, and currently, there are no published standards about management requirements of vicuñas that are kept in corrals. A third plan consists of a repopulation program, wherein animals caught in more populated areas are transferred to communities that have few vicuñas. These animals are not released but are maintained in corrals.

All participating communities are required to formally organize vicuña management committees and to register with the government in order to participate in the fiber-shearing and marketing program. They are also required to organize an-

tipoaching patrols, reinvesting a portion of proceeds from the sale of fiber to this end.

POTENTIAL COSTS AND BENEFITS OF THE CURRENT MANAGEMENT PLANS

Some concerns have been expressed about the techniques employed (Bonacic 1996; Wheeler and Hoces 1997), especially regarding the levels of stress experienced by the animals and its effect on their subsequent well-being. Few data exist on the effect of capture and shearing on rates of mortality, fertility, and social structure of vicuñas in the wild. Bonacic (1996) studied levels of stress in animals captured and shorn in Chile. Working only with males and following them for eight days in captivity, he showed that capture increased cortisol secretion for two days but that, in and of itself, stress from capture did not contribute directly to vicuña mortality. Instead, Bonacic's 1996 results suggest that perhaps a more important factor affecting mortality is lowered body temperature because of shearing, which leads to decreased immunological response. His data show that total and partial body shearing caused respiratory disease in some cases, with completely shorn animals suffering higher mortality than partially shorn animals. Captured, but not shorn, animals did not suffer any mortality during the study.

Bonacic's work highlights the importance of including physiological stress as one factor in vicuña management plans. Stress could be especially important for pregnant females, which in many cases are gestating and lactating at the same time and have high energetic requirements. Thus, time of year and climate is likely an important factor to consider when scheduling shearing. Presently in Peru the capture and shearing of vicuñas starts in winter (June) and continues until spring (November). This long shearing season is due to the lack of sufficient capture netting, which necessitates preparing a timetable for transporting and sharing equipment.

Since the widespread commercial exportation of fiber products began in 1995, management of the vicuñas has moved in the direction of animal husbandry proposals and projects to the detriment of investment in wildlife management initiatives. In 1996 a new management proposal was devised via an agreement between the National Breeders Society, the Ministry of Agriculture, and CONACS (Consejo Nacional de Camelidos Sudamericanos, or the National Council for South American Camelids). This proposal, "Convenio de Coóperacion Interinstitucional Para el Uso Sustentable de la Vicuña," significantly changed the scope of the free-ranging/capture/live-shear program previously in place. It outlined a new Ministry of Agriculture project, Programa de fortalecimiento de la competitividad comunal en la crianza de vicuñas (Program to strengthen community competitiveness in the breeding and care of vicuñas).

One of the major premises of this program was that "sustainable use modules", or large corrals, were more efficient, productive, and profitable than the free-ranging program currently in place. Furthermore, the proposal stated that the use of

corrals constitutes the "best alternative for the rational management of the species". The specific objectives of the program call for: (a) protection and conservation of the vicuña (no reference is made to wild vicuñas), (a) reintroduction of vicuñas into appropriate habitats, (c) production of fiber from live-shorn animals, (d) legal commercialization of fiber, and (e) generation of a productive activity for Andean campesinos. The state has been actively promoting these management alternatives and is implementing them on a wide scale throughout Peru.

The program called for the implementation of corrals in 600 campesino communities by the year 2000 (Ministerio de Agricultura 1997), a task that has been completed for approximately 260 communities (Hoces 2000). It has been estimated that 250 vicuñas are needed for the corral scheme to be economically viable; an economically viable system would therefore require 150,000 vicuñas to be in what is euphemistically called semicaptive management, a number that has not been reached because it is greater than the current population of vicuñas in Peru. This program, unfortunately, completely neglects the management of free-ranging vicuñas. In fact, no free-ranging management plan currently exists in Peru.

The plan's assumption that the so-called sustainable use modules are more efficient, productive, and profitable was untested at the time that the program was implemented on a national level. Unfortunately, although under certain well-defined circumstances it could be argued that corrals might be necessary for vicuña management, the implementation of this program has caused confusion regarding appropriate management practices. It can be argued that implementation of this program has been detrimental in some respects to the overall conservation program of the vicuña in Peru. For example, the implementation of corrals to date has cost Andean communities approximately US$ 2,500,000.00, while little has been spent on strengthening antipoaching efforts, which has been one of the primary concerns of campesino communities in Peru (Sociedad Nacional de la Vicuña 2000). It is evident that a coherent management plan must be formulated to maintain viable wild populations of vicuñas in Peru and that at present the term sustainable use modules has led to confusion about what sustainable use of the vicuña means, both at the professional and the community level.

The maintenance of vicuñas in large corrals has been the least studied option from both technical and socioeconomic perspectives. Initially, this modality was proposed by the state to facilitate monitoring of vicuñas and consequently to lower rates of poaching. Another presumed advantage is greater capture efficiency and consequently greater economic benefits for campesinos (Zuñiga 1997).

This option has an initial economic disadvantage because it requires an upfront high capital investment; each corral costs $23,000.00, not including labor, which campesinos provide for free. For many communities this quantity is more than the income received from the sale of vicuña fiber. Communities with few vicuñas that become involved in this program become immediately indebted to the state. A cost-benefit analysis conducted by Lichtenstein et al. (in press) compared two communities that utilized free-range management with two communities that utilized

semicaptive management. By the time the study ended, the two communities that utilized semicaptive management had not received any short-term benefits, and long-term benefits were considered low income and high risk. In contrast, the two communities that utilized free-range animals had received cash that was used for community improvement projects. Lichtenstein et al. (in press) concluded that management of free-ranging vicuñas, while being a moderately high-risk venture, also had high chances of being profitable.

Biological impacts of maintaining vicuñas in corrals or in semicaptive management can be significant, both in the short and long term. By increasing densities within fenced-in areas, reproductive rates can decrease if there are density-dependent effects. Also, an increase in density can facilitate the transfer of disease and parasite load. An immediate effect is change in dispersal behavior and movement patterns, changes that can ultimately influence genetic structure at the metapopulation level as well as for animals within corrals.

As for the repopulation program, which could arguably be socially, economically, and biologically necessary, Wheeler et al. (2000) have identified four genetically distinct populations of vicuñas within Peru. They recommend caution with regards to the repopulation program, and suggest that repopulation efforts occur within the four distinct sub-populations. They also recommend caution regarding corrals and the potential for inbreeding effects. From a population dynamics perspective, if no interaction is permitted between vicuñas in the wild and vicuñas placed in corrals , these animals may as well have been harvested from the population. If too many animals from a wild population are placed within corrals, these de facto harvests may be unsustainable (Sahley 2000; see table 10.1).

Another factor is that animals within corrals may receive more vigilance and attention than animals left in the wild, thus putting animals in the wild at greater risk for poaching. Because emphasis is placed on shearing animals within corrals because of purportedly increased efficiency, free-ranging vicuñas may not be shorn. Shearing vicuñas has been proposed as a disincentive to poachers. In fact, the original motto surrounding the vicuña management program has been "a vicuña sheared is a vicuña saved."

An additional concern is that animals in semicaptive management may be more susceptible to predators (Sociedad Nacional de la Vicuña 2000). This may not only jeopardize vicuñas within the corrals but also create negative attitudes toward predators, such as the puma (predator control for vicuñas in corrals was a concern voiced by several campesino delegates at the SNV 2000 conference). Further, at the interface between the vicuña and its habitat, the removal of animals from the wild and into the corrals has immediate effects on the interaction of vicuñas and the landscape of the Andean puna.

Finally, no standards exist as to management of vicuñas within corrals. For example, animals in the "repopulation program" currently do not undergo quarantine before they are transferred to less populated areas. While in the short-term corrals for repopulation programs could be justified, in the long-term, if animals are

TABLE 10.1 Vicuña Census Data for Animals Within and Outside of Corrals, as Well as Fiber Production for the Year 1999

COMMUNITY	DISTRICT	PROVINCE	VICUÑAS WITHIN CORRAL	VICUÑAS OUTSIDE CORRAL	FIBER PRODUCTION 1999	INCOME GENERATED
San Juan de Tarucani	S. J. Tarucani	Arequipa	106	158	12.99	3,553.09
Salinas Huito	S. J. Tarucani	Arequipa	11	65	1.59	441.36
Tambo Cañahuas	Yanahuara	Arequipa	0	560	16.49	4,449.09
Toccra	Yanque	Caylloma	144	62	18.71	5,239.39
Total			261	845	49.79	13,682.93

Source: Data from CONACS (Consejo Nacional de Camelidos Sudamericanos)
Note: All communities are located within the National Salinas Aguada Blanca Reserve. The Toccra corral is located just outside the park border, which is a highway.

kept behind fences, these translocations cannot be considered legitimate reintroductions of the vicuña. Currently, no timetables are set for the eventual release of repopulated animals, and no conditions have been established for eventual releases into the wild should animals in semicaptive management reach carrying capacity within corrals. Extremely limited data exist on the biological effects corrals are having on vicuña populations.

STUDY AREA AND METHODS

We utilized information from CONACS, the governmental agency in charge of camelid management in Peru. We also utilized data and reports from the National Society of Vicuña Breeders, which represents the Andean communities and which is in charge of commercializing vicuña fiber and distributing profits.

Field data were obtained from within a 75-km^2 zone pertaining to the campesino community of Tambo Cañahuas, located within the boundaries of the Salinas-Aguada Blanca National Reserve in Arequipa, Peru. The study site is primarily a large plain surrounded by mountainous terrain. The area belongs to the subalpine, subtropical desert scrubland as defined by the Holdridge system (INRENA 1995). Data on habitat use, density, and fertility of vicuñas were obtained from the end of 1996 through 2000, using fixed-width repeated transects as well as opportunistic observation. When a vicuña was observed during a transect count, we noted activity, number of vicuñas, social group, and position of group or individual using GPS. In 1999 and 2000 wild-caught vicuñas were marked with plastic colored and numbered ear tags, which allowed us to identify animals by individual, age, and sex categories. Tagging caught and shorn animals allowed us to experimentally compare the effects of capture and shearing on female fertility with uncaptured and unshorn vicuñas. Additional data regarding community management of the vicuña were obtained during informal interviews with state officials and members of the community of Tambo Cañahuas, attendance at community meetings, regional meetings, workshops, and personal observations.

RESULTS

VICUÑA POPULATIONS, FIBER HARVESTS, AND PROFITS

Information obtained from CONACS (1996) indicates that at a national level, community interest in participating in the live-capture and shearing program is high. Since 1994 more than 300 communities registered with CONACS in order to participate. By 1996 more than 600 communities had formed conservation committees and registered with the government to participate in the program (fig. 10.1). This number has increased to approximately 780 communities and over 250,000 families (Sociedad Nacional de la Vicuña 2000). However, many communities are not yet participating because of a lack of infrastructure and organizational capacity.

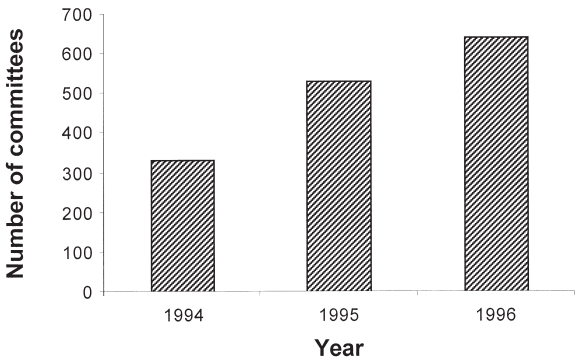

FIGURE 10.1 Formation of vicuña management committees, 1994–1996 (Data from CONACS).

The level of interest indicated by the formation of vicuña management committees and the animated and passionate debates at local and regional meetings (pers. obs.) is a positive development, especially given the participation of community members in the process of decision making and commercialization. However, the politics of vicuña management are still mainly organized in a top-down fashion, with the state maintaining a large influence in the decision making and implementation process. In addition, community interest does not necessarily lead to commercial success, as we shall see in the next section.

There is one question of extreme importance regarding the utilization of vicuña fiber by campesino communities: does giving communities a direct interest in conservation of the vicuña through economic incentives have a positive impact on vicuña populations? No published studies exist that show a direct link between fiber commercialization and vicuña conservation, although convincing circumstantial evidence exists. Government censuses conducted at a national level indicate a continuous increase in the vicuña population, even though a black market still exists for vicuña pelts (fig. 10.2). Nonetheless, a total of 30,391 vicuñas were shorn and contributed a total of 6.5 tons of fiber between 1994 and 1997, and by 1997 279 campesino communities had participated in the chaku (Hoces 2000; table 10.2).

Perhaps the most vexing problem is the economic and social sustainability of the current system, at least in the short term. Unlike hunting, vicuña capture requires capital investment and a high degree of community organization and technical skills for the monitoring, capture, and shearing of animals. For example, the approximate cost of a capture net is US$ 2,700 (Wheeler and Hoces 1997). Communities must first program the dates of the chaku in a regional assembly, and thereafter community meetings need to be organized and held in order to plan the assembly of the capture nets, monitoring of vicuñas, and finally capture and shearing. In many communities, the ultimate limitation in this system is the low number

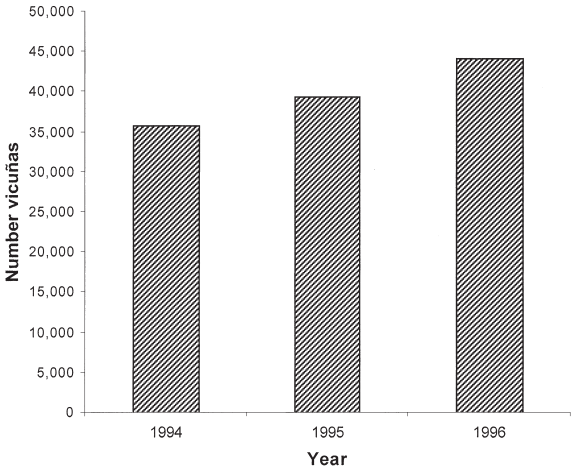

FIGURE 10.2 Government census data for vicuñas, 1994–1996. The same areas were not censused every year; therefore only those areas for which data were available in all years are included in the graph. Thus, this data represents a trend, not an actual total for Peru.

