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Patterns of Use and Hunting of Turtles in the Mamirauá Sustainable Development Reserve, Amazonas, Brazil

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Turtles have been, and continue to be, one of the principal sources of protein from the wild for indigenous and riverine populations in Amazonia. Pressure on the resource increased with the arrival of the first European colonizers, who exploited almost all species of Amazonian quelonians (Ayres and Best 1979). The most heavily exploited species was *Podocnemis expansa*, sought after for its size, eggs and for the quality of its meat.

Several authors have reported on the exploitation of female turtles and their eggs, especially those in the genus *Podocnemis* (Bates 1863; Smith 1979a; Fachín-Terán 1994; Fachín-Terán, Chumbe, and Taleixo 1996; Rebelo and Lugli 1996; Landeo 1997). Turtles are more vulnerable during their annual reproductive period than at other times, and the protection of eggs and nesting areas is considered a high priority. Turtle exploitation levels have been quantified and recorded through research projects of short duration (Bates 1863; Smith 1979a; Moll 1986; Polisar 1995; Fachín-Terán, Chumbe, and Taleixo 1996; Thorbjarnarson, Perez, and Escalona 1997; Landeo 1997), but few studies have monitored the capture of Amazonian turtles (Rebelo and Lugli 1996; Fachín-Terán, Vogt, and Thorbjarnarson 2000). In combination with data on harvest levels, long-term research projects describing the characteristics of turtle populations will enable us to evaluate the biological impact of current harvests.

Historically, populations of three species of *Podocnemis* that occur in the Mamirauá Sustainable Development Reserve (Reserva de Desenvolvimento Sustentável Mamirauá, or RDSM) were abundant. Bates (1863) reports that from this section of the Solimões River, in the neighborhood of Ega (present-day Tefé), and from the Madeira River, approximately forty-eight million *P. expansa* eggs were collected annually between 1848 and 1859, for exportation to Pará.

Pressure on the resource continues to this day, bringing P. expansa to the brink of extinction in this part of the Amazon. Interviews with the oldest inhabitants of the area indicate that populations of two other species in the genus, *Podocnemis unifilis* and *Podocnemis sextuberculata*, have also diminished drastically because of to the continuous hunting pressure to which they have been subjected. In a recent assessment by the IUCN Freshwater Turtle and Tortoise Specialist Group, *P. unifilis*, *P. sextuberculata* and *Geochelone denticulata* were placed on Appendix I of CITES as endangered species, and *P. expansa* on Appendix II as a species at low risk but dependent on conservation (IUCN 1996).

Podocnemis expansa was placed on Appendix II rather than Appendix I because for the past twenty years it has been under an intensive conservation program by the Brazilian government. The program includes nesting beach protection and the release of over two

million hatchlings per year into the wild. However, there is no scientific proof that this program is working, and in fact populations are diminishing within some of the protected reserves, notably Rio Trombetas Biological Reserve. Throughout the remainder of its range in other countries, *P. expansa* populations have been drastically reduced (e.g. Peru; Soini 1997), and remain at high risk of local extinction.

The present study examined turtle hunting patterns in the RDSM. These patterns include species, number and size of individuals extracted, hunting methods and season, and habitats where turtles are most frequently captured.

METHODS

The study was carried out in the Jarauá sector of the RDSM. The reserve covers 1,124,000 ha between the Japurá, Solimões and Auti-Paraná rivers, near the city of Tefé, Amazonas state, Brazil (03º 08'S, 64º 45' W and 2º 36' S, 67º 13'W). Crampton et al. (this volume) give a detailed description of the reserve.

Information on species, number, sex, weight, method, habitat and use of turtles was gathered in the communities of São Raimundo de Jarauá (2º 51'S 64º 55'W), Nova Colômbia (2º54'S 64º54'W), Novo Pirapucu (2º53'S 64º51'W) and Manacabi (2º50'S 54º52'W) through both interviews and direct observations. These communities were selected because they are located near turtle-nesting beaches and near lakes designated for preservation, personal use or commercialization on the Japurá river and the Jarauá Paraná. Fifty families were interviewed on two occasions in these four communities, the first time between September 22 and October 12, 1996, and the second between November 17-18, 1997. All communities had few households and were therefore completely sampled. Data on turtle captures were collected from September 1996 to April 1998.

The consumption of turtles during the study period was identified based on the presence of ectodermal shields (Thorbjarnarson, Perez, and Escalona 1993). Species were identified using external shell characteristics. Carapace length was measured in a straight line at the point of greatest separation between the anterior and posterior edges (Medem 1976). Sex was determined by size, head color, carapace length, plastron shape, invagination of the anal plate, pre-cloacal length and thickness of the tail (Ponce 1979; Pritchard and Trebbau 1984) and in some cases by asking the interviewee if he had noted the gonads of the turtle before it was consumed. Turtles were weighed with spring scales.

Varzea ecosystems comprise a diversity of aquatic features and habitat types, many of which appear only seasonally. Often there are no direct, concise translations for the names of these unique habitats, and we use the local Portuguese language terms in the text. Here we give a brief description of these habitat types, and also of terms that refer to changes in the hydrological cycle:

Enchente: rising water phase in the annual hydrological cycle
Vazante: dropping water phase in the annual hydrological cycle

Repiquete: temporary rises in the water level (oscillating water levels) that usually precede the main enchente. In the Central Amazon these usually occur around December and January; from February to April the water usually rises steadily.
Remanso: an eddy that occurs in little curved inlets along the edge of main river channels. These curved inlets are usually caused when a chunk of forest falls into the river (*terra caida*); the water flows into the new inlet and forms an eddy.
Restingas: levees in the floodplain.
Poças: ponds or static pools of water in the forest or sometimes on beaches, created by rainwater or when water is stranded in the floodplain when water levels drop.
Paraná: side branch of main river channel which winds its way through the várzea floodplain. It is always connected at both ends to whitewater river.
Canos: channels that drain lakes in the várzea
Lagos: floodplain lakes
Enseada: outer curve of a meander or curve in a river where erosive processes at their strongest. Remansos often form along the enseadas.
Ressaca: an inlet or branch to any water body (usually lake or channel) that dead-ends.