TABLE 10.2 Summary of Capture/Live-shear Fiber Production, 1994–1997

	TOTAL: 1994–1997			
DEPARTMENT	Captured Vicuñas	Shorn Vicuñas	Kg of Fiber	No. of Campesino Communities
Ayacucho	39,474	17,597	4,028.66	76
Arequipa	682	350	69.35	8
Apurimac	2,100	1,573	245.28	22
Cajamarca	95	52	13.00	1
Cusco	298	202	41.185	8
Huancavelica	744	517	112.20	12
Ica	1,018	657	125.80	7
Junin	3,396	2,442	466.54	15
Lima	2,208	1,552	362.278	24
Puno	10,118	5,449	1,076.94	106
Total	60,133	30,391	6,541.15	279

Source: CONACS (taken from Hoces 2000)

of vicuñas, which are still recuperating from several poaching cycles. Thelast of these cyles occurred in 1992–93, just prior to the vicuñas' downgrading to Appendix II in CITES.

Compounding the problems of low vicuña densities in many areas of the Peruvian Andes is the fact that fiber production per vicuña is low, with an average of 250 g/individual. Vicuña fiber grows so slowly that animals can be shorn only once every two years. At current prices (US$ 300.00/kg fiber) an average vicuña will produce, at best, US$ 42.00/year. Despite low fiber production, however, the price of vicuña fiber far exceeds that of the alpaca, another luxury fiber (which has an extremely low price of US$2.00/kg) and that of sheep, US$0.15/kg (prices correspond to those of 2001–2002). Thus, the addition of vicuña fiber as an additional economic option for Andean campesinos is significant. This benefit is real even if prices were to drop further, as might be expected when other Andean countries, Bolivia, Chile, and Argentina, enter the market.

Another limitation is the unequal distribution of vicuñas in Peru. The departments of Ayacucho, Lima, Puno, and Apurimac (INRENA 1994) have the highest populations of vicuñas, and these numbers have led to higher fiber production in these zones (table 10.2). Large differences exist in the production of fiber in different geographic localities, as well as the number of campesino communities involved. Compare, for example, the 4,028 kg of fiber harvested in Ayacucho in 1994–1997 with the 69 kg of fiber harvested in Arequipa. These differences in the production of fiber and income can affect power relations of the communities with respect to management and organizational methods at regional and national scales and will surely influence the attitudes of people toward vicuñas in different zones. Indeed, signs of such changes are apparent. In the year 2000 some representatives from the community of Lucanas in Ayacucho (an area of high vicuña density and fiber production) expressed their desire to commercialize their fiber independently from the SNV (Sociedad Nacional de la Vicuña 2000). The political ecology of community interaction and relationships with the fiber industry is one that merits additional attention.

TAMBO CAÑAHUAS, AND TOCCRA, AREQUIPA: A CASE STUDY

Human census data indicate that approximately 115 families inhabit the 50,000-ha, legally recognized communal territory of Tambo Cañahuas. Approximately 50% of the families dedicate themselves in large part to raising livestock, principally alpacas and llamas and, on a smaller scale, sheep (Torres 1998). Censuses indicate that within community lands there are approximately 400 vicuñas.

Once a year the community of Tambo Cañahuas plans and implements the chaku. The base price for fiber is approximately US$ 300.00 /kg, lower than the US$ 500.00 /kg offered by the International Vicuña Consortium in previous years. In addition to paying for capture nets, the community is also discounted the price for additional equipment, as well as 10% for the Vicuña Breeders Society (SNV).

The 10% discount for the Sociedad Nacional de la Vicuña goes to the regional delegates and contributes to their administrative and travel costs.

It is evident that, although the shearing program is generating income, the quantities currently received will probably not drastically change the economic conditions of the community. However, even a few thousand dollars per year distributed at the community level can make a difference in terms of financing small community-based projects or businesses (table 10.3). By the year 2000, for example, the town of Tambo Cañahuas had received enough income to pay for equipment costs and to purchase a large truck as an investment not only for vicuña-related necessities but also for use in other community-based enterprises. Because the town residents were able to capture and shear vicuñas in 1995, they perceived immediate economic benefits (although because of bureaucratic delays, they did not receive money for two years).

Thus, the live shearing of wild vicuñas produced short-term gains (small debt and immediate returns). These short-term gains will last as long as the community continues to capture and shear animals because data indicate that the capture and live-shearing process is biologically sustainable, and the population is growing (table 10.4). Although the actual income of the capture/shearing/release program is not high, it can cover the cost of capture equipment and provide a surplus within a short time frame. From the point of view of wildlife management, the capture/release program has the added benefit of maintaining populations of wild vicuñas. This maintenance is especially important in Tambo Cañahuas, which falls within a National Reserve, and has populations that are still recuperating from a severe poaching event in 1992–1993.

In the case of Tambo Cañahuas, which began shearing vicunas in 1995, a ten-

TABLE 10.3 Fiber Production and Projected Income for the Community of Tambo Cañahuas, Arequipa, Peru

YEAR	NO. ANIMALS CAPTURED	FIBER	PROJECTED INCOME (US$)[a]
1995	48	8.185 kg ($434.00/kg)	$2,863.82
1996[b]	21	5 kg ($434.00/kg)	$1,953.00
1997[b]	16	1.5 kg ($434.00/kg)	$650.00
1998[c]	0	0 ($300.00/kg)	$ 0.00
1999[c]	55	16.5 kg ($300.00/kg)	$4,449.09

Source: Data from CONACS (Consejo Nacional de Camelidos Sudamericanos)

[a]These figures do not add up if the price is US$ 300 or US$ 434, as per contract for clean fiber; thus the communities must have been discounted for not selling the fibers previously cleaned, or for another rule. There is a convoluted system of discounts during the processing of the gross fiber and the clean fiber to the final product, and the actual discounts are not made available to the community in the reports.

[b]Second lot

[c]Third lot

TABLE 10.4 Vicuña Census Data for Catchement Area, Tambo Cañahuas, Arequipa

YEAR	TOTAL NUMBER	λ	AVERAGE DENSITY/KM^2	NUMBER YOUNG	PROPORTION YOUNG-FEMALE
1997	187		2.8 (SE = 0.6)	38	0.48
1998	242	1.22	1.27 (SE = 0.24)	53	0.70
1999	264	1.09	2.8 (SE = 0.33)	35	0.33
2000	284	1.07	2.0 (SE = 0.20)	55	0.48

dency (table 10.3) toward diminished capture success and fiber harvests existed from 1996 to 1998. The reasons for diminished success are various. The decrease was not due to the reduction of vicuña populations from poaching or the shearing program. Census data indicate the population is increasing at an average rate of r = (0.14), which is within normal range of the species (Sanchez 1984; Cattan and Glade 1989).

Observations conducted since 1995 indicate that two significant factors were influencing the success of vicuña capture. First is the lack of sufficient equipment to overcome the logistic difficulties of capture and the second is lack of capacity in several aspects of community organization. For the community it is difficult to organize meetings to plan communal activities. Tambo Cañahuas makes up an area of approximately 54,000 ha and many inhabitants have to walk for several hours to reach the community center. Planning a meeting can take weeks, as meeting announcements have to be individually given by a courier traveling by bicycle and on foot. Delays in the scheduled chaku can occur because of bad weather, but more significantly they occurred because of lack of sufficient logistic assistance or necessary equipment. Often, members of the community do not have the necessary means to transport the wood posts and netting to areas of highest vicuña densities. For example, due to the lack of trucks to transport equipment in 1996 and 1997, temporary capture corrals had to be set up in an area near the village and not in the area of highest vicuña density.

Since 1995, when the community relied heavily on state assistance for transportation and planning, people have become more organized and the capture process has become more streamlined and almost routine. Although the state agency CONACS has tried to persuade the community to install permanent corrals, the people of Tambo Cañahuas have not yet agreed to construct them.

It is important to note that in 1995, the first year the program was implemented in Tambo Cañahuas, the local state agency was involved in planning and logistics. In that year vehicles were loaned to transport people and equipment to a high-density area of vicuñas, resulting in a successful chaku. Subsequently, conflicts between the local state agency and the community led to a decrease in communica-

tion and collaboration between the two groups. The disillusionment with the poor capture success in 1996 was another factor that contributed to low yields in 1997 and 1998.

It is evident that, with the absence of telephones, radios, and vehicles that would permit communication and transport between community members during the planning and implementation of the chaku, at the outset of the program it was necessary to have some degree of assistance form the state or from other sources. The capture and shearing program was not easy to implement in the first few years. Nonetheless, persistence on the part of the community, sporadic state assistance, and logistic support from NGOs has made the wild-caught vicuña shearing enterprise an independently economically sustainable one within a few years.

Data collected during our study indicate that partial shearing of animals in the spring (September-October) has no negative effect on the vicuña population (Sahley, Torres, and Santos unpublished data). Our data thus far indicate that, if properly managed, capture, shearing, and release of free-ranging vicuñas is a biologically sustainable option. Moreover, the experience in Tambo Cañahuas has shown that the wild-caught system originally proposed is feasible and results in better short-term economic gains than the corral system.

Beyond economics, maintaining wild vicuñas on communal lands may not only serve to promote vicuña conservation but also of the Andean landscape and its associated flora and fauna. An additional benefit is the strengthening of the cultural identification of Andean people with an iconic wildlife species in Peru. The strengthening of pre-Colombian tradition in communities and their passionate attachment to the new vicuña enterprise is a fascinating combination of the meeting of tradition, human interaction with the wild landscape, and the global marketplace. As such, the case study in Tambo Cañahuas illuminates myriad complex interactions that have yet to be revealed. Thus far it seems that it is possible to combine Western wildlife management with a traditional system of resource use that can serve to strengthen cultural and historical ties with the landscape and also work with an international market. We believe that the information and data collected in Tambo Cañahuas can serve as a model for other communities in the Andes.

TOCCRA: AN ABBREVIATED CASE STUDY OF THE CORRAL SYSTEM

Adjacent to the campesino community of Tambo Cañahuas is the village of Toccra. Located at a slightly higher elevation (approximately 4,300 meters above sea level) and more sparsely populated by both humans and vicuñas, this village was chosen as the site of a vicuña "repopulation" effort. With strong support from the state and vigorous promotion by the Inca Group (the Peruvian company that has sole rights to the production of vicuña textiles and is part of the International Vicuña Consortium), a corral was installed a few meters outside the boundaries of the Salinas-Aguada Blanca Reserve but within its buffer zone.

In 1997 ninety-five vicuñas were brought from Pampa Galeras to Toccra and placed in the corral. Shortly thereafter, these animals became part of a highly publicized international vicuña festival, which attracted several hundred American tourists. A staged capture was enacted, in which tourists were allowed to participate, but animals were subsequently not shorn. Members from neighboring communities were asked to help with the capture. Although some community members did help, others did not, because of a lack of any compensation for labor (even though festival organizers charged tourists for the spectacle). Due to pressure from the industry, local state officials focused on organizing this event and virtually ignored other communities in the area such as Tambo Cañahuas, which subsequently had low capture success that year.

Efforts to study the biological effects of the corrals on vicuñas by comparing biological parameters of the captive animals with those of the wild populations in Tambo Cañahuas were unfortunately hampered by vicuña politics. Nevertheless, we did obtain census data in 1998, 1999, and 2000. Through interviews we learned that wild vicuñas were caught when possible and placed in corrals. Thus data on population dynamics and sources of vicuña births and mortality are impossible to quantify precisely. What our census data showed was that in 1998, an El Niño year, production of young was significantly lower in Toccra than in Pampa Cañahuas (Sahley 2000). After three years population growth of animals in the corrals was similar to that in the wild, even though animals had been introduced into corrals to apparently compensate for undocumented mortality or low birth rates. Fiber production for Toccra in 2000 was only 2 kg more than that for Tambo Cañahuas, and the meager economic gain (US$ 780.00 table 10.1) in comparison to Tambo Cañahuas did not compensate for the expense of the corral and veterinary treatment for vicuñas that had contracted mange or had brought mange with them from Pampa Galeras. While Tambo Cañahuas saw an increase in vicuña populations, as well as direct profit from the shearing of wild vicuñas, Toccra continues to pay off the debt incurred by the corral expenditure.

CONCLUSION AND RECOMMENDATIONS

Data obtained from this study indicate that live shearing of vicuñas in Peru has much potential for the sustainable utilization of this species and can also benefit Andean communities that traditionally have been marginalized in Peruvian society. While the "privatization" of the vicuña may cause social and economic conflict by promoting the construction of corrals, it remains unclear how the economic and social sustainability of this process will be influenced. However, it is apparent that vicuña management needs to be conducted in collaboration with technicians familiar with wildlife management theory and techniques. Although implementation of the program is still fairly recent, we believe it is more prudent to develop methods to improve capture efficiency of wild vicuñas and to protect them from poachers instead of changing this methodology for the more risky and costly

option of maintaining vicuñas under conditions of captivity. We suggest emphasis be placed on the following efforts:

1. Measure biological and socioeconomic costs for each community or region that will have different advantages and disadvantages with respect to vicuña management.
2. Proceed with great caution with the implementation on a large scale of permanent corrals. Research is urgently needed to compare health, fertility, social behavior, movement patterns, and effects on the landscape between wild and captive vicuñas.
3. Strengthen community organization and basic wildlife management techniques at local levels. If communities are going to be legally responsible for vicuña management and conservation, they must receive training in basic concepts of monitoring and management of vicuñas.
4. It is critical for communities to have complete information on the commercialization process and sale of fiber (for example, what percent of profits are they receiving?) and also to be able to understand the full implications of any contract or agreement presented to them by state or private institutions.
5. While community management may have several advantages for the vicuña, one potential disadvantage is that management on regional or national scales could be overlooked. This oversight could have a negative effect on the structure of the metapopulation of the vicuña or have important effects on the Andean landscape. It is important to maintain regional and national perspectives regarding management of wild vicuñas. This need requires collaboration and cooperation with state and nongovernmental organizations, as well as the creation of a national management plan for the vicuña.

Fortunately, the interest of Andean campesinos, who are important protagonists in this saga, is high. We hope that management practices based on scientific principles will lead to a conservation success story in Andean Peru.

POSTCRIPT

Since the completion of this article, a new presidential decree was signed by former President Fujimori. This decree grants individuals, as well as communities, the right to own vicuñas that occur on their land. Thus, privatization of the vicuña has, for the time being, been increased in scope. This expansion has resulted in a protest by the Society of Vicuña Breeders, which represents communities, and raises important issues regarding the privatization of a wild mammal and the future social, economic, and biological implications this decree might have.

In 2002, under the new government of President Toledo, a vicuña working group was established. This working group will examine the biological, legal, commercial, and social aspects of vicuña management and current legislation. Recommendations from the working group are as still pending.

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11

Captive Breeding Programs as an Alternative for Wildlife Conservation in Brazil

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The incorporation of wild species into the meat production industry has attracted the interest of Brazilian farmers in the last few years because of the increased demand for products and by-products of wild mammal origin. The use of new protein sources for the human population is also of great social interest. Rational use of native resources can be a beneficial process, resulting in economic and social advantages, while at the same time reducing damage to wild animal populations caused by irrational hunting and habitat destruction.

Additionally, there is a great demand in the international market for wild animal leathers. Germany, Italy, and the United States are the main importers of collared peccary (*Tayassu tajacu*) leather from Peru (Bodmer and Pezo 1999). In Argentina, where leather is the main product of capybara (*Hydrochaeris hydrochaeris*) exploitation, skins are used for such luxury products as shoes, jackets, and gloves (Nogueira-Filho 1996). This demand for wildlife leather has always been met by commercial hunting in several South American countries, especially in Brazil. From the 1960s and 1970s on, commercial hunting became illegal in many of these countries. Nevertheless, traffic in wildlife products continued. In the 1980s, for example, one German importer purchased 36,000 collared peccary skins from Paraguay (Redford and Robinson 1991).

Commercial hunting is forbidden in Brazil. However, wildlife farming in full or semicaptivity is permitted, and Brazilian law includes a provision that enables this use of wildlife. The Brazilian forest code—one of the most important laws for the protection of Brazilian forests—requires farmers to protect a part of their property as an rea de Reserva Legal, or legal reserve area. This is an area inside the agricultural proprerty required for the protection of wildlife and biodiversity conservation. Depending on the region, the legal area ranges from 20 to 80% of the property. In

the Amazon region the Área de Reserva Legal can comprise up 80% of rural properties, and in the Cerrado ecosytem, up to 35%. The sustainable use of natural resources is allowed in these protection areas, and some Brazilian farmers are using part of their legal protection areas for the semi-intensive production of wildlife. Unfortunately, landowners do not always support or respect this law, and a draft proposal is currently in discussion in the Brazilian congress that will reduce the size of the protection areas across the country.

Currently IBAMA, the Brazilian Environmental Agency responsible for wildlife use and protection, allows capybaras, rheas (*Rhea americana*), and other wild animals to be raised, on an experimental basis, in a low management-intensity system such as ranching. IBAMA classifies this kind of wildlife exploitation as an extensive production system (Francisco Neo, pers. comms.). Such extensive production gives farmers the option of conserving forests by making wildlife an economically valuable resource. The hope is that wild animal production, whether in full captivity or through ranching, will meet the meat and leather demands on wild animals and, in consequence, decrease illegal hunting.

In this article we describe the biological characteristics, products, and by-products of capybara and collared peccary, as well as the current production systems adopted in Brazil to produce these two species commercially. Analyses of economic parameters such as inputs, outputs, and financial return of the three production systems are also compared.

PART I. CAPYBARA: SPECIES CHARACTERISTICS, PRODUCTS, AND BY-PRODUCTS

BIOLOGY

Among Brazilian wild mammals, the capybara is the species that has the highest productive potential in captive, intensive small-scale farm settings, as well as in natural, extensive ranch settings (Parra, Escobar, and González-Jiménez 1978; Lavorenti 1989; González-Jiménez 1995; Nogueira-Filho 1996). It is herbivorous, grows rapidly, and adapts easily to captivity. There is also a great potential market for its meat and leather (Ojasti 1991; González-Jiménez 1995; Andrade et al. 1996; Nogueira-Filho 1996).

Capybara habitat consists of a combination of water bodies (rivers and lakes), pasture, and available natural cover. Its semiaquatic habit and its reliance on wetlands led some authors to propose capybara ranching as an alternative in order to enhance wetland benefits for local communities (Ojasti 1973; González-Jiménez 1995). The ranching system allows rural inhabitants of wetland regions, such as the Brazilian Pantanal, to use this species as a source of protein and income as long as they safeguard its natural habitat. Alternative uses, such as cattle ranching and agriculture, require extensive land draining.

MEAT CHARACTERISTICS

In Venezuela and Colombia capybara meat is traditionally eaten during Easter. In the sixteenth century, in response to a petition from the people, the Pope decreed the capybara a fish (Mukerjee 1994). Consequently, its meat can be eaten by Catholics during periods of abstinence from red meat.

In the biggest Brazilian cities, such as São Paulo, Rio de Janeiro, and Belo Horizonte, capybara meat is sold for up to US$ 7.5 per kilogram. To introduce capybara meat to the market, the following strategy was used in São Paulo. Initially, the meat was offered only at a few luxury restaurants, at which it was presented as an exotic product and listed at the highest price on menu. This process increased the demand for wild meat in urban centers, resulting in incentives for commercial captive breeding (Nogueira-Filho 1996).

Some rural peoples, however, reject capybara meat as having a disgusting taste, probably because they have consumed meat from hunted animals. In general, hunted animals are slaughtered without care, and under inadequate hygienic conditions, results in meat contaminated by intestinal contents. On the other hand, people that tested the meat of captive-reared animals in a double-blind experiment found no differences in scent and flavor among capybara, pig, and cow meat (Frasson and Salgado 1990). The captive animals used in the test had been fed a diet of elephant grass (*Pennisetum purpureum*), supplemented with corn and soybean meal ration and slaughtered under adequate conditions. Nevertheless, more studies of the fatty acid composition of capybara meat are necessary to establish how diet affects its organoleptic characteristics. Capybara meat contains on average only 4.5% of fat and 24.5% of crude protein (Lavorenti et al. 1990), for a total of 89.4% of digestible protein and 61.3% of biological value (Frasson and Salgado 1990).

ECONOMIC CONSIDERATIONS

In addition to high quality meat, capybaras produce light and resistant leather. This leather can be used for footwear, glove, jacket, and bag production (González-Jiménez 1995). In Buenos Aires, jackets made from capybara leather sell from US$ 400 to 720, while a pair of gloves sells for US$ 80 (Nogueira-Filho 1996).

Brazil exported 3,500,000 tons of capybara skins between 1956 and 1969, an amount that brought around US$ 10,700,000 to the country (Mourão 1999). However, because of the high market price of capybara meat, currently in Brazil the skin is sold incorporated to the carcass (Nogueira-Filho and Nogueira 2000). Capybara leather will only be marketed separately when there is sufficient production to guarantee a constant supply to the industry.

Capybara oil, derived from the body fat, is popularly used for such illnesses as asthma, bronchitis, rheumatism, and allergic diseases and as a growth tonic

(Nogueira-Filho 1996). A recent study showed that it functions to control cholesterol in mice fed a diet rich in saturated fat (Fukushima et al. 1997). Capybara body fat contains high levels of polyunsaturated fatty acids, including omega fatty acids (Fukushima et al. 1997) that may be responsible for its therapeutic action. The conjugated linoleic acid (CLA), which has anticarcinogenic properties (Bauman et al. 1998), may also be present in capybara body fat. The possibility that capybara meat and fat contain substances that can bring benefits to human health can be used for marketing purposes.

CAPYBARA SOCIAL BEHAVIOR AND CAPTIVE MANAGEMENT

Capybaras live in social groups ranging in size from one male and two females up to 100 individuals; the larger groups include several adults of both sexes with their offspring (Ojasti 1973; Macdonald 1981; Schaller and Crawshaw 1981). Groups are cohesive with a complex social structure characterized by a dominance hierarchy and individual specialization of functions (Azcarate-Bang 1980). A dominant male protects the group, is possessive of the females, and through threats and attacks maintains subordinate males at the periphery (Ojasti 1973). Satellite males sometimes copulate with young females in estrus (Ojasti 1973; Macdonald 1981; Schaller and Crawshaw 1981). Offspring remain in the original group until they reach sexual maturity, at which time females may be incorporated and males expelled following a hierarchical dispute with the dominant male (Ojasti 1973). Expelled members often form new groups (Ojasti 1973; Schaller and Crawshaw 1981).

Some authors have suggested the existence of cooperative care or alloparental behavior among capybaras (Ojasti 1973; Macdonald 1981). In the wild, capybara females have been seen with twelve to fourteen infants (Macdonald 1981; Schaller and Crawshaw 1981; Alho, Campos, and Gonçalves 1987), although the maximum litter size is seven (González-Jiménez 1995; Nogueira 1997). In captivity, juveniles spend more time with one female than with other group members (Nogueira 1997). Nogueira et al. (2000) studied the alloparental behavior of two capybara family groups in captivity and concluded that females did not discriminate between young when suckling because each suckled her own infant as often as those of other group females.

Despite the occurrence of alloparental behavior, breeding capybara in full or semi-intensive captivity can be very problematic because of the high rates of infanticide (Nogueira 1997). The hypothesis that infanticide is caused by lack of experience in primiparous females has been discarded (Nogueira et al. 1999). Rather, infanticide was associated with reproductive groups containing females who had not been together since weaning. Unfamiliar females lived together without apparent conflict until the occurrence of births when they killed their pen-mates' offspring (Nogueira et al. 1999). When a capybara group is set up with females that have been living together since weaning, infanticide does not occur, and females do

not have to be isolated to farrow either in intensive or semi-intensive breeding (Nogueira et al. 1999).

CAPYBARA FEEDING HABITS

Capybaras feed mostly on grasses (Lavorenti 1989; González-Jiménez 1995) and therefore do not compete directly with humans for food (Nogueira-Filho 1996). They enhance their nutrient intake from food by increasing the efficiency of their digestion by extensive mastication and hindgut fermentation (Mones and Ojasti 1986). The cecum represents 74% of the whole gastrointestinal tract of capybaras (González-Jiménez and Parra 1972). Cecum pH is around 6.0 (0.3 (González-Jiménez 1977), providing an optimal environment for microbial fermentation of structural carbohydrates (cellulose and hemicellulose) and liberation of volatile fatty acids that are an energy source for the host (González-Jiménez 1995).

Capybaras may be able to use microbial protein from the cecum through either (a) reingestion of the cecal content (Herrera 1985; Mendes 1999; Mendes et al. 2000; Hirakawa 2001) or (b) digestion and absorption of microbial protein in the large intestine (González-Jiménez 1995). This ability suggests that expenses for supplements of essential nutrients, such as amino acids and vitamins, can be decreased for adult animals in captivity. Nevertheless, the best growth results were obtained when the diet of young animals was supplied with protein supplement (Silva-Neto 1989; Andrade, Lavorenti, and Nogueira-Filho 1998). Under these conditions young animals gain up to 110 g per day and reach slaughter weight more quickly than when just fed grass, which results in 60 gram of daily weight gain (Ojasti 1973).

REPRODUCTION

Although capybaras can breed throughout the year, in the wild they do so most frequently at the onset of the rainy season (Mones and Ojasti 1986). Capybara gestation lasts approximately 150 days (López-Barbella 1984), and females usually produce one litter per year in the wild (Mones and Ojasti 1986).

Nogueira (1997) analyzed data obtained from the experimental captive-breeding project at the University of São Paulo at Piracicaba (ESALQ/USP). From November 1984 through December 1995, 243 young were born in 80 litters. Births peaked in the rainy months of November, December, and January. Mean litter size was 3.3 (range 1–7) with a male-female sex ratio of 53:47. Mean birth weight ((SD) 1,988.0 g ((346.7) for males and 1,991.0 g ((356.8) for females.

Ed.: double parens? Is there a special character that should be there?

Females could reach sexual maturity at seven months of life, but there was some individual variation in the age at which females produced their first litter (1,449.9 (744.2 days of age). The mean interbirth interval was 380.0 days ((163.7). However, females could reinitiate reproductive activity just twenty days after farrowing. The potential for postpartum estrous with ovulation, unlike what was observed by

López-Barbella (1984), allows capybaras to produce young at a faster rate than animals that are unable to ovulate soon after parturition. There was a significant difference in interbirth interval among females of different ages. The number of young per litter decreased, and the interbirth interval increased after six years of age (Nogueira 1997).

Data from this study also showed that intensive breeding and handling procedures led to stress and poor condition in captive animals, with negative impact on productivity. It is therefore necessary to improve husbandry practices through behavioral studies and to implement a selection program to improve reproductive parameters and to reduce the enormous variability observed. Nogueira (1997) concluded that the variability in reproductive parameters could be partially explained by individual temperament as a consequence of adaptation to captivity. Nogueira et al. (2000) proposed that subordinate females take better care of juveniles than do dominant females. This observation may be one possible explanation for the variability in reproductive parameters showed by capybara females in captivity.

Lack of adapted husbandry practices for this species in captivity may also have consequences for reproductive performance. For example, the delay in entrance into reproductive life was due partly to the fact that young females and males of nearly the same age made up the reproductive groups. Capybara males reach sexual maturity between fifteen and twenty-four months of age (Ojasti 1973), females between seven and twelve months (López-Barbella 1982; Nogueira 1997). Groups composed of young females with adult males should be tested to verify the possibility of reducing the age at which capybara females produced their first litter.

CAPYBARA CAPTIVE-BREEDING SYSTEMS

INTENSIVE PRODUCTION SYSTEM

In the intensive breeding system family groups comprising a male and up to eight females are maintained in small enclosed reproduction paddocks (120 to 400 m^2, depending on group size), with at least 20 m^2 per adult animal (Nogueira-Filho 1996). Paddocks should contain a water tank, feeders, and a sheltered area. Additional paddocks,with the same facilities and space per animal are used for rearing juveniles (Andrade, Lavorenti, and Nogueira-Filho 1998).

Females introduced to each of the reproduction paddocks must belong to the same family group in order to avoid fights and infanticide (Nogueira et al. 1999). The male can be from a different origin than the females, allowing the exchange of genetic material from different populations. If wild-reared females are used, adaptation to captivity is facilitated by placing them in a paddock already containing a captive-born adult male (Nogueira 1997). An alternative reproductive group composition is to place in one paddock juveniles no more than sixty days old from several groups. Because they will grow to maturity together, fighting and infanticide will not occur (Nogueira et al. 1999).

Adult animals are fed supplementary ration (12% CP) at 1.0% of live weight on a dry matter basis and grass ad libitum. Young animals receive grass ad libitum and a protein supplement at 1.5% of live weight on a dry matter basis. Since all live grass is removed from the confinement area, grass must be cut and brought to the paddock. The forage crop of choice is the elephant grass (*Pennissetum purpureum*), which has high productivity (Nogueira-Filho 1996).