RESULTS

COMMUNITIES STUDIED

São Raimundo de Jarauá is the largest and most important community in the Jarauá sector. It comprises eighteen houses with twenty families, who engage primarily in commercial fishing and who also practice subsistence farming. Turtles are captured in the Japurá river and in the paranás, ressacas, canos, and floodplain lakes of the Paraná do Jarauá Hydrological System. The high number of *P. sextuberculata* (n = 386) and *P. unifilis* (n = 177) registered for this community reflects the knowledge that community dwellers have of turtle behavior and of the areas where turtles occur.

Novo Pirapucu comprises nine houses and ten families. The community engages in both subsistence and commercial fishing activities and in subsistence agriculture. Its location near a *P. sextuberculata* nesting beach on the Japurá river explains the high consumption of females of this species (n = 37) by community members. During the 1996 nesting season, community members agreed to preserve 50 % of the area of the beach in order to allow turtle researchers from the Mamirauá project to study the species reproductive biology (protection of the beach continued through 2002). This protection reduced the rate of capture of reproductive females in the area. In 2003 this community offered to preserve 75% of the beach.

The community of Manacabi comprises nine families in nine houses and relies primarily on subsistence agriculture and subsistence fishing. Small turtle nesting beaches emerge during the dry season in the paraná that provides access to the community. In 1996, four *P. sextuberculata* and one *P. unifilis* females were captured there.

Nova Colômbia, with ten houses and eleven families, relies primarily on agriculture and less intensively on subsistence fishing. Of the eleven *G. denticulata* registered for this

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community, eight were captured in the restingas of the Paraná do Jarauá and three in the restingas of Nova Colômbia.

Through interviews and direct observations in the field, we were able to locate the carapaces of dead turtles. Members of these communities eat four species of quelonians (table 22.1), in the following order of importance: *P. sextuberculata* (66.6 %, n = 447), *P. unifilis* (30.0 %, n = 201), *G. denticulata* (2.8 %, n = 19) and *Chelus fimbriatus* (0.6 %, n = 4). Of 671 quelonians captured by community members, 655 (97.6 %) were consumed, ten (1.5 %) were sold, and six small individuals (0.9 %) were kept to be raised in captivity.

TABLE 22.1. Species, Sex and Number of Quelonians Consumed in Four Coummunities of the Jarauá Sector of the RDSM.

	Podocnemis sextuberculata			*Podocnemis unifilis*			*Geochelone denticulata*		*Chelus fimbriatus*		
SITE	M	F	N/D	M	F	N/D	M	F	M	F	TOTAL
São Raimundo de Jarauá	210	130	46	84	85	8	3	3	1	1	571
Novo Pirapucu	12	37	0	0	10	0	0	0	0	0	59
Manacabi	4	6	0	0	7	0	2	0	0	1	20
Nova Colômbia	0	2	0	3	4	0	6	5	0	1	21
Total	226	175	46	87	106	8	11	8	1	3	671

Note: M is male; F, female, and N/D, not determined.

SPECIES AND SIZE

Two members of the Pelomedusidae family (*Podocnemis sextuberculata* and *P. unifilis*), one of the Chelidae (*Chelus fimbriatus*) and one of the Testudinidae (*Geochelone denticulata*) were recorded. There was variation in size and number of animals captured in each species. *Podocnemis sextuberculata* and *P. unifilis* showed sexual dimorphism in size, males being smaller than females (table 22.2).

CAPTURE METHODS AND SEASON

Of the 447 *P. sextuberculata* registered in the study, 363 were captured with gill nets in different aquatic habitats of the Paraná do Jarauá, and 45 females at nesting beaches. Of the 301 *P. unifilis* registered, 51 were captured with gill nets and 74 females were captured by probing in the mud of shallow lakes with a wooden pole. The eleven *G. denticulata* were captured by hand. One male and two female *C. fimbriatus* were captured with gill nets and one female with a harpoon (table 22.3).

Podocnemis sextuberculata is captured primarily during the dry season and when water levels begin to rise (start of the enchente) (fig. 22.1). Almost all size classes are captured during this period (fig. 22.2). During the nesting season, in August, September and October, individuals are captured by hand when they emerge to lay eggs on the beaches.

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Gill nets are used in the paranás and ressacas during temporary oscillations in the water levels in October and November and at the start of the flood season from December/January through March.

The size of the mesh influences the size classes of turtles captured with nets. Mid-sized males and females are most frequently caught with gill nets. This size bias in net captures, which also occurs with the drag nets used in the remansos, has led to the popular local belief that the population contains many males and few females. Studies using Trammel nets indicated that gill nets used by fishermen are not efficient enough to capture the larger females, which are found in the deeper sections of the water channel where the current is weaker. As a result, a large portion of the adult population escapes capture.

TABLE 22.2. Statistical Summary of Measurements of Quelonians Captured in the Jarauá Sector of the RDSM.