Infants born in the reproduction paddock will stay with the group until they are sixty days old. Then they are weaned and transferred to a juvenile growth paddock until they reach the weight/age of 20 kg/6 months or 35–40 kg/12–18 months, depending on local market preferences (Nogueira-Filho 1996).

Space allowances for captive capybara are much higher than those used for domestic animals and easily meet the animals' behavioral needs. Even farmers who adopt the intensive production system use at least up to 20 m^2 per individual, whereas pig farming typically allocates 2 m^2 or less per animal (Nogueira-Filho 1996; Andrade, Lavorenti, and Nogueira-Filho 1998). In cases where appropriate handling practices, feeding requirements, enclosure facilities, and social environment are not supplied, low productivity, low growth rates, infanticides, or even lethal fights will occur, leading to breeding failure (Nogueira 1997; Andrade, Lavorenti, and Nogueira-Filho 1998; Nogueira et al. 1999).

SEMI-INTENSIVE PRODUCTION SYSTEM

Over 90% of the 137 capybara farming facilities in Brazil use the semi-intensive production system. Females are farrowed and juveniles raised to maturity in fenced areas, ranging from 5,000 to 40,000 m^2, including a lake or impoundment of at least 200 m^2 surrounded by arboreal vegetation (Nogueira-Filho 1996). One or more traps are built in the breeding area. The trap must allow the capture of multiple animals in order to reduce the costs of trapping and handling. Inside the traps mineral salts, grain corn, or supplementary ration are supplied in sheltered feeders. The number of traps and their size depend on the number of animals in the breeding area, which in turn depends on the size of the area and the farm's capacity for food (grass) production.

A family group comprising a male and up to nine females is captured from the wild or purchased from another breeder and introduced into the paddock. If the animals were captured in the wild, only animals caught in the trap at the same time should be used in order to avoid the inclusion of a nongroup member (Nogueira 1997). If the capybaras were purchased from another breeder, the group individuals should have been living together at least since weaning (Nogueira et al. 1999). Inside the breeding area the group will increase only by reproduction—no more animals are added from the wild or captivity in order to avoid fights and infanticide (Nogueira 1997).

Appropriate density studies are still required, but at densities of 100 m^2 per adult animal, weaning should take place at sixty days of age. Juveniles are ear-tagged, and

young males placed in a growth paddock with an area ranging from 200 to 800 m^2—at least 20 m^2 per young (Andrade, Lavorenti, and Nogueira-Filho 1998)—where they will grow more quickly without competition from the adult animals. Young females can be maintained with the adults. When a breeder needs to replace an adult female, he can select among those presenting faster growth; because they already belong to the group, there will no difficulty with group incorporation (Nogueira-Filho 1996).

At lower densities, on the other hand, weaning occurs naturally and young males grow up with the adults until they reach the weight/age of 20 kg/6 months old. After this age young males are subject to aggressive behavior from adult males. At this time they should be slaughtered or transferred to a juvenile growth paddock until they reach 35–40 kg/12–18 months old, depending on local market preferences (Nogueira-Filho 1996).

Normally, the adult diet is grass and mineral salt, while the young receive a protein supplement in a creeper feeder. As in the intensive system, cut elephant grass is placed in the trapping devices. The grass growing inside the area is not considered in the feeding plan because capybaras are selective feeders who choose forage plants with high protein content, such as plant seedlings, using their incisors to clip vegetation at ground level. Given this behavior, large areas and a pasture rotation system would be required to ensure adequate natural pasture supply. This practice is not cost effective because of the high prices of the stout galvanized chain link wire fences used in capybara farming (Nogueira-Filho 1996).

We consider this breeding system as semi-intensive, despite food supplementation, because the groups are maintained in large areas and because there is no individual control on reproductive parameters as in the intensive system. When analyzing reproductive parameters, the breeder considers only the average group reproduction data, such as interbirth intervals or number of young produced per female each year.

EXTENSIVE PRODUCTION SYSTEM

In some portions of Brazil, especially in the states of São Paulo and Minas Gerais, capybaras are shot as agricultural pests because they harm corn, rice, sugarcane, and other crops and may compete with cattle and other domestic livestock for food during the dry season (NRC 1991; Moreira and Macdonald 1997). An alternative way to control and use these animals is through extensive production or ranching. This production system in particular has the ecological benefit of preserving wetlands rather than draining them as would be done for cattle ranching. Currently IBAMA allows this kind of exploitation system only on an experimental basis.

In this system capybara population density is assessed, and a selective quota determined, ranging from 10 to 30% of the population; the range depends on annual population variations. This system is used in the Venezuela Llanos (Ojasti 1973); however, there are some differences between the experimental system in Brazil

and the better-known Venezuelan harvest. In Brazil the animals are live-captured, allowing ranchers to select the animals that will be slaughtered. Furthermore, animals can be slaughtered before they reach sexual maturity. IBAMA requires that all ranched animals be identified with electronic microchips, and only young born after ranching is implemented may be slaughtered. Therefore monitoring is easier than in the Venezuelan harvest system, and it is possible to avoid the overharvesting that has occurred in the Venezuelan Llanos (Ojasti 1991).

An example of the extensive production system in São Paulo state is the Perobal farm, whose main activity is beef cattle production. There, a population of 800 capybaras shares the pasture with cattle. On alternate days grain corn is placed inside the traps that allow animals to be handled. These trapping devices, with an ingenious system of automatic doors, are set one day before the planned capture and allow the rancher to hold and select the animals that will be slaughtered (Nogueira-Filho 1996).

The main problem with this production system is that capybaras can quickly degrade the pasture because of their selective feeding on seedlings. Animals thus have to be moved out of some areas while the pasture recovers, potentially resulting in confrontations when transferred groups encounter resident groups in new areas. Therefore specific husbandry practices must be developed for this production system, especially those that allow an increase in the extraction quota.

ECONOMIC ANALYSIS OF THE THREE CAPYBARA PRODUCTION SYSTEMS

An essential practical consideration in evaluating a productive activity is its cost in terms of the return obtained for the product. While it is obvious that the financial aspects of breeding operations cannot be neglected, the expression of the results in terms of dollars, unless properly interpreted, may obscure rather than clarify the facts because monetary statements are not experimental results. The latter are based upon factors that are not under experimental control, the same combination of which may never happen again. The relative prices of feeds and the selling prices of product vary from time to time and from place to place, according to market conditions.

Let us consider a hypothetical comparison, based on data obtained from commercial breeders, regarding the farm expenses and income of a dairy farmer who wants to breed capybara through either intensive, semi-intensive, or extensive production systems. The farm has an available area with arboreal vegetation and a 600-m^2 lake, and in another area a large group of capybaras is harming a corn crop and grass pasture used by the cows.

We simulated the expenses and income for intensive, semi-intensive, and extensive breeding system on this farm (table 11.1). In the intensive system the breeder will need to build six paddocks, each with an area of 400 m^2, a 20-m^2 water tank, and a 40-m^2 sheltered area. Three reproduction groups, each comprising a male

TABLE 11.1 Initial Expenses for the Maintenance of Twenty-four Female and Three Male Adult Capybaras in Intensive, Semi-intensive, and Extensive Breeding Systems

INITIAL EXPENSES (US$)	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE
Consultant[a]	500.00	500.00	500.00
IBAMA[b]	100.00	100.00	100.00
Purchase of animals	1,350.00	—	—
Materials and labor for facilities building	6,820.00	4,500.00	1,500.00
Equipment	200.00	200.00	200.00
Total	8,970.00	5,300.00	2,300.00

[a]The breeder needs to contract a consultant to develop the project.
[b]The breeder must pay an initial charge to IBAMA to legalize the project.

and eight females, will occupy three of those paddocks. The other three paddocks will be designated for juvenile growth. In the semi-intensive system the breeder will need to surround two hectares (20,000 m^2) with a 1.5-m high wire fence around the lake to contain a breeding group comprising three males and twenty-four females, which will be captured on the farm. It will also necessary to build a trap for animal handling. For the ranching system the breeder will need to build two panel traps, establish electrified fences around crops to avoid damage, and increase the carrying capacity of the habitat by enriching the habitat with supplementary food—e.g., elephant grass—that capybara groups can use throughout the year in order to increase their production.

To estimate farm expenses (table 11.2) and incomes (table 11.3) from the three breeding systems, we used a spreadsheet for computing costs and expenses designed by researchers at the Economics Department at ESALQ/USP. Intensive and semi-intensive productivity data are from Nogueira (1997) and Nogueira-Filho (1996), respectively. Currently, there are no data available on the productivity of capybara ranching in Brazil; therefore we used the natural productivity data from González-Jiménez (1995). We considered an extraction quota of 30%, the experimental extraction quota currently allowed by IBAMA.

In spite of the apparent high annual potential net income (table 11.3), the small scale of commercialization limits actual profits. Only a few big producers can sell their production directly to the consumers, mainly restaurants, and so obtain the highest incomes. Most capybara farmers sell their production to intermediaries who pay only US$ 1.5 per kilogram of animal live weight. Therefore, farmers must organize themselves to sell their joint production directly to the consumers and to obtain additional income through the industrialization of capybara leather and fat (Nogueira-Filho and Nogueira 2000).

Ranching incurs the lowest expense per kilogram of animal produced (table 11.2) but also the lowest financial return (table 11.3). Contrary to the situation in the

TABLE 11.2 Analysis of the Total Expense (per kg) of Live Animal Weight in Intensive, Semi-intensive, and Extensive Breeding Systems for Capybara

EXPENSE ITEMS	INTENSIVE (US$)	%	SEMI-INTENSIVE (US$)	%	EXTENSIVE (US$)	%
Feeding[a]	1.19	64.3	1.17	75.0	0.36	52.9
Labor	0.22	11.9	0.10	6.4	0.10	14.7
Capital interests[b]	0.25	13.5	0.14	9.0	0.10	14.7
Fuel, electricity, and telephone	0.03	1.6	0.02	1.3	0.05	7.4
Veterinarian and medicines	0.04	2.2	0.04	2.6	0.02	2.9
Other expenses[c]	0.12	6.5	0.09	5.8	0.05	7.4
Total expense per kg of live animal weight	1.85	100	1.56	100	0.68	100

[a]US$ 7.00/t of *Pennisetum purpureum* grass, crushed and placed in the feeder (labor included) and US$ 0.15 per kg of supplementary growth ration—both used in intensive and semi-intensive system. US$ 5.00/t of grass grazed by the animals itself (expenses for pasture recovery) in the extensive system.
[b]Includes interests (6% per year) on total initial costs
[c]Includes expenses with interests (6% per year) on operational capital, taxes, and commercialization expenses

TABLE 11.3 Projection of the Production, Costs, and Annual Incomes for Twenty-four Adult Female and Three Male Capybaras in Intensive, Semi-intensive, and Extensive Breeding Systems

ANNUAL INDICES	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE
Mean number of young	118.6	144	204.3
Number of commercial animals sold[a]	110.2	134.4	69.4
Total weight of commercial animals (kg)	3,306.0	4,032.0	2,082.0
Total weight of discarded reproducers (kg)	173.3	173.3	—
Labor per kg of commercial animal produced (hours)	0.4	0.1	0.1
Kg of food consumed/kg of commercial animal[b]	58.8	55.6	126.2
Facilities and equipment expenses per female (US$)	292.50	195.83	70.83
Hypothetical annual total production expenses (US$)	6,438.00	6,568.00	1,992.00
Hypothetical annual net income (US$)[c]	5,743.00	8,151.00	5,295.00

[a]Currently, the IBAMA adopts an annual extraction quota of 30%.
[b]In the extensive system the farmer will need to feed all animals but only a percent of the young will be slaughtered.
[c]Selling the production at US $ 3.5/kg of animal live weight.

Venezuelan Llanos where ranchers incur only slaughter expenses, Brazilian breeders incur expenses for supplementary food and landscape management to maximize the capybara carrying capacity. Furthermore, IBAMA does not allow breeders to slaughter the oldest animals. The rancher thus incurs expenses for all animals but obtains economic benefit only from animals born after ranching is implemented. Because natural predators are controlled in ranching, capybara density will greatly increase after a few years. Therefore IBAMA extraction quotas should be increased in order to make this production system economically feasible. Breeders will incur further costs carrying out the studies required to win approval of a higher extraction quota.

PART II. COLLARED PECCARY: SPECIES CHARACTERISTICS, PRODUCTS, AND BY-PRODUCTS

The collared peccary occurs throughout Brazil in habitats ranging from arid environments to tropical rainforest (Sowls 1997). Adult collared peccaries measure from 80 to 90 cm in length, 25 to 45 cm in height, and attain weights of up to 27 kilograms in captivity (Emmons 1999; Nogueira-Filho 1999). Currently, peccary meat is sold for up to US$ 10 per kilogram in the city of São Paulo. Unlike capybara meat, peccary meat is a preferred wildlife product throughout Brazil (Nogueira-Filho 1999) and is also the game meat most frequently sold at the urban market of Iquitos, Peru (Bodmer and Pezo 1999). The meat has 22.7% of crude protein and less than 1.5% of fat in its composition (Carrilo 1999). The species also produces excellent quality thin, soft, durable, and stain-resistant leather, characteristics rarely found combined in any one leather (Bodmer and Pezo 1999).

The Province of Salta, Argentina, exported 12,600 peccary skins between the years of 1988 and 1992, even though the trade was illegal. In Salta hunters receive the equivalent to US$ 3 for each skin (Barbarán 1999), while tanned leather is offered to footwear manufacturers at US$ 45 per m^2, and a pair of boots is offered to the public for around US$ 150 (Barbarán 1999). The market is relatively stable because Europeans traditionally use products made from peccary leather (Bodmer and Pezo 1999; Bodmer, Lozano, and Fang this volume). The United States provides another important market; a pair of peccary gloves at Barneys, New York, retails for up to US$ 195.

Today the demand for peccary leather is met primarily by the harvest of natural populations in Amazonian Peru (Bodmer and Pezo 1999) and by illegal hunting in several other South American countries, especially Brazil (Nogueira-Filho 1999). The collared peccary adapts well to captivity (Nogueira-Filho 1999), can support high indices of extraction in natural populations (Bodmer 1999), and would be an ideal animal for incorporation into agroforestry projects (Sowls 1997). For these reasons commercial projects are being developed in several South American countries in order to exploit the species in a sustainable way (Bodmer 1999; Nogueira-Filho 1999).

SOCIAL BEHAVIOR AND CAPTIVE MANAGEMENT

Collared peccaries live in stable and cohesive herds containing from six to thirty-four individuals with an approximately 1:1 sex ratio (Emmons 1999; Fragoso 1999). The smaller herd size may be characteristic of hunted areas or areas of low productivity (J. Fragoso pers. comm.). Herd members eat, sleep, and forage together (Sowls 1997). In captive groups comprising individuals from different sources, however, feeding and sleeping subgroups frequently form according to their origin, and females are more cohesive than males (Nogueira-Filho, Nogueira, and Sato 1999). Therefore, in order to avoid the occurrence of conflicts during feeding, several feeders must be available in the enclosures (Lima-Neto, Nogueira, and Nogueira-Filho 2001). Conflicts occur mainly because certain individuals retain definite dominance over others, but dominance ranks are ill defined (Diaz 1978; Sowls 1997; Nogueira-Filho, Nogueira, and Sato 1999).

Captive groups tolerate the presence of several adult males without noticeable conflicts, even when receptive females are present. Unlike the situation with capybara groups, male and female subadult peccaries are also tolerated (Nogueira-Filho, Nogueira, and Sato 1999). Even though collared peccary groups usually reject the introduction of solitary animals into an established colony (Lochmiller and Grant 1982), they tolerate the introduction of groups of three or more related individuals, which leads to the observed subgroup composition (Nogueira-Filho, Nogueira, and Sato 1999).

If the group contains unrelated or unfamiliar females at high densities, pregnant females should be isolated to farrow in order to avoid infanticide (Packard et al. 1990; Nogueira-Filho 1999). However, this practice increases breeding expenses due the need for special facilities and the lengthening of the interbirth interval (females can have postpartum oestrus; López-Barbella 1993). One solution is to breed peccaries at low densities of about 250 m^2 per adult animal (Engel 1990), but this requirement implies the need to enclose large areas, a very expensive procedure for small producers because of the high prices of the wire fences and concrete or rock base used in peccary farming (Nogueira-Filho 1999). The best solution, if the rural producer decides to adopt the semi-intensive production system, may be to build small paddocks and set up groups only with related females. These paddocks will range from 200 to 400 m^2 each, according to group sizes and the breeder's financial resources. Young animals produced from these groups can then be raised together from weaning to make up familiar groups in a larger area; this practice helps prevent later infanticide (Nogueira-Filho 1999).

FEEDING AND NUTRITION

Collared peccaries are largely frugivorous and also eat a wide variety of roots, tubers, greens, bulbs, and rhizomes (Kiltie 1981; Bodmer 1989; Sowls 1997; Fragoso 1999). In captivity they adapt easily to different kinds of food, including cassava,

cassava hulls, pumpkin, grain corn, sorghum silage, corn silage, crushed sugar cane, and commercial ration for pigs (Liva et al. 1989; Nogueira-Filho 1999).

Collared peccaries have a forestomach with active fermentation (Langer 1979; Cavalcante-Filho et al. 1998), which has given rise to considerable speculation regarding their ability to utilize coarse roughage by transforming the dietary fiber to usable volatile fatty acids (VFA) (Sowls 1997). Lochmiller et al. (1989) proposed that the VFAs found in collared peccary forestomachs arise from noncellulose components of the diet. Shively et al. (1984) concluded that fiber digestion in the collared peccary is considerably lower than in true ruminants. Strey and Brown (1989) suggested that collared peccaries might be concentrate selectors, selecting highly digestible forages and plant parts over forages with higher fiber contents. In other studies Gallagher, Varner, and Grant (1984) and Comizzoli et al. (1997) showed that collared peccaries could digest forage like true ruminants, while Nogueira-Filho (1990) determined that this species could digest even low quality roughage with high lignin contents and that peccaries could handle up to 30% of roughage in their diet. This characteristic should reduce farm expenses and the dependence on external products through the use of coarse products like grasses and leaves from farm and agroindustry by-products.

The protein demand for adult collared peccary maintenance is relatively low, around 0.82 g $N/kg^{0.75}$ a day, or 6.9% of crude protein (CP; Gallagher, Varner, and Grant 1984; Gary and Brown 1984). Part of this protein requirement could be furnished by nonnitrogen sources, such as urea (Leite et al. 2001). Daily digestible energy needs are 148.5 kcal/ $kg^{0.75}$ (Gallagher, Varner, and Grant 1984).

Growing young, on the other hand, have higher protein requirements. Different levels of crude protein (12, 15, or 18% CP) were tested in the diet of twelve collared peccaries in the initial phase of growth. Animals that received a higher protein ration (18% CP) showed superior weight gain and better feed:gain ratio (F:C; Nogueira-Filho et al. 1991). These results are preliminary, and more experiments are needed to determine the species' nutritional demands in the growth phase.

In tests with an experimental growth ration with 16% of crude protein and 4,100 kcal/kg of gross energy, an average daily weight gain of 80 g from 60 days to 120 days of age was achieved with 380 g/day of dry matter intake, resulting in a F:C of 4.7:1. Between 120 and 300 days of age, an average daily weight gain of 55.1 g was obtained with 634 g/day of dry matter intake, for a F:C of 11.5:1. Above ten months of age, when juveniles weighed 18.5 kg on average, the average daily gain weight was 19 g with a F:C of 21.7:1. These data were used to estimate a mean slaughter weight for collared peccaries of around 18.5 kg of animal live weight at ten months of age (Nogueira-Filho and Lavorenti 1997).

REPRODUCTION

From April 1986 through December 1991, forty-three young were born in twenty-six collared peccary litters at ESALQ/USP. Reproduction took place during the whole year, and gestation ranged from 140 to 148 days. Mean litter size was 1.6 (range 1–3),

with a male:female ratio of 43:57. Mean birth weight was 710 g and 617 g for males and females, respectively. Females could reach sexual maturity at seven months, but on average females produced their first litter when they were 416 days old ((88.9). The mean interbirth interval was 215.1 days ((57.1) (Nogueira-Filho and Lavorenti 1997). López-Barbella (1993) established that collared peccaries can come into estrous at 46.0 (24.8 days postpartum (range from 14 to 92 days) and estimated 224.2 (63.8 days for the farrowing interval. However, he also found high fetal mortality and the possibility of estrous without ovulation or low fertility in the first postpartum estrous. Studies that provide data on the reproductive physiology of the collared peccary are necessary in order to improve management plans and productivity.

Ed.: special character missing?

COLLARED PECCARY CAPTIVE -BREEDING SYSTEMS

INTENSIVE PRODUCTION SYSTEM

Currently only scientific breeders at universities or other research centers adopt the intensive production system in Brazil (e.g., Universidade Estadual de Santa Cruz, the Universidade Federal do Pará, and Centro de Multiplicação de Animais Silvestres, that is, CEMAS). In this breeding system family groups, comprising a male and up to three females, are maintained in small pens that range from 12 to 40 m^2. Alternatively, peccaries are maintained in small herds of up to fifteen individuals (maintaining a male to female ratio of 1: 4–5) in paddocks ranging from 100 to 600 m^2. Paddocks should contain a watering trough, feeders, and a sheltered area. Additional pens with 20 to 40 m^2 are required for growth of young.

Females introduced in each one of the reproduction pens must belong to the same family group in order to prevent fights and infanticide (Nogueira-Filho, Nogueira, and Sato 1999). The male could be from a different origin than the females, ensuring genetic diversity. Adult animals are fed grain corn or cassava at around 3.5% of live weight on a dry matter basis and ad libitum mineral salts. Pumpkins, bananas, or other fruits or foodstuffs available from farms are offered ad libitum. Meanwhile the young receive grain corn and a protein supplement (16% of crude protein) at 5% of live weight on a dry matter basis until they reach 12 kg of live weight. After that the young receive the same diet as adult animals.

Usually, if the peccary herds are maintained in small pens, females are isolated to farrow in an available free pen. In larger paddocks of at least 200 m^2, the females can farrow inside the confinement area. In both situations, infants will stay with the mother until they are sixty days old. Then they are weaned and transferred to a juvenile growth pen until they reach the weight/age of 18.5kg/10 month (Nogueira-Filho 1999).

SEMI-INTENSIVE PRODUCTION SYSTEM

Currently there are twenty-one collared peccary commercial breeders in Brazil, most of them using the semi-intensive production system. Some breeders use areas

of their farms that cannot be used for traditional agriculture because of edaphic and/or topographic factors. Other farmers use parts of their legal protection areas. The semi-intensive production system thus provides an alternative for the integral use of the farms.

In semi-intensive production areas ranging from 1,000 to 50,000 m^2 and including arboreal vegetation enclosed with wire fence on a concrete or rock base. These areas are used for farrowing females and growing young (Nogueira-Filho 1999). Peccaries are purchased from another breeder or captured in the wild in places in which they are considered agricultural pests and introduced into the paddock in a proportion of one male to four to five females. The captive group will increase through reproduction or by the introduction of new members from the wild or from captivity, up to a density of 250 m^2 per adult animal. At this density infanticide does not occur (Engel 1990). One or more trapping devices are built in the breeding area, and mineral salts, grain corn, cassava, or supplementary ration are supplied in sheltered feeders within the traps. The number and size of trapping devices and feeders depends on the number of groups put together inside the area (Nogueira-Filho 1999; Lima-Neto, Nogueira, and Nogueira-Filho 2001).

Normally, the animals are fed cassava or grain corn, supplemented with pumpkin, banana, other fruits, and protein supplements, as in the intensive system. Fruits produced by trees inside the area are not considered in the feeding plan. As in the case of capybara farming, this breeding system is considered semi-intensive because the group is maintained in a large area and because there is no individual control on reproductive parameters. The infants are ear-tagged at approximately sixty days of age. Weaning is natural and young grow up with the adults until they reach the weight/age of 18 kg/10 months, at which time they are designated for slaughter or for the formation of new reproduction groups.

The main problem with this production system is that, at densities of less than 250 m^2 per adult animal, peccary rooting damages natural vegetation and can provoke erosion, primarily near the capture areas (Nogueira-Filho et al. 1991). Such damage can be minimized with the use of mobile panel traps, like those used to trap and handle feral pigs in the U.S.A. (Sweitzer et al. 1997).

EXTENSIVE PRODUCTION SYSTEM

Collared peccary herds harm cassava and other crops in some areas of Brazil (e.g., southeastern Bahia) and are shot as agricultural pests (Nogueira-Filho and Nogueira 2000). As with capybara, ranching allows the use and control of the species and provides an alternative to destructive use of the land. However, to date there is no experience in Brazil with collared peccary ranching. To develop a rational ranching system, we require information on the ecology of natural populations. Currently, several research institutions, UESC, EMBRAPA-Pantanal, CIRAD-EMVT and DICE (Durrell Institute of Conservation Ecology, University of Kent, are studying peccary ecology in northeastern Brazil and in the Pantanal as part of the project De-

velopment of Different Production Systems for the Sustainable Exploitation of the Collared Peccary in Latin America, which is financed by the European Commission. Research on feeding ecology, habitat use, population size, reproductive productivity, and limiting and keystone resources during periods of low food production is aimed at determining sustainable levels of collared peccary harvest.

As with capybara IBAMA will allow ranching only on an experimental basis. All ranched animals must be identified with electronic microchips, and only young born after ranching is implemented will be slaughtered. Once a selective quota is determined based on local population density, individuals will be live-captured in order to allow selection of animals for slaughter. As in capybara ranching this production system requires specific husbandry practices, such as traps that capture multiple animals, thus reducing the costs of trapping and handling.

ECONOMIC ANALYSIS OF THE THREE COLLARED PECCARY PRODUCTION SYSTEMS

We carried out a hypothetical comparison, based on data obtained from commercial breeders, of the farm expenses and income of a beef cattle farmer who wants to breed collared peccaries using either of the three production systems. The farm has an available area with arboreal native vegetation and abandoned pig facilities comprising fourteen pens with 12 m^2 each and four pens with 24 m^2. In another part of the property, a group of twelve female and twelve male peccaries is harming a cassava crop meant for subsistence use by the farm workers.

In *the intensive system* the farmer will need to increase the height of the walls in the old pig facilities with wire mesh to prevent peccaries from escaping. Eight reproduction groups comprising one male and three females each will occupy eight of the 12-m^2 pens. The other six pens will be used for farrowing, while the four 24-m^2 pens will be used for juvenile growth. In the semi-intensive system the breeder will need to surround 7,500 m^2 with a 1.5-m high wire fence around the native vegetation to create a breeding group of six males and twenty-four females purchased from another breeder. At least two panel traps will be built to handle the animals. For ranching the breeder will need to build two panel traps, establish electrified fences around crops to avoid damage, furnish supplementary food to animals at the bait station, and increase the carrying capacity by enriching the habitat with supplementary foods, such as abandoned crops of corn, sweet potato, and cassava that peccaries can use throughout the year (table 11.4).

We used the intensive productivity data from Nogueira-Filho and Lavorenti (1997) and semi-intensive productivity data from Nogueira-Filho (1999) to estimate farm expenses and incomes from breeding systems (table 11.5). There are no available data on productivity of Brazilian collared peccaries through ranching; therefore we used the reproductive parameters in the wild from Bodmer (1999). Presently, there is no annual extraction quota established by IBAMA. Therefore we used a harvest level of 30% that was considered sustainable by Bodmer (1999).

TABLE 11.4 Initial Expenses for Maintenance of Twenty-four Female and Eight Male Adult Collared Peccaries in Intensive Breeding System, Twenty-four Females and Six Males in Semi-intensive System, and Twelve Females and Twelve Males in Extensive Breeding System

INITIAL EXPENSES (US$)	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE
Consultant[a]	500.00	500.00	500.00
IBAMA[b]	100.00	100.00	100.00
Purchase of animals	1,600.00	1,500.00	—
Materials and labor for facilities building or adaptation	2,000.00	5,756.00	1,500.00
Equipment	400.00	200.00	200.00
Total	4,600.00	8,056.00	2,300.00

[a]The breeder needs to contract a professional consultant to develop the project.
[b]The breeder must pay an initial charge to IBAMA to legalize the project.