		CARAPACE LENGTH (cm)				**WEIGHT (kg)**			
SPECIES	**SEX**	**X**	**S.D.**	**RANGE**	**N**	**X**	**S.D.**	**RANGE**	**N**
P. sextuberculata	M	20.7	1.9	11.1-24.4	162	0.9	0.2	0.17-1.4	160
	F	20.9	4.7	12.4-31.2	90	1.1	0.7	0.2 -3.8	78
P. unifilis	M	21.6	5.8	7.6-31.0	68	1.5	0.8	0.06-3.3	46
	F	32.9	10.2	8.7-46.0	74	4.4	3.5	0.105-14	16
G. denticulata	M	44.4	3.6	39.3-50.3	9			9	1
	F	42.3	3.9	36.6-46.5	9	8.9	1.0	7.55-10	4
C. fimbriatus	M			29.2	1			3.3	1
	F			40.5-43.0	2			13	1

Note: M is male; F, female; x, MEAN; s.d., standard deviation; and N, sample size.

TABLE 22.3. Methods Used to Capture Four Quelonian Species in the Jarauá Sector of the RSDM.

	Podocnemis sextuberculata			*Podocnemis unifilis*			*Geochelone denticulata*		*Chelus fimbriatus*		
METHODS	**M**	**F**	**N/D**	**M**	**F**	**N/D**	**M**	**F**	**M**	**F**	**TOTAL**
Gill net	217	106	40	31	20	1	0	0	1	2	418
By hand	0	45	0	2	31	1	11	8	0	0	98
Jaticá	1	15	0	0	3	0	0	0	0	0	19
Wooden pole	0	0	0	46	23	5	0	0	0	0	74
Harpoon	4	7	0	2	16	0	0	0	0	1	30
Diving	0	2	1	0	0	0	0	0	0	0	3
Drag nets	3	0	0	0	0	0	0	0	0	0	3
Unknown	1	0	5	6	13	1	0	0	0	0	26
Total	226	175	46	87	106	8	11	8	1	3	671

Note: M is Male; F, Female, N/D, not determined.

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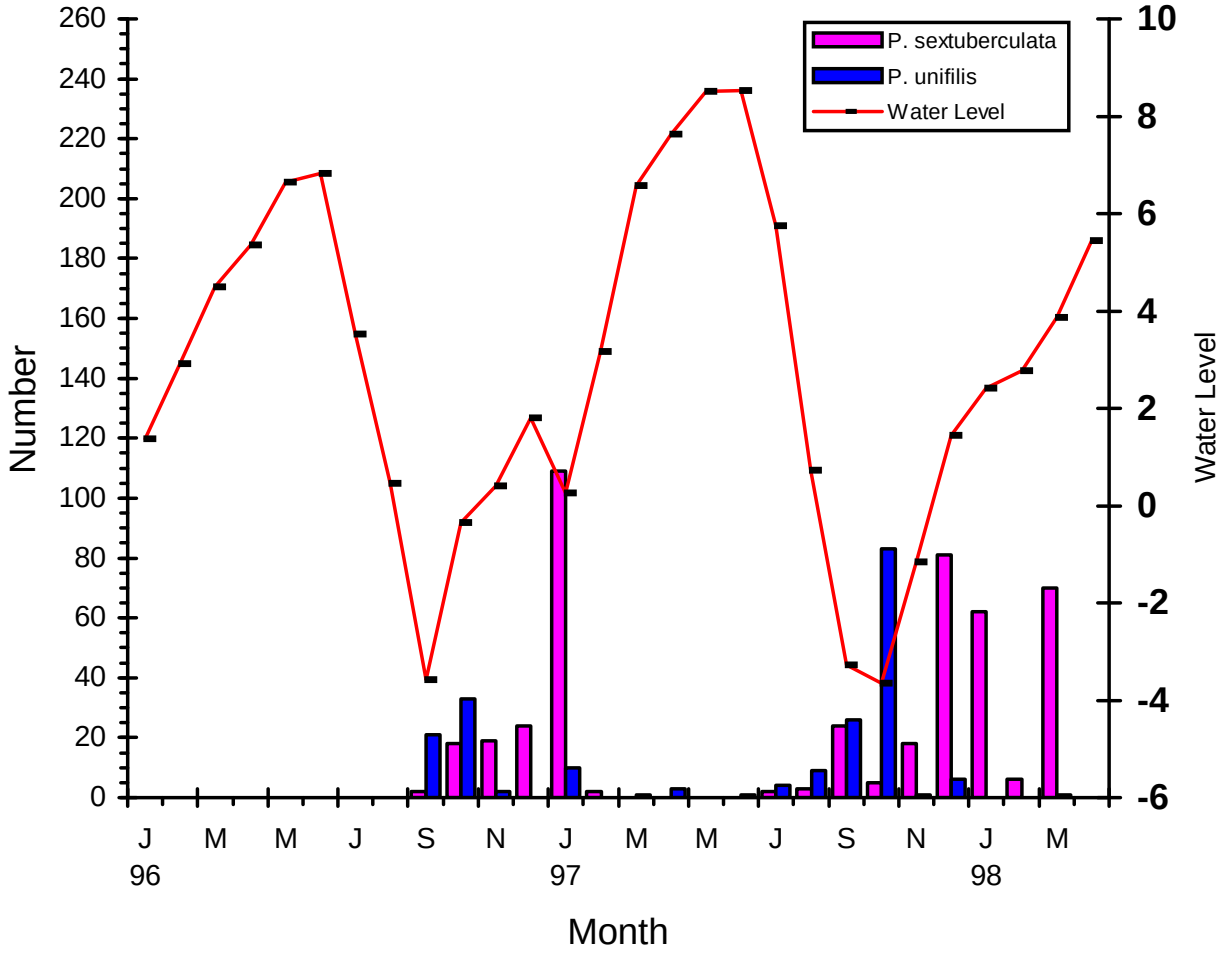

FIGURE 22.1 Capture of the species of *Podocnemis* in the Jarauá sector of the RDSM (Mamirauá Sustainable Development Reserve) with respect to water levels.

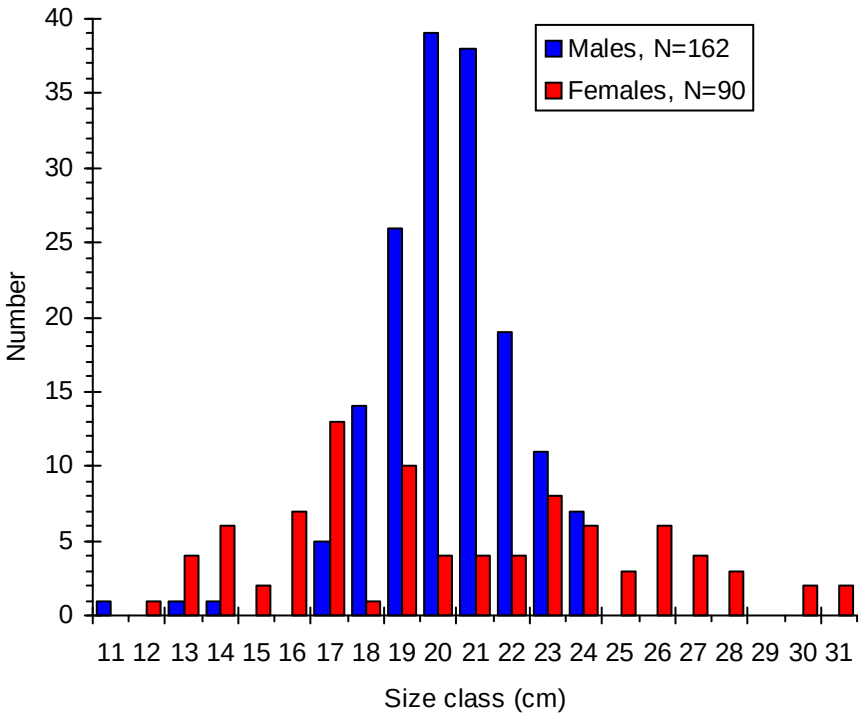

FIGURE 22.2 Size-Class distribution for *P. sextuberculata* captured in the Jarauá sector of the RDSM (Mamirauá Sustainable Development Reserve).

During the dry season the *P. unifilis* population is concentrated in the canos and poças of the ressacas and lakes. In the 1996 dry season, adult males and females were the most common age class captured (fig. 22. 3). Because of the concentration of the population in these habitats during the dry season, however, the potential exists for fishermen to capture animals of all sizes and of both sexes, as they did in October of 1997 (fig. 22.4).

Podocnemis unifilis is captured primarily with wooden poles (see below), with gill nets, by hand, and with harpoons. Capture with gill nets is occasional and occurs primarily when fishermen are seeking tambaqui fish (*Colossoma macropomum*). These nets have a stretched mesh size of 22 cm, and do not capture hatchlings and juveniles.

Following the nesting season, *P. unifilis* females remain in canos and small pools with abundant macrophytes, where they burying themselves to a depth of about 20 cm in the mud until the water level rises again. Inhabitants of São Raimundo de Jarauá know this behavior, as well as the sites where *P. unifilis* can be found in the dry season from September to October. They have developed a searching technique that involves the use of a three-meter long wooden pole. They locate the buried turtle by the characteristic sound produced when the stick impacts on its carapace, then capture it by hand. Using this method, one community member captured twelve females in one day.

Additionally, individuals of *P. unifilis* swimming just under the surface of the water are identified by the size and shape of air bubbles visible at the surface, and captured with

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harpoon, jaticá, or by diving. A harpoon consists of a long pole with an iron tip secured to a strong line. The tip of the harpoon releases when it enters the prey but remains attached to the line, allowing the animal to be captured. The strike causes a small wound in the carapace but does not kill the animal. Harpoons with smooth, unbarbed tips are known as jaticás.

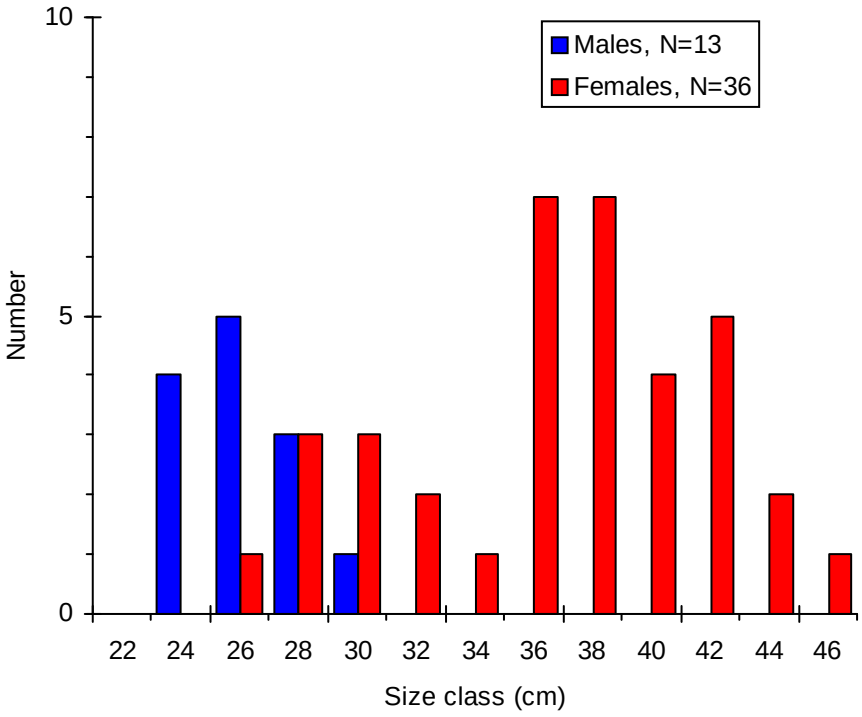

FIGURE 22.3 Size-Class distribution for *P. unifilis* captured in the Jarauá sector of the RDSM (Mamirauá Sustainable Development Reserve) from September 1996 through April 1997.