TABLE 11.5 Analysis of the Total Expenses (US$) (per kg) of Live Animal Weight of Collared Peccaries in Intensive, Semi-intensive, and Extensive Breeding Systems

EXPENSE ITEMS	INTENSIVE	%	SEMI-INTENSIVE (US$)	%	EXTENSIVE (US$)	%
Feeding[a]	1.47	42.5	0.94	39.7	0.37	15.9
Labor	0.47	13.5	0.13	5.5	0.50	21.5
Capital interests[b]	0.56	16.3	0.77	32.5	0.84	36.0
Fuel, electricity, and telephone	0.18	5.2	0.10	4.2	0.19	8.1
Veterinarian and medicines	0.36	10.4	0.21	8.8	0.19	8.1
Other expenses[c]	0.42	12.1	0.22	9.3	0.24	10.3
Total expense per kg of live animal weight	3.46	100	2.37	100	2.33	100

[a]US$ 0.08/kg of peccary ration
[b]Includes interests (6% per year) on total initial costs
[c]Includes expenses with interests (6% per year) on operational capital, taxes, and commercialization expenses

As is the case for capybaras, ranching yields the lowest financial return (table 11.6) because there will be expenses with all animals but economic return only from young born after ranching is implemented. Productivity is further limited by the peccary's 1:1 sex ratio.

In spite of the apparently highest annual potential net income (table 11.6), if our

TABLE 11.6 Projection of the Production, Costs, and Annual Incomes for Twenty-four Female and Eight Male Adult Collared Peccaries in the Intensive Breeding System, Twenty-four Females and Six Males in the Semi-intensive Breeding System, and Twelve Females and Twelve Males in Extensive Breeding System

ANNUAL INDICES	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE
Mean number of weaned young	27.6	51.5	23.0
Number of commercial animals sold[a]	24.4	47.5	14.0
Total weight of commercial animals (kg)	451.7	879.4	259.0
Total weight of discarded reproducers (kg)	100.5	88.5	—
Labor per kg of commercial animal produced (hours)	0.9	0.2	0.8
Kg of food consumed/kg of produced commercial animal[b]	18.4	11.7	4.6
Facilities and equipment expenses per female (US$)[c]	100.0	250.00	250.00
Hypothetical annual total production expenses (US$)	1,909.00	2,291.00	985.00
Hypothetical annual net income (US$)[d]	300.00	1,581.00	52.60

[a]In the extensive system we used an annual extraction quota of 30%.
[b]In the extensive system only supplementary food furnished to animals at the bait station was considered.
[c]Remember that for the intensive system only expenses with facilities adaptation were considered. If we considered building expenses (US$ 75 per m^2), the facilities and equipment expenses per female in intensive system will increase to US$ 850.00.
[d]Selling the production at US$ 4.00/kg of animal live weight

hypothetical beef cattle farmer chooses the semi-intensive production system to produce collared peccaries, he will have some problems because of small-scale commercialization. Most peccary farmers sell their production to intermediaries who pay at most US$ 2.0 per kilogram of animal live weight, resulting in economic loss to the farmers. Thus farmers will need to market their production jointly to obtain better prices. They could also seek additional income through the industrialization of peccary leather.

CONCLUSION

Wildlife farming has been indicated as a possible source of animal protein for poor populations in developing countries because native mammals have specific advantages over domestic species (Lavorenti 1989; NRC 1991; González-Jiménez 1995). We suggest that wildlife farming should also be considered an alternative source of income for Brazilian farmers since wild animal meat is sold at high prices as an exotic product in Brazil's largest cities (Nogueira-Filho and Nogueira 2000).

Relative to species of domesticated livestock, wild animals may thrive as meat producers in their native habitat because they possess heat tolerance, resistance to local diseases and parasites, and overall hardiness and tolerance for poor nutritional conditions (Nogueira-Filho and Nogueira 2000). Another advantage is the smaller environmental damage they cause relative to domestic animal production—consider the environmental pollution and deforestation caused by pig or cattle production, respectively (Nogueira-Filho 1996; Nogueira-Filho 1999).

Wildlife captive breeding, in either full captivity or semi-confinement, is an alternative use for unproductive areas of agricultural holdings, which for one reason or another are unfit for any other agricultural production. Also, in particular for Brazilian farmers, it is an economic alternative use for the legal protection area (Nogueira-Filho 1996, 1999). Semi-intensive captive breeding is not a high-tech or capital-intensive agrobusiness. However, it is not always practical because of the reality of small-scale commercialization. Therefore, farmers must become organized to sell their production jointly and directly to the consumers. Furthermore, the industrialization of subproducts (e.g., leather) will encourage more farmers to consider wildlife breeding as an alternative for the integral use of their property and as a way to diversify production.

On the other hand, the extensive system or ranching is frequently considered the preferred conservation/management tool because it gives farmers an alternative to conserve forests and wetlands by making wildlife a valuable resource. This activity could be especially beneficial in places where wild animals are considered very abundant or agricultural pests, as is the case for capybara in the Pantanal and collared peccaries in southeastern Bahia. Nevertheless, the projection of production, expenses, and annual incomes show that the ranching system for both capybara (table 11.3) and collared peccary (table 11.6) will only be economic feasible if harvest levels are increased. Such a change in policy will only be possible through studies of the ecology of natural populations, aimed at improving landscape-scale management to maximize carrying capacity. However, these studies are very expensive, and they must be developed in each and every place where the breeders intend to establish an extensive system.

Because of the high cost of the intensive system and the lack of knowledge in the extensive system, Brazilian farmers are choosing the semi-intensive production system to breed wild animals. Nevertheless, it is still necessary to improve husbandry practices to increase production and to lower costs in this system. We believe that the establishment of an efficient semi-intensive exploitation system of wild animals will help create an economic alternative for land use that in turn will help to conserve the natural ecosystem and its wildlife.

12

Economic Analysis of Wildlife Use in the Peruvian Amazon

RICHARD E. BODMER, ETERSIT PEZO LOZANO, AND TULA G. FANG

Successful conservation programs often depend on practitioners and researchers integrating the biological limitations of species with the social and economic realities of people (Barbier 1992). Indeed, there has been considerable dialog about the need to extend the reach of conservation biologists into the realms of social and economic analysis (McNeely 1988). The need to integrate biology with social and economic considerations is particularly relevant in tropical countries (Plotkin and Famolare 1992).

Conservation efforts must deal with all levels of wildlife use from local hunters to international trade. However, wildlife conservation efforts will only be successful if they focus on the level of wildlife use that ultimately influences hunting pressure. Economic analyses help determine what level is most critical. For example, there is debate whether conservation efforts should be directed at the level of national and international trade and their corresponding policies, or at the local level and community-based actions (Swanson 1992). This debate is particularly relevant in tropical countries where funds for wildlife conservation are limited. The scarce funding must be used efficiently to have an impact on conservation.

This article uses economic analyses of wildlife use in the Peruvian Amazon to help determine where conservation efforts should be directed. Should the focus be directed toward rural hunters who harvest wildlife, toward the national meat trade in urban markets, or toward the international pelt trade? Economic analyses also identify factors that drive overhunting and strategies that can be used to reduce overhunting of economically valuable species.

Wildlife and wildlife products in tropical forests are used for subsistence food, local meat markets, and national and international trade. Subsistence and commercial use of wildlife has traditionally been part of the economy in the Peruvian Amazon (Pinedo-Vasquez 1988; Dourojeanni 1990). Currently, wildlife is an important resource for the regional economy in terms of subsistence food, local meat sales,

and international pelt exports. People from both the rural and urban sectors are involved with the commercial use of wildlife, with some uses being legal and others illegal. In addition, the peccary (*Tayassu pecari* and *T. tajacu*) pelt trade in the Peruvian Amazon is economically important both nationally and internationally (Bodmer et al. 1990).

Conserving wildlife in the Peruvian Amazon will have socioeconomic consequences because of the importance of wildlife to the rural sector, regional economy, and international trade. Restricting wildlife use will have negative economic consequences to the people who subsist on and commercialize wildlife products. Likewise, overhunting will result in negative economic returns and a loss of biodiversity. This paper is based on the premise that the well-managed use of wildlife will result in continued subsistence benefits and economic returns, and will contribute to biodiversity conservation (Freese 1997a).

BACKGROUND: LEGAL STATUS OF WILDLIFE HUNTING IN THE PERUVIAN AMAZON

Due to excessive hunting during the professional pelt period between 1940 and 1973, the Peruvian Ministry of Agriculture enacted a national management law in 1973 that prohibited professional pelt hunting in the Peruvian Amazon. This legislation permitted the use of certain wildlife species for subsistence by rural Amazonians (Bodmer 1994). Skins obtained from these species could be commercialized if the pelt originated from an animal killed by subsistence hunters. The law prohibiting professional pelt hunters was apparently successful in curbing the pelt trade (COREPASA 1986; Bodmer, Fang, and Moya 1988b).

Subsequently, in 1976 the Ministry of Agriculture noted increasing sales of wildlife meat in the city markets of Iquitos. To curb professional meat hunting, the Ministry of Agriculture enacted a management law in 1979 that restricted sale of wildlife meat to cities under 3,000 inhabitants. Again, only animals listed as sources of subsistence wildlife meat could be commercialized. While the professional meat law appears to have curbed hunting, its implementation was fraught with difficulty. Management authorities could not effectively control small unlicensed meat vendors in city markets. The demand of wild game meat from urban populations added to the problem of controlling meat sales. The 1979 law restricting wildlife commercialization in city markets has had little effect on actual wildlife meat sales, and such meat is currently openly sold in city markets.

More recently there have been a number of legislations in Peru dealing with wildlife use. Some promote captive breeding, while others are apply to hunting in timber and conservation concessions.

METHODS

Four representative sites in the Department of Loreto, northeastern Peru, were used to evaluate hunting by rural people (fig. 12.1). The major landscape features of

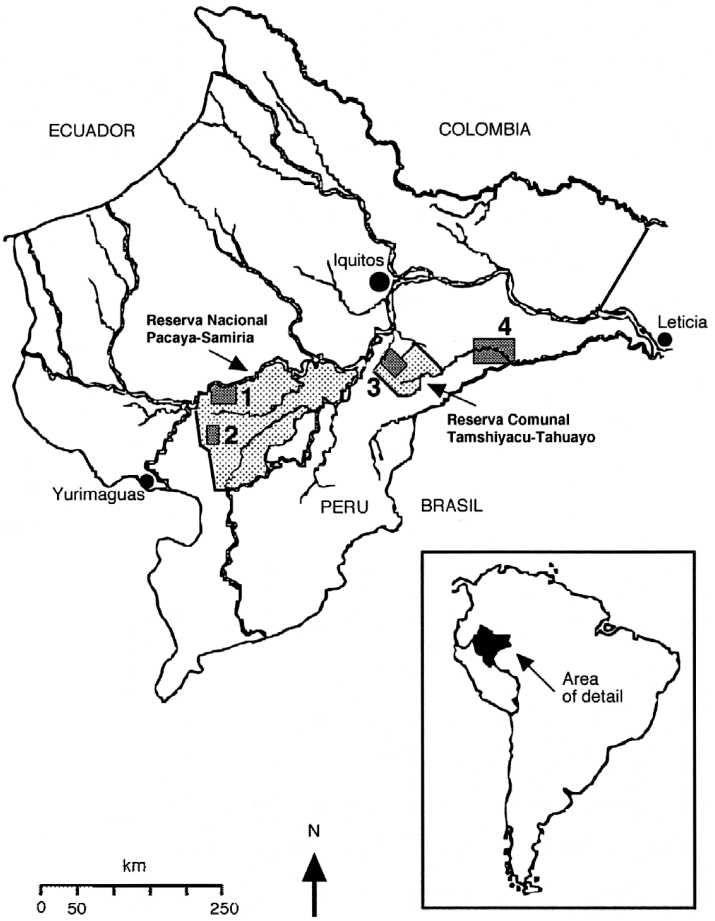

FIGURE 12.1 Map of Loreto, Peru, showing the four representative sites: flooded forest with heavy hunting (1); flooded forest with light hunting (2); upland forest with heavy hunting (3); and upland forest with light hunting (4). The map also shows the city of Iquitos.

Loreto include the seasonally flooded (*várzea*) forests and the nonflooded upland (*terra firme*) forest. Two representative sites were in seasonally flooded forests and two in upland forests. The two upland sites were located in and around the Reserva Comunal Tamshiyacu-Tahuayo in the forests that divide the Amazon and Yavari valleys (fig. 12.1). The principal forms of habitat in upland forest include vegetation on hill tops, in stream valleys, on inclines, and in backswamps.

The two flooded forest sites were in and around the Pacaya-Samiria National Reserve. Water level in the flooded forests of the Pacaya-Samiria National Reserve vary by approximately 11 meters between June and October. The principal forms of vegetation consists of two forested areas (high and low *restingas*), one area intermediate between forest and open habitat (*chavascal*), and palm and nonpalm swamps.

Data on hunting pressure were collected in the two flooded forest sites and the two upland forest sites. To cover the range of hunting pressures in Loreto, each forest type had one site with greater hunting (heavily hunted) and another site with lesser hunting (lightly hunted).

HUNTING PRESSURE

Information on hunting pressure for all mammalian species was obtained by involving hunters in data collection in all four representative areas, totaling approximately 100 hunters and their families. Studies were run for a minimum of three years at each site. Information was collected continuously by the hunters and recorded by wildlife extensionists every few months. Hunting pressure was determined by recording the number of animals hunted in each area from skulls collected by hunters and from hunting registers. An error margin was added to the calculation of hunting pressure to account for animals that were hunted but not recorded either by skulls or registers. The error was calculated by determining which local hunters were not participating in the study. The error margin varied between study sites.

The total number of mammals hunted annually in Loreto was estimated using wildlife harvests from the four representative sites and the annual peccary pelt harvests. We assumed that the annual peccary pelt harvests were a realistic estimate of the total number of peccaries harvested in Loreto, an assumption that appears valid (Pacheco 1983). The numbers of peccary pelts discarded by Peruvian hunters appears to be balanced by the number of pelts entering Peru illegally from Colombia, Ecuador, and Brazil. We used the proportional harvests in the four representative sites to estimate the annual harvests of other mammalian species solving PH/PP = SPH/SPL, where PH is the peccary harvest in each of the four representative sites, PP the peccary pelt exports from Loreto, SPH the harvest in each of the four representative sites of the species being estimated, and SPL the estimated annual harvest in Loreto of that species. The peccary pelt harvest in the Department of Loreto was estimated by government records of peccary pelt exports to Lima. This trade is closely monitored since peccary pelts exported out of Peru must have a Departmental certificate before being issued a CITES certificate.