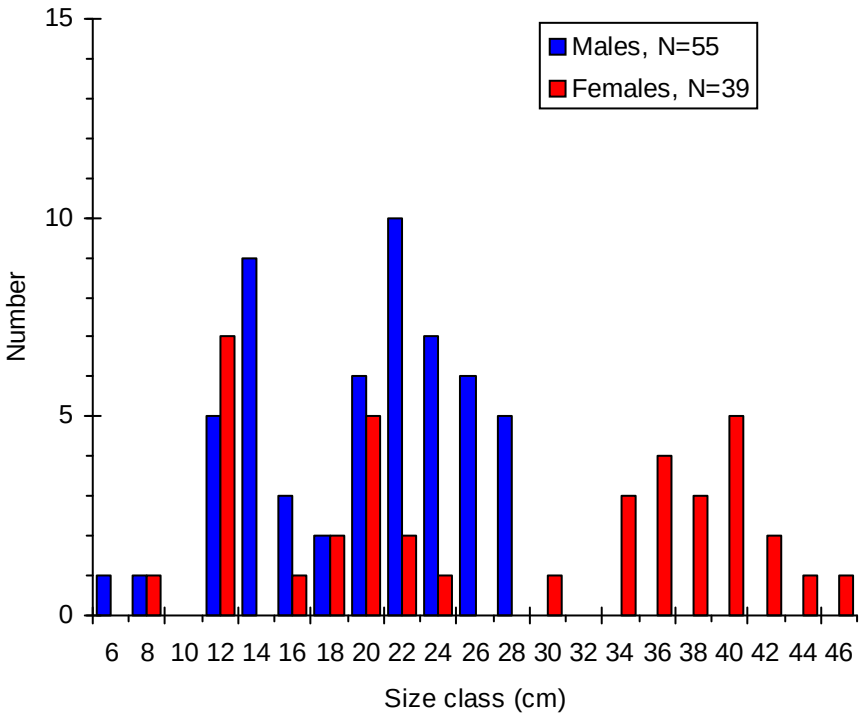

FIGURE 22.4 Size-Class distribution for *P. unifilis* captured in the Jarauá sector of the RDSM (Mamirauá Sustainable Development Reserve) from May 1997 through April 1998.

HABITATS WHERE QUELONIANS WERE CAPTURED

Podocnemis sextuberculata was captured primarily in ressacas (54.8 %) and paranás (28.6 %), while *P. unifilis* was captured most frequently in canos (37.8 %), lakes (20.4 %) and ressacas (18.9 %). *Chelus. fimbriatus* was also captured in three habitat types: paranás, ressacas and canos. *Geochelone denticulata* was captured only in restingas (table 22.4).

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TABLE 22.4. Habitats Where Quelonians Were Captured in the Jarauá Sector of the RDSM

	P. sextuberculata		*P. unifilis*		*Chelus fimbriatus*		*G. denticulata*	
HABITAT	N	%	N	%	N	%	N	%
Unknown			15	7,5			2	10,5
Ressaca	245	54,8	38	18,9	1	25,0		
Paraná	128	28,6	7	3,5	2	50,0		
River-Beach	43	9,6	12	6,0				
River-Remanso	15	3,4						
River-Enseada	7	1,6	8	4,0				
Lake	9	2,0	41	20,4				
Cano			76	37,8	1	25,0		
Restinga							17	89,5
Island			4	2,0				
Total	447	100,0	201	100,0	4	100,0	19	100,0

DISCUSSION

HUNTING OF TURTLES

The three most sought-after genera of quelonians in Amazonia are *Podocnemis*, *Peltocephalus* and *Kinosternon*. The genus *Podocnemis* includes six species, all exploited to varying degrees depending on local preference, but *P. expansa* and *P. unifilis* are the most sought after overall for the preparation of several dishes considered to be delicacies (Alho 1986).

The capture of quelonians in the RDSM primarily provides food for local consumption. When *P. sextuberculata* and *P. unifilis* are captured in large quantities by professional fishermen outside of RDSM, however, it is always for commercial (illegal) purposes. These two species are also eaten in appreciable quantities in Itacotiara and other cities near Manaus, the capital of Amazonas State, with *P. unifilis* the most frequently consumed species (Smith 1979a; Santos 1996).

In the RDSM, unsustainable exploitation of the Amazonian turtle (*P. expansa*) has virtually eliminated the species from the area. Quelonian hunting therefore focuses primarily on two species, *P. sextuberculata* and *P. unifilis*, which make up 96.6 % of captures. Similarly, quelonian extraction in Jaú National Park focuses on three species: *Peltocephalus dumerilianus*, *Podocnemis unifilis* and *P. erythrocephala*, which represent 95 % of captures (Rebêlo and Lugli 1996). In Cinaruco-Capanaparo National Park, Venezuela, 100 % of captures are of three species, *P. unifilis*, *P. vogli* and *P. expansa* (Thorbjanarson, Perez, and Escalona 1997). In all three locations, populations of *P. expansa* are small, with isolated females nesting only when river levels are low. According to Rebêlo (1985), the 261 quelonians confiscated in Manaus and on the Purus, Negro and Uatumâ rivers included four commercial species: *P. expansa*, *P. unifilis*, *P.*

sextuberculata and *Peltocephalus dumerilianus*. Of these four, *P. sextuberculata* was the species most frequently sold on the Purus river (50 %), and *P. unifilis* the most frequently sold in Manaus (63 %).

SIZES OF CAPTURED TURTLES

All size classes of *P. sextuberculata* are affected by fishing, because fishermen use a mesh size 10 or 15 cm in length. Furthermore, the entire animal is cooked, so consumption is independent of the size of the animal. On the other hand, capture of *P. unifilis* focuses primarily on adults, and females are the most affected. A similar pattern was observed by Thorbjarnarson, Perez, and Escalona (1993) on the Capanaparo River, Venezuela, where adult males and females are the most frequently captured size classes.

The smallest reproductive female *P. sextuberculata* recorded in this study, captured while egg-laying at a beach on the Paraná do Manacabi, measured 26 cm. Vanzolini (1977) examined eleven *P. sextuberculata* from three rivers in the Brazilian Amazon, and found that the smallest female containing eggs measured 27.1 cm. If 26 cm is the minimum reproductive size for the species, then 19 % (n = 17) of the ninety females for which we obtained a carapace length were sexually mature. The proportion of adult females in samples is probably higher, given that we were unable to measure carapace length in 49 % (n = 95) of the 175 captured females.

The mean size of *P. unifilis* females captured within the RDSM was smaller (X = 32.9 $\pm$ 10.2 cm, [mean$\pm$sd.], n = 74) than that reported by Smith (1979) for Itacoatiara, Amazonas, Brazil (X = 35.5 $\pm$ 5.5 cm, n = 15) or by Thorbjarnarson Perez, and Escalona (1993) for the Capanaparo River in Venezuela (X = 33.1 $\pm$ 3.3 cm, n = 109). The largest sizes documented by any study for captured females are those reported by Fachín-Terán, Chumbe, and Taleixo (1996) for Pacaya-Samiria National Reserve in Peru (X = 41.0 + 3.0 cm, n = 145).

Of ten individuals of *P. unifilis* examined by Vanzolini (1977) in Brazil, the smallest female with eggs measured 33 cm. If this is the minimum reproductive size for the species, then 64 % (n = 47) of the seventy-four females captured during this study for which carapace length was measured were above this size. This proportion may be somewhat larger, because we could not measure carapace length for 30 % (n = 32) of the 106 females captured. This is still a smaller proportion than that reported by Thorbjarnarson, Perez, and Escalona (1993), who found that 82.6 % of 109 females measured on the Capanaparo River in Venezuela were of reproductive age. An even higher value was obtained by Fachín-Terán, Chumbe and Taleixo (1996) for Pacaya-Samiria in Peru, where 95 % of females eaten in the communities that border the reserve were of reproductive age. These differences are due to the fact that animals of all sizes were captured at RDSM, while in the other studies, which report only large individuals of reproductive size, the turtles were apparently captured at the nesting beaches.

Mean carapace lengths of *Geochelone denticulata*, both for males (X = 44.4 $\pm$ 3.65 cm, n = 9) and females (X = 42.3 $\pm$ 3.97cm, n = 9), were larger than those reported by Fachín-

Terán Chumbe and Taleixo (1996) for Pacaya-Samiria in Peru, where mean carapace length for ten males was 36.5 ± 5.6 cm and for nine females 32.4 ± 11.3 cm. Capture of *G. denticulata* in the RDSM is occasional and can occur at any time of year.

CAPTURE METHODS AND SEASON

Podocnemis sextuberculata is primarily captured with gill nets. Fishermen near Itacoatiara use the same method, leaving their nets up overnight and capturing turtles as well as the targeted fish (Smith 1979a). In the dry season, reproductive females are captured at night on the beaches of the Japurá and Solimões rivers in the RDSM. The same occurs near Itacoatiara (Smith 1979).

Podocnemis unifilis is captured during the dry season in canos, lakes and ressacas, primarily using the wooden pole method and gill nets. A different pattern was reported for this species in the Itacoatiara area, where it is captured year round with espinhel (long line with multiple baited hooks) and with harpoons. Most captures occur during the season of rising water levels (May and June), when *P. unifilis* moves into the flooded forest to feed on flowers and fruits (Smith 1979a). The long line was also the method most frequently used to capture turtles on the Capanaparo river in Venezuela (Thorbjarnarson, Perez, and Escalona 1997). Harpoons are also used on the Orinoco river, Venezuela, to capture *P. expansa* during the rainy season (Ojasti 1971) and in Belize to capture *Dermatemys mawei* while it floats on the surface of the water (Moll 1986).

Podocnemis unifilis is also captured by hand at night when the females emerge to lay eggs on islands and lake margins (Smith 1979). In the RDSM, capture by hand is also accomplished at night during the egg-laying season, when females emerge on the beaches of the Japurá and Solimões rivers.