ECONOMIC ANALYSIS

The economic analysis of wildlife use was done for both the rural and urban sectors. The rural sector consisted of the transactions of wildlife meat prior to being sold by market vendors. This sector includes hunters, carriers, and intermediaries. The urban sector consists of market vendors and urban consumers. Market vendors usually buy meat from carriers or intermediaries and then sell meat to the public in city markets.

To evaluate the economic value of wildlife meat in the rural areas, prices of meat

sales in twenty towns and villages were determined from informal interviews at representative sites along the Rio Yavari, Rio Tigre, Rio Marañon, and Rio Amazonas. There are numerous ways that wildlife meat is transacted by the rural sector; these methods are outlined in Bendayán (1991). Hunters usually have to pay transportation costs and/or intermediaries in order to sell wildlife meat in Iquitos, the largest city in Loreto. The transportation and intermediary costs for hunters varies primarily depending on (a) distance to markets and (b) knowledge hunters have about markets. From informal interviews conducted at the four representative sites, we estimated that transportation and intermediary costs to hunters were between 40 to 80% of the income earned from meat sales, with an estimated average of 60%.

To analyze the economic importance of wildlife meat in the urban sector, we conducted a year-long survey of wildlife meat sales in the city markets of Iquitos, the capital of the Department of Loreto with a population of around 274,759 inhabitants (INEI 1993). For comparison, in rural Loreto, which covers an area of 368,851 km^2, there are around 412,523 inhabitants, of which 123,663 live in towns (INEI 1995). Wildlife meat sales were surveyed in the Mercado Belén and Mercado Modelo in Iquitos. Bendayán (1991) showed that 91% of meat sales in Iquitos took place at these two markets, with the other markets in Iquitos only selling small amounts. These sales were recorded from January through December 1996 for all months expect May. Sales for May were extrapolated from the averages of April and June.

Surveys were conducted through interviews with market vendors. All market vendors were surveyed between 6 and 11 A.M. daily Monday through Saturday. Markets were closed on Sundays. During some months surveys were not conducted every day. During these months the averages from days surveyed were used for days not surveyed.

Market vendors participated willingly in the study. They were informed of the purpose of the study and that their names would be kept confidential. During the year of the survey there were no decommissions of wildlife meat from the markets, and market vendors did not fear loosing their products.

Information obtained during the surveys was recorded separately for each species and included the kilograms sold daily and the prices of sales. Prices were determined for meat bought and for meat sold in the markets of Iquitos. Meat bought represents the price paid to the rural sector, including the hunters, carriers, and middlemen. The difference between the price bought and sold represents the profit to market vendors. The number of vendors selling wildlife meat during the day was also recorded.

The number of individual animals sold at market was estimated by converting the kilogram of meat sold to individuals. Wildlife meat is sold in four distinct forms in Iquitos: *fresco* (fresh), *ahumado* (smoked), *seco salado* (dry salted), and *fresco salado* (fresh salted). Dried salted and smoked meat had a conversion of 40% of live weight, whereas fresh and fresh salted had a conversion of 60% of live weight. Average body weights were used for each species and the total number of individuals of each species sold annually in Iquitos was then estimated.

RESULTS

HUNTING PRESSURE

The site with greatest annual hunting pressure was the heavily hunted upland forest (255 individuals/100 km^2), followed by the heavily hunted flooded forest (133 individuals/100 km^2). The flooded forest with lighter hunting had slightly more mammals harvested per year than the upland forest with lighter hunting (73 and 54, respectively). In both upland forests and the lightly hunted flooded forest, ungulates were the most frequently hunted group (Bodmer and Pezo 2001). In the heavily hunted flooded forest, rodents were the most frequently hunted group.

Ungulates had much greater amounts of biomass extracted than the other species in all four sites and were the most important species for meat. In terms of biomass extracted, rodents were the next most important, followed by primates, marsupials, edentates, and carnivores. White-lipped peccary, collared peccary, and lowland tapir (*Tapirus terrestris*) had the greatest amount of meat extracted from the representative forest sites (Bodmer and Pezo 2001).

ECONOMICS OF WILDLIFE FOR THE RURAL SECTOR OF LORETO

There are an estimated 113,000 mammals hunted in Loreto annually. The average annual white-lipped peccary harvests are 14,000; collared peccary, 20,000; brocket deer (*Mazama* spp.), 5,000; lowland tapir, 4,000; paca (*Agouti paca*), 17,000; agouti (*Dasypracta fuliginosa*), 10,000; and primates, 28,000. Using these estimates, the value of wildlife meat for the rural sector is estimated at US$ 1,131,910 annually (Bodmer and Pezo 2001). Lowland tapir has the greatest annual meat value for the rural sector of US$ 291,235, followed by collared peccary at US$ 268,853, white-lipped peccary at US$ 237,512, primates at US$ 104,617, and paca at US$ 75,447.

THE URBAN MEAT MARKET

The number of individuals of each species annually sold in the Iquitos meat markets was estimated from the market surveys. A total of sixteen mammal species were sold during the study. The greatest number of individuals sold in the Iquitos market were from collared peccary with an estimated 2,542 individuals sold annually, followed by white-lipped peccary with 2,316 individuals, and paca with 1,860 individuals (table 12.1). There were fewer individuals of the other large wildlife species sold in the Iquitos meat markets with an estimate of only 232 red brocket deer (*M. americana*), 110 wooly monkeys (*Lagothrir lagothrica*), 76 grey brocket deer (*M. govazovoira*), 76 capybara (*Hydrochaeris hydrochaeris*), and 43 lowland tapir.

An estimated 72,972 kg of wildlife meat was sold in the Iquitos meat markets during 1996. By weight, the most frequently sold meat was white-lipped peccary, contributing 42.6% of all wildlife meat sales. The next most frequently sold was col-

TABLE 12.1 Estimated Number of Individual Mammals Sold in the Iquitos Markets During 1996

SPECIES	FRESH MEAT KG (INDIVIDUALS)	FRESH SALTED KG (INDIVIDUALS)	SMOKED KG (INDIVIDUALS)	DRY SALTED KG (INDIVIDUALS)	BODY WEIGHT KG	NUMBER OF INDIVIDUALS
Tayassu pecari	338 (17)	207 (10)	1,925 (146)	28,295 (2,143)	33	2,316
Tayassu tajacu	461 (31)	149 (10)	2,277 (228)	22,735 (2,273)	25	2,542
Mazama americana	341 (17)	57 (3)	428 (32)	2,373 (180)	33	232
Mazama gouazoubira	75 (8)	42 (5)	79 (13)	300 (50)	15	76
Tapirus terrestris	110 (1)	208 (2)	83 (1)	2,540 (40)	160	43
Agouti paca	1,115 (206)	162 (30)	2,354 (654)	3,491 (970)	9	1,860
H. hydrochaeris	560 (31)	354 (20)	165 (14)	134 (11)	30	76
Dasyprocta fuliginosa	18 (6)	8 (3)	5 (2)	101 (51)	5	62
Lagothrix lagothrica	0	15 (2)	25 (6)	451 (102)	11	110
Ateles spp.	3 (1)	0	0	13 (4)	7.8	5
Alouatta seniculus	0	0	0	8 (2)	8	2
Dasypus novemcinctus	45 (15)	13 (4)	36 (18)	17 (9)	5	46
Didelphis marsupialis	0	5 (8)	0	0	1	8
Tamandua tetradactyla	5 (2)	7 (2)	0	0	5	4
Nasua nasua	0	0	0	10 (8)	3	8
Potos flavus	0	0	0	3 (2)	3	2
Total					7,392	

Note: Number of individuals was estimated from (meat factor) (body weight). A factor of 2.5 or 40% of live weight was used for dried salted and smoked meat, and 1.66 or 60% for fresh and fresh salted meat (Bendayán 1991).

lared peccary, contributing 35.8% of sales. Combined, peccaries dominated the wildlife meat market contributing 78.4% of all sales. Other species that were commonly sold included paca (9.5%), red brocket deer (4.4%), lowland tapir (4%), and capybara (1.8%). Other species contributed less than 1% of wildlife meat sales.

Fresh meat made up 4.2% of wildlife meat sales; smoked, 10.2%; dry salted, 83.8%; and fresh salted, 1.7%. Paca and capybara were the species most frequently sold as fresh meat and paca, collared peccary, and white-lipped peccary as smoked meat. The two peccary species dominated the dry salted sales, and capybara was the species most frequently sold as fresh salted.

Total profits for the rural sector from meat sales in Iquitos were estimated at US$ 156,040 annually. Of this amount, approximately US$ 93,624 were profits for hunters, with the remainder going to carriers and intermediaries. The white-lipped peccary brought the greatest profits to the rural sector with an estimated earnings of US$ 69,206, followed by collared peccary at US$ 57,694, paca at US$ 14,464, brocket deer at US$ 8,080, and lowland tapir at US$ 4,493 (table 12.2). In terms of meat types the greatest profit to the rural sector were from the sale of dried salted meat, which had an annual earning of US$ 132,439, followed by smoked meat at US$ 17,700, fresh meat at US$ 4,649, and fresh salted at US$ 1,252.

Total profits to the urban meat vendors were estimated at US$ 94,228 annually. There were twenty meat vendors in the two markets surveyed, resulting in an aver-

TABLE 12.2 Annual Profits and Consumer Values of Wildlife Meat Sales in the Markets of Iquitos

SPECIES	PROFIT FOR RURAL SECTOR	PROFIT FOR URBAN SECTOR	CONSUMER VALUE
Tayassu pecari	69,206	37,837	107,043
Tayassu tajacu	57,694	32,382	90,076
Tapirus terrestris	4,493	3,022	7,515
Mazama americana	7,021	4,375	11,396
Mazama gouazoubira	1,059	721	1,780
Agouti paca	14,464	13,795	28,259
Dasyprocta fuliginosa	121	220	341
Hydrochaeris hydrochaeris	993	1,001	1,994
Dasypus novemcinctus	166	219	385
Lagothrix lagothrica	789	630	1,419
Ateles spp.	21	16	37
Alouatta seniculus	13	10	23
Total	156,040	94,228	250,268

Note: Profits for the rural sector include hunters, carriers, and middlemen. Profits for the urban sector include the market vendors. Consumer value or total value is the monetary value consumers paid for wildlife meat. All values are in $US.

age annual income per vendor at US$ 4,711 or US$ 393 per month. White-lipped peccary brought the greatest annual profits for the market vendors at US$ 37,837, followed by collared peccary at US$ 32,382, paca at US$ 13,795, brocket deer at US$ 5,096, and lowland tapir at US$ 3,022. The greatest profit to the market vendors was from the sale of dried salted meat, which had an annual earning of US$ 71,024, followed by smoked meat at US$ 14,736, fresh meat at US$ 6,885, and fresh salted meat at US$ 1,583.

Consumers spent US$ 250,268 annually on wildlife meat in the Iquitos markets. This amount reflects the total value of wildlife meat sales in Iquitos. White-lipped peccary had the greatest value, followed by collared peccary, paca, brocket deer, and tapir. Dried salted meat had the greatest total value followed by smoked meat, fresh meat, and fresh salted meat.

The amount of wildlife meat sold in Iquitos has increased over threefold during the ten-year period from 1986 to 1996, amounting to an increase of 48,911 kg of meat (1986 survey of the markets is from Bendayán 1991) (table 12.3). The largest increase in meat sales was for white-lipped peccary, which has increased by 27,447 kg/year, followed by collared peccary by 14,888 kg/year, brocket deer by 2,468 kg/year, and paca by 2,047 kg/year.

COMPARING THE RURAL AND URBAN SECTORS

Wildlife harvests in the rural sector were compared to wildlife sold in Iquitos. Overall, only 6.5% of the mammals hunted in Loreto were sold in the markets of Iquitos (table 12.4). The remainder was used in the rural sector as subsistence food or were

TABLE 12.3 Differences in the Sale of Wildlife Meat in the Markets of Iquitos Over a Ten-year Period

SPECIES OR SPECIES GROUP	KG SOLD IN 1986	KG SOLD IN 1996	DIFFERENCE
Tayassu pecari	3,654	31,101	+27,447
Tayassu tajacu	11,211	26,099	+14,888
Mazama spp.	1,305	3,773	+2,468
Tapirus terrestris	1,584	2,905	+1,321
Agouti paca	4,855	6,902	+2,047
Dasyprocta fuliginosa	298	130	–168
Hydrochaeris hydrochaeris	572	1,332	+760
Primates	315	536	+221
Marsupials and Edentates	180	22	–158
Carnivores	36	15	–21
Total	24,010	72,921	+48,911

TABLE 12.4 Percent of Mammals Hunted in Loreto That Are Sold in Iquitos Markets Versus the Percent Used in the Rural Sector for Subsistence Food or for Sale in Villages and Towns

SPECIES OR SPECIES GROUPS	PERCENT OF HARVEST SOLD IN IQUITOS	PERCENT OF HARVEST USED FOR SUBSISTENCE OR SOLD IN RURAL AREAS
Tayassu pecari	16	84
Tayassu tajacu	13	87
Mazama spp.	6	94
Tapirus terrestris	1	99
Agouti paca	11	89
Dasyprocta fuliginosa	0.6	99.4
H. hydrochaeris	4	96
Primates	0.4	99.6
Marsupials and Edentates	1	99
Carnivores	0.1	99.9
Total	6.5	93.5

sold in villages and towns. White-lipped peccary had the greatest proportion of its harvest sold in Iquitos with 16% going to market, followed by collared peccary with 13%, paca with 11%, and brocket deer with 6%. The lowland tapir had only 1% of its harvest sold in Iquitos, while primates only had 0.4%.

SUPPLY AND DEMAND OF MEAT TYPES

The type of meat sold was used to examine supply and demand relationships. For hunters there was no supply and demand relationship between the price paid to the rural sector and the supply of meat types (fig. 12.2a). In contrast, market vendors were driven by supply and demand of meat types (fig. 12.2b). Fresh and smoked meat has a small supply and prices sold to consumers were high. On the other hand, supply of dried salted meat was large, and prices sold to consumers were lower.

Hunters and market vendors see the economics of wild game meat from different perspectives. Hunters are concerned with the number of animals killed in terms of individuals because animals are hunted as individuals. In contrast, market vendors are interested in the kilogram of meat and the type of meat since their earnings depend on the amount of meat bought and sold.

For example, the price paid to hunters for peccary and deer meat is about the same in terms of the kilogram per live animal whether it is fresh, smoked, or dried salted. This relationship is important for the hunters since the price paid for an animal hunted is about the same. Therefore hunters consider effort and logistics involved in preparing the type of meat they sell. Fresh meat has little effort in terms

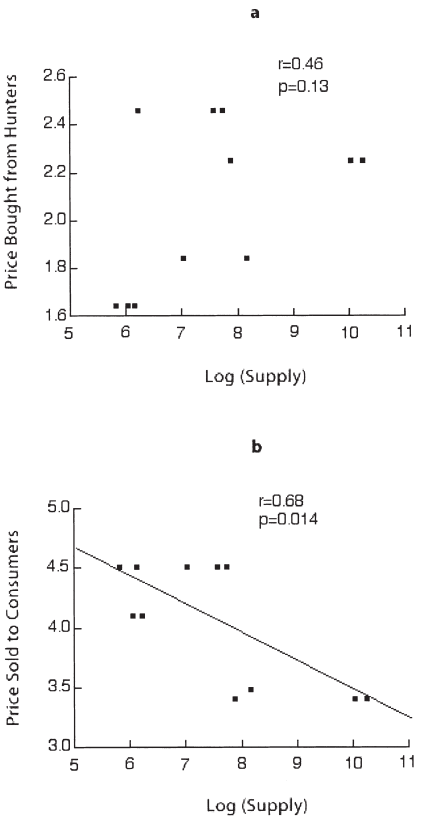

FIGURE 12.2 Supply and demand relationship of meat bought and sold in the Iquitos meat markets.

of preparation but can only be sold if the animals are hunted close to the city. Smoked meat has little financial input but takes much effort in time required to smoke meat and maintain it in a sellable condition. Dried salted meat takes financial input for salt but much less effort in time spent preparing meat. Also, salted meat usually lasts longer than smoked.

Most peccary and deer meat is prepared as dried salted since these species are rare in forests close to the city and are usually hunted in remote areas at distances too far from the city to sell as fresh meat. Hunters receive considerably more money for fresh paca than for smoked or dried salted paca. Thus, hunters prefer to sell fresh paca meat. Paca can still be hunted in areas close enough to the city to be sold fresh.

SEASONAL CHANGES IN SUPPLY AND DEMAND

Supply and demand relationships can also be examined between low- and high-water seasons for the sale of peccary meat in Iquitos. Substantially more peccary meat

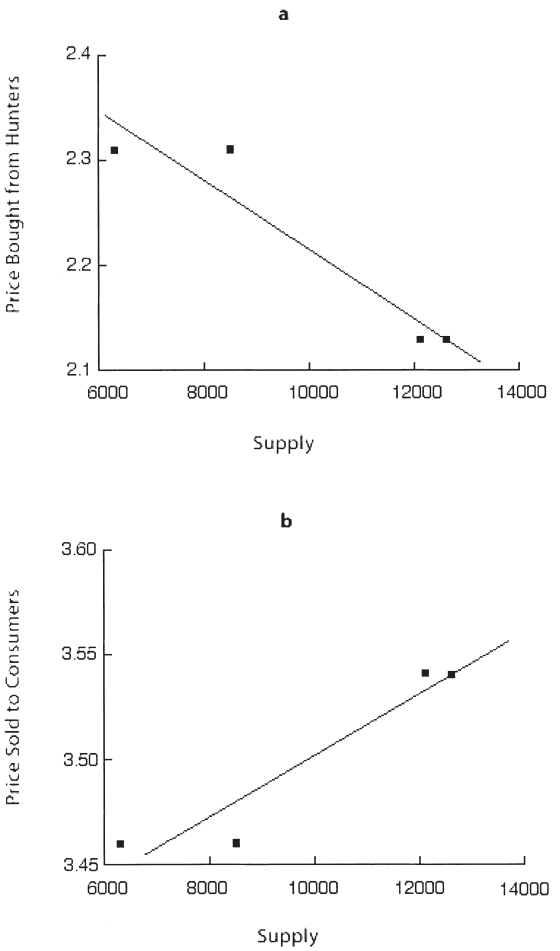

FIGURE 12.3 Supply and demand relationships of peccary meat bought and sold in the Iquitos meat markets between different seasons.

was sold in Iquitos during the high-water season, with 24,719 kg sold during high water and 14,796 kg sold during low water.

The seasonal changes in the prices paid to the rural sector for peccary meat appear to be driven by supply and demand relationships. When the supply of peccary meat decreases, the price paid to the rural sector increases, and when the supply increases, the price paid to the rural sector decreases (fig. 12.3a).

In contrast, the urban sector does not show this supply and demand relationship. As the supply of peccary meat increases, the price sold to the consumer also increases, and when the supply of peccary meat decreases, the price sold to the consumer also decreases (fig. 12.3b). What appears to be driving the seasonal price paid by the consumer for peccary meat is the total amount of meat products available at

market. During the dry season when peccary meat supplies are low, the total supply of meat products is at its greatest because the supply of fish is at its highest. During the flooded season the supply of peccary meat is at its greatest, but the total supply of meat products is at its lowest because of a decrease in the supply of fish.

VALUE OF THE PECCARY PELT TRADE

Pelts from species listed as subsistence wildlife can be legally exported for commercial profits from Peru if the species is not listed on Appendix I of CITES. However, in Peru peccary pelts are the only legally exported mammalian pelt that has any significant economic importance. Peccary pelts are sold principally to West Germany, Italy, Japan, and the United States (table 12.5). Peccary leather is used mainly for gloves, shoes, belts, and watchbands. The peccary pelt market is relatively stable because peccary products have traditionally been used by continental Europeans. Peccary leather is prized for its softness and durability, two qualities that are rarely found in a single leather.

The peccary pelt trade has economic value to rural hunters. Rural hunters in Loreto usually sell peccary pelts between US$ 2 to US$ 5 and obtain approximately US$ 74,500 annually. However, the total value of peccary meat for hunters is around US$ 633,265 annually, including the value of both subsistence food and market sales. Thus, pelts only contribute around 11% of the total value of peccaries for rural hunters.

Peccary pelts are bought by intermediaries who air cargo the skins to tanneries in Lima and Arequipa. The tanneries carry out the initial tanning process, which involves rehumidifying, degreasing, and chrome tanning. Peccary hides are then exported at approximately US$ 16 each. The national intermediaries and tanneries have substantial costs because of air transportation, tannery equipment, supplies, labor, government taxes, and CITES permits. Profits for the pelts are approximate-

TABLE 12.5 Exports of Collared and White-lipped Peccaries from Peru

COUNTRY	PRODUCT	COLLARED PECCARY	WHITE-LIPPED PECCARY
Germany	Skins	163,175	83,572
	Gloves	449	1,540
Italy	Skins	69,239	38,693
Japan	Skins	9,822	6,080
USA	Skins	615	200
	Specimens	20	15
Uruguay	Skins	256	64
France	Gloves	150	—
Total		243,726	130,164

ly US$ 4 to US$ 7 per hide, resulting in total profits to the national peccary pelt industry of around US$ 187,000 annually and a total value of US$ 544,000.

A substantial number of peccary pelts are exported to Germany, Italy, and Japan each year. Peccary is an expensive leather, with a pair of peccary gloves currently retailing in Europe at around US$ 125 a pair. A single pelt is usually used for a pair of gloves. There are substantial costs involved in preparing a pair of gloves. These costs include the costs of finishing the hides, cutting and sewing the gloves, transporting the hides and finished products, and the costs of CITES permits and customs. The net value of a peccary pelt is estimated at around US$ 40 after subtracting all the costs. Profits made by the international leather industry on peccary pelts from Loreto are around US$ 1,360,000 annually, with a total value of around US$ 4,250,000.

Combined, profits of US$ 1,621,500 are earned annually from peccary pelt sales in Loreto, with 5% earned by rural hunters, 12% by the national pelt industry, and 83% by the international leather industry. The total value of the peccary pelt trade is estimated at US$ 4,868,500, with 1.5% contributed by the rural sector, 11.1% by the national pelt industry, and 87.3% by the international leather industry.

TOTAL ECONOMIC VALUE OF THE WILDLIFE HARVESTS IN LORETO

The total annual economic value of wildlife harvests from Loreto is estimated at around US$ 6,250,678 for all three socioeconomic sectors combined; rural, urban and international (table 12.6). The rural sector obtains an estimated 21.8% of the to-

TABLE 12.6 Total Annual Economic Value of Wildlife Harvests in Loreto, Peru, by Socioeconomic Sector

SOCIOECONOMIC SECTOR	ECONOMIC VALUE	PERCENT
Rural sector		
Subsistence, eat	1,131,910	18.1
City market meat sales	156,040	2.5
Peccary pelt sales	74,500	1.2
Subtotal	1,362,450	21.8
Urban sector		
City market meat sales	94,228	1.5
Peccary pelt sales	544,000	8.7
Subtotal	638,228	
European sector		
Peccary pelt sales	4,250,000	68.0
Total	6,250,678	100

Note: All values are in $US.

tal value, the urban sector in Peru 10.2% and the international sector obtains the greatest proportion at 68%.

The meat markets in Iquitos only account for 3% of the total estimated value of wildlife harvests. Subsistence food and sales in small villages and towns in the rural sector account for 18.1% of the total estimated value. The greatest value is for the peccary pelt trade, which accounts for 79%. However, most of the value of the peccary pelt trade is in the international sector, not in Peru.

DISCUSSION

Economic value of different wildlife species varies considerably between the rural and urban sectors. In the Iquitos markets the lowland tapir and primates made up very little of the annual value. In contrast, in the rural sector, lowland tapir and primates are very important sources of wildlife meat.

Results from this study clearly show the importance of the rural sector in the use of wildlife meat. The results also show that the Iquitos wildlife meat market only consumes a small part of the wildlife harvests in Loreto. Totally prohibiting the wildlife meat markets in Iquitos would only result in a 6.5% reduction of the total harvests of Loreto. Legalizing the wildlife meat markets might promote a further uncontrolled and unmanaged hunt, which would lead to greater overharvesting and more local extinctions. In Iquitos there has been a threefold increase in wildlife meat sales over the past ten years.

These results show the importance of managing wildlife hunting with a focus on the rural sector, not the Iquitos meat markets. Management programs directed at hunters, villages, and towns of rural Loreto are imperative for the success of wildlife management in the Peruvian Amazon.

Management of wildlife in Loreto must reduce overhunting. Previous studies in the four representative areas of Loreto have shown that primates and lowland tapir are usually overhunted, while peccaries, deer, and large rodents are usually not (Bodmer, Eisenberg, and Redford 1997). Therefore wildlife management programs need to reduce the hunting of primates and lowland tapir and maintain a sustainable harvest of peccaries, deer, and large rodents.

There will be short-term economic costs if overhunting is reduced in Loreto. These economic costs can be estimated by examining what happens if the hunting of primates, lowland tapirs, carnivores, edentates, and marsupials is stopped, and the current harvest levels of peccaries, deer, and large rodents are maintained (Bodmer and Lozano 2001).

This management approach would have only minor economic costs to the meat markets in Iquitos, with these costs estimated at 3.6% of the economic value of the meat markets. In contrast, the short-term economic costs to the rural sector would be significant, with the rural sector having a 36.4% decrease in the economic benefits from wildlife hunting, or an annual loss of US$ 412,978 (Bodmer and Lozano 2001).

If management programs are not set up, there will be further overhunting and an increase in local extinctions. It is likely that these local extinctions would result in species extinctions and an overall loss of biodiversity to Peru. Thus, the economic costs to the rural sector must be weighed against the biodiversity loss to Peru.

ECONOMICS OF THE CURRENT PELT TRADE

Professional pelt hunting is prohibited in Peru, and peccary pelts exported from Loreto should only be collected by subsistence hunters. Pelt hunters obtained a relatively good income from peccary skins in the 1950s, 1960s, and early 1970s, and peccary pelt exports from the Peruvian Amazon exceeded 200,000 skins/year (Grimwood 1969). Since the pelt trade has become both less lucrative for hunters and more strictly controlled, exports have fallen to the current level of around 34,000 skins/year.

Peccary pelts from the Peruvian Amazon are usually of poor quality and can not be used for such large leather products as jackets but only for such smaller products as gloves, shoes, belts, and watchbands. The poor quality of peccary pelts results from a combination of causes that include (a) epidermal parasites, especially ticks, infecting free-ranging animals; (b) scars from intraspecific aggression; (c) shot holes produced by the 16-gauge shotguns used by most rural hunters; (d) cuts and holes caused by the rough skinning by rural hunters; (e) blisters caused by drying skins in direct sunlight; and (f) mold and pest damage caused by storing pelts in the humid Amazonian climate.

Rural hunters, however, have little interest in improving their processing techniques because the price paid to hunters for pelts does not make it profitable for them to improve their methods. The international tanneries and leather manufactures, on the other hand, are very interested in getting better quality pelts.

Increasing the price paid to hunters for pelts as a strategy to increase the quality of pelts might add value for hunters and lead to improved pelt quality. However, this increase can only be done sustainably if peccary hunting is well managed. If pelt prices are increased without improved management programs, then hunting pressure on peccaries might exceed sustainable levels and cause overhunting of peccary populations. On the other hand, if added value for peccary pelts is provided to hunters who manage their hunting practices, especially through community-based approaches, this added value could be an incentive for better wildlife management practices. Indeed, added value for peccary pelts could act as a broad incentive for community-based wildlife management.

HUNTING PRESSURE AND ECONOMIC VALUE

In order to focus wildlife management programs, it is imperative to understand what factors are influencing hunting pressures. In the case of the Peruvian Amazon, there is a clear disjunct between the realized hunting pressure and the eco-

nomic value of wildlife. Hunters are harvesting species primarily for the value of subsistence meat, secondarily for the value of meat sales in the urban markets, and lastly for the value of peccary hides. In contrast, the greatest value of the wildlife is in the international market of peccary hides. Still, the international pelt trade is not a major influence in determining hunting pressure of wildlife in the Peruvian Amazon. Likewise, the urban meat market is influencing hunting pressure to a much lesser degree than the use of wildlife meat in the rural sector.

The success of conservation efforts in the Peruvian Amazon will depend on the success of working with the rural hunters. This effort includes the sale of wildlife meat in villages and towns. One promising management strategy that focuses on wildlife management with rural hunters is community-based wildlife management (Bodmer and Puertas 2000). Community-based management is focused at the level that can actually influence hunting pressure.

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