Data gathered from twenty-one *extrativistas* (subsistence forest dwellers) from the lower and middle Jaú river, who capture primarily *Peltocephalus dumerilianus, Podocnemis unifilis* and *P. erythrocephala*, suggest that 64 % of stocked turtles were attracted with a bait of fish and captured with jaticá, 20 % were caught with several types of baited hooks (float-line, rod and line, long line,) and 15 % were captured on land by ambushing (*viração*). *Geochelone denticulata* was captured during incidental encounters (Rebêlo et al. 1996). Polisar (1995) reported three techniques used to capture *Dermatemys mawei* in Belize: harpoon, net, and diving. Free diving is the most efficient of these techniques. When well organized, diving can lead to the almost complete removal of turtles from an area.

Although *Geochelone denticulata* is a preferred diet item, this species is captured only occasionally because they do not nest communally they are usually hard to find. Santos (1996), however, reported an unusual incident whereby in one flood season one person captured about sixty animals at a small settlement in the Barroso sector of the RDSM. The water level that year was extremely high and the normally terrestrial tortoise was easy to spot floating in the flooded forest.

Chelus fimbriatus is only occasionally captured and is of less importance in the local diet than are *Podocnemis* turtles (Smith 1979a). Fachín-Terán, Chumbe, and Taleixo (1996) observed the same ranking in Pacaya-Samiria National Reserve in Peru, and this was confirmed for the RDSM in this study, in which *C. fimbriatus* was the least captured species. *Chelus* is uncommon in RDSM. Additionally, because of its strong musky odor, most people do not find it an attractive food item.

HABITATS WHERE QUELONIANS WERE CAPTURED

In the RDSM, *P. unifilis* uses several microhabitats for reproduction, but relies on the beaches of the Japurá River less than on reproductive sites on the margins of its lakes, ressacas and canos. The majority of the population remains in these habitats until the next flood, making them vulnerable to predation by humans. In other portions of its range, such as Pacaya-Samiria in Peru and the Guaporé and Trombetas Biological Stations in Brazil, the species nests primarily on sand beaches that emerge along river edges, and for this reason females are captured more frequently than males (Fachín-Terán 1992; Soini and Coppula 1995; Soini and Soini 1995; Fachín-Terán, Chumbe, and Taleixo 1996).

Podocnemis unifilis uses lakes, ressacas and the flooded forest during the enchente, while in the dry season the majority of the population remains buried in the mud of canos and pools that form in the ressacas. Such aestivation behavior has not previously been reported for the species. One of us (RCV) observed this same behavior in December of 1990, when he collected forty-three specimens of *P. unifilis* at the Trombetas Biological Reserve. Aestivation thus appears to be common, but less predictable and probably less documented in areas with short dry seasons (Gibbons, Greene, and Congdon 1990). According to Vaillant and Grandidier (1910) and Tronc and Vuillemin (1973) (cited in Kuchling 1988), most *Erymnochelys* bury themselves in the mud during the dry season, even though the habitats they occupy are not completely dry.

CONSERVATION AND MANAGEMENT

Following the decline of *P. expansa* populations in Peru and Brazil, more pressure was placed on *P. unifilis*, *P. sextuberculata* and *Peltocephalus dumerilianus* (Fachín-Terán, Chumbe, and Taleixo 1996; Vogt and Soini in press). The progressive substitution of large, valuable species by smaller species was confirmed in the RDSM. Here, *P. unifilis* and *P. sextuberculata* are more frequently consumed, specially the latter species, which is captured in large quantities by professional fishermen at different locations of the Reserve and sold in the cities of Tefé and Alvarães. This trend in the exploitation of Amazonian turtles is reminiscent of that observed in the whaling industry, leading Mittermeier (1975) to characterize the aquatic quelonians of Amazonia as suffering from the whaling syndrome.

Factors contributing to the decrease in turtle populations in the Reserve include lack of protection of nesting sites, capture of adult females and over-harvesting of their eggs, artisanal and commercial fisheries in paranás, ressacas, canos and lakes by both

community dwellers and those commercial fishermen who carry out their activities within the area of the reserve, the commercial demand in urban centers, lack of control of illegal trade in urban centers, and loss of nests due to the repiquete. However, the most predatory hunting method, which causes the greatest harm to the population and which poses the greatest threat to reproductive animals, is the use of drag nets by professional fishermen and some community dwellers who capture large numbers of *P. sextuberculata* in river remansos. Using this method, one community member captured 130 individuals of the species in August of 1996 in the remanso of Praia Machado on the Solimões River. In 1997, in the same area and season, we only captured two males and two females during forty-eight hours of sampling. Similarly, Ojasti (1971) observed fishermen using drag nets to capture *P. expansa* on remansos of the Orinoco River.

To initiate the recuperation of quelonian populations in the reserve, a protection and management program accompanied by an environmental education program must be developed in the short term and with the agreement of the communities. Community leaders have already agreed during assemblies to forbid the use of gill nets, fence or encirclement nets (redinhas) and arrastadeiras (drag nets used along beaches) near turtle nesting sites. They also identified lakes and nesting sites that should be preserved in different locations of the reserve by prohibiting the capture of turtles, eggs and hatchlings.

It is a priority to implement these agreements with the full participation of community members, who would thus help to protect the resource and would no longer represent a threat to the survival of these reptiles. According to Rebêlo and Lugli (1996), only the active participation of local inhabitants in the planning and implementation of a quelonian management plan will guarantee the success of the plan; local peoples are both the problem and the long term solution for large areas that require permanent inhabitants to protect them. Additionally, the Brazilian Agency for the Environment and Renewable Natural Resources (IBAMA), should invest greater effort in inspecting and monitoring turtle sellers and intermediaries in the trade.

To reduce the intentional capture of turtles, which is illegal in Brazil, it is necessary to apply our knowledge of the species ecology (Alho 1985). There is a proven synchronization between the flood regime and nesting behavior. Therefore, in addition to protecting nesting and breeding sites, it is possible and essential to protect the migrating population and the migratory routes themselves as turtles move out of their aquatic habitats. This is the time when the population is most vulnerable to gill nets as they move through narrow river channels. In the river the reproductive population is vulnerable to drag nets, when turtles are located in the remansos near the beaches. Hunting in this locations and seasons will negate any benefit derived from turtle protection in water bodies.

Captive breeding has been suggested as a way of minimizing illegal harvest of turtles in Amazonia (Alho 1985). Captive breeding may be a temporary salvation for some species that have reached the point were they are unable to survive in the wild. However, it is not recommendable to spend money raising species in captivity when the funds are better

spent in measures to prevent their extinction in the wild (Magnusson 1993). In varzea areas, where it is difficult carry out captive breeding due to both socioeconomic and ecological reasons, other alternatives such as management in the wild should be implemented in agreement with local communities.

Podocnemis sextuberculata nesting sites in the Japurá and Solimões rivers should be identified and permanently protected, and the capture of the species should be temporarily forbidden. Some beaches should be completely protected while others managed by dividing them half and half into a protected section and a section that can be used for egg collection by local inhabitants. The lower beaches where nests are bound to fail should be considered as harvestable beaches. These actions should be coordinated between the personnel of the Mamirauá Project and the local communities. If natural predation and egg loss due to the repiquete and capture of juveniles are controlled, then high survivorships may be obtained.

Unlike *P. sextuberculata*, whose nests are concentrated on sandy beaches, *P. unifilis* nests on dispersed sites and uses a variety of substrates. Therefore, it is crucial to identify *P. unifilis* nesting sites within the reserve and to protect them permanently from human interference during the dry season. Nest loss due to the repiquete should be minimized by translocation of eggs to sand beaches on the Japurá and Solimões rivers. Hatchlings should then be released at the site where eggs were collected.

Because of the risk of extinction faced by *P. expansa* in the Reserve, all surviving individuals must be protected until the population recovers, which may occur in 80 to 120 years. Initially, the recovery of *P. expansa* populations can be aided by total protection of nesting beaches to prevent predation by humans, and translocation of nests that are in danger of flooding by the repiquete. It may also be necessary to release into the reserve hatchlings of this species collected on nesting beaches farther upstream in the Solimões and Japurá rivers. The release of five to ten thousand PIT (Passive Integrated Transponder)-tagged hatchlings per year during ten years would serve as an experiment to determine the effectiveness of this technique.

Protective measures should be implemented year round. For now, we lack demographic data to determine whether areas such as the RDSM are sufficient to conserve quelonians in the Amazon basin (Santos 1996). The most basic information about the minimum area required to protect *Podocnemis* turtles is still unknown. In the Trombetas Biological Reserve, all *P. expansa* nesting beaches are protected. However, once the reproductive season is over, the turtles move at least 65 km downstream to feeding sites, where they are often captured by fishermen (Moreira and Vogt 1990). In the RDSM, the opposite situation exists: feeding areas are protected, but little effort is put into protecting nesting sites. Still, a new factor may soon alter this scenario. The Amana Sustainable Development Reserve was created in 1997. Together with Jaú National Park and the RDSM, it makes up the Central Amazonian Ecological Corridor, which may enable the maintenance of genetically healthy populations with increasing recruitment rates.

This study shows that commercial sale of turtles is low in the communities; however, there is a substantial trade in *P. sextuberculata* in Tefé. Over 300 animals are sold every 8 to ten days during the season of vazante and the start of the enchente. It is interesting to note that most animals sold are male *P. sextuberculata*. Capture for commerce takes place in the ressacas and remansos, primarily with gill nets and drag nets; the latter methods captures nearly all of the reproductive population. This was confirmed by our field observations, when in a remanso of the Piranhas beach, on the Solimões river, we captured 132 males and 19 females in 48 hours of sampling.

Individuals of *P. unifilis* from the Tefé, Japurá and Juruá rivers are sold in Tefé. The few female *P. expansa* that emerge to lay eggs on the beaches of the Solimões and Japurá rivers are also captured for sale. Johns (1987) reported that local inhabitants of Tefé estimated that 300 *P. expansa* are sold annually. This may be an underestimate, because some turtles are transported directly to Manaus. Santos (1996) recorded 400 *P. sextuberculata* unloaded at the Tefé market on one occasion. Smith (1979) estimated that 8,000 *P. unifilis* were captured annually in a 60 km radius around Itacoatiara; of these, about 6,000 were unloaded in Tefé and half of them were eventually sent to Manaus. Cooked *Podocnemis expansa* were still being served openly in restaurants in Tefe in September 2003 as part of the local noon luncheon buffet, as well as other wild game (R.C. Vogt, pers. obs.)

To preserve and make rational, sustainable use of this important resource, the following studies are needed in the short term: quantify and describe the *P. sextuberculata* and *P. unifilis* trade in Tefé and Alvarães; map the nesting beaches and their level of exploitation on the Japurá and Solimões rivers; and evaluate and monitor *P. unifilis* and *P. sextuberculata* populations in all of the RDSM. According to Calouro (1995), the effects of hunting on animal populations are not easily quantified, because one must estimate both the hunting pressure to which the populations are exposed and their basic population parameters. In parts of the RDSM where turtles are captured by riverine communities and where commercial fisheries still take place, a long-term study is required to compare the population structure and densities in hunted and unhunted areas. This will allow us to determine whether populations decline because of exploitation and whether current hunting patterns are efficient. This information will serve as a base from which we can design strategies for the recovery and management of turtles in the RDSM, so that they may continue to provide a source of food for its inhabitants.

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