Chelonian Conservation and Biology, 1999, 3(3):419–424

Nesting Ecology of *Podocnemis sextuberculata* (Testudines, Pelomedusidae) in the Japurá River, Amazonas, Brazil

Juarez C.B. Pezzuti[1] and Richard C. Vogt[1,2,3,4]

[1]*Instituto Nacional de Pesquisas da Amazônia - INPA, Depto. de Ecologia, C.P. 478, Manaus, Amazonas, CEP 69011-970 Brazil;*
[2]*Estacion de Biologia Tropical Los Tuxtlas, Instituto de Biologia, Universidad Nacional Autonoma de Mexico, Apt. Post. 91, San Andres Tuxtla, Veracruz, 95700 Mexico;*
[3]*Projeto Piabia, Ingeneria Pesca, Federal Universidad de Amazonas, Manaus, Amazonas, Brazil;*
[4]*Corresponding Author for Reprint Requests*

Abstract. – We studied turtle nesting behavior on Pirapucu beach on the Japurá River inside the focal area of the Reserva de Desenvolvimento Sustentado Mamirauá (RDSM), State of Amazonas, Brazil, between September and November 1996. We investigated the spatial distribution and density of *Podocnemis sextuberculata* nests, nest survivorship, incubation duration, and the causes of mortality of embryos, including egg harvesting by local people. An area of nearly 0.6 km^2 of Pirapucu beach was protected against harvest of eggs by local inhabitants. We mapped each nest the morning after laying. Nests that produced hatchlings and those destroyed by rising water levels of the river were discriminated through a logistic regression analysis. We located 193 nests (3.47 nests/ha). Females nested in areas that were central, higher, and more distant from the water. In the unprotected area, nearly 100% of eggs were harvested, and only one nest was found intact. In the protected area, rising water levels destroyed 111 nests (56% of total). Day of oviposition and location on the beach differentiated successful and drowned nests ($p = 0.00059$ and $p = 0.00011$, respectively). Hatchlings from 4 nests were depredated by sarcophagid fly larvae. Evaluation of the mortality caused by rising water levels and monitoring of nest temperatures and hatchling sex ratios in other years will be necessary to understand these phenomena and their annual variations.

Key Words. – Reptilia; Testudines; Pelomedusidae; *Podocnemis sextuberculata*; turtle; ecology; reproduction; nests; mortality; Amazon; Brazil

Chelonians and their eggs are widely used as a food source in many parts of the world (Mittermeier, 1978; Smith, 1979; Cornelius, 1982; Woody, 1986; Johns, 1987; Robinson and Redford, 1991; Lagueux, 1991). Early naturalists who traveled through the Amazon basin in the 19th century described the extraordinary abundance of Amazon River turtles (genus *Podocnemis*), especially *P. expansa*, the largest and most abundant at that time (Silva Coutinho, 1868; Bates, 1892). Actually, eggs and adults are still an important protein resource for the local people.

Information on the reproductive ecology of Amazon River turtle species and the impact of human predation on the annual production of hatchlings is necessary to establish a management program for the region. The conservation of these species is important not only for the preservation of biodiversity, but also to guarantee the availability of a valuable and highly appreciated food item for local inhabitants (Vogt, 1994).

Nests are also subject to natural predation (Fachin, 1992; Soini, 1995) and environmental variations such as flooding (Alho and Padua, 1982; Soini, 1995). Nest site selection can directly influence probabilities of success of a given nest, and success also depends upon annual climatic variation.

In this study we investigated the spatial and temporal distribution and the causes of mortality of *Podocnemis sextuberculata*, locally known as *iaçá* (Fig. 1), nests at the Reserva de Desenvolvimento Sustentável Mamirauá, State of Amazonas, Brazil. Implications for conservation and management program issues are also discussed. This study is a part of a large integrated project aimed at developing a plan for the sustainable use of the natural resources in this reserve.

METHODS

Study Area. — The Reserva de Desenvolvimento Sustentável Mamirauá (RDSM) covers an area of 1,124,000 ha of seasonally flooded "vareza forest" near the confluence of the Solimões and Japurá rivers in Amazonas, Brazil (Fig. 2). During the wet season, RDSM is entirely flooded by the rising rivers, but in the dry season, it is possible to distinguish many aquatic systems with dendritic structures. This study was developed on a beach in the Jaruá sector of the Japurá River which forms the eastern boundary of RDSM. Pirapucu beach (2°52.899'S; 64°54.218'W), 2 km long and 600 m wide, was chosen as our study site after talking with local people, who confirmed its importance as a nesting site for *P. sextuberculata*. It is composed of fine sand with irregular relief, including both high and low areas with scattered low vegetation

Monitoring. — Following discussions with local communities, nearly half of Pirapucu beach (ca. 0.6 km^2) was protected against collection of eggs. On the other part of the beach the local inhabitants were not prevented from collecting eggs or nesting females.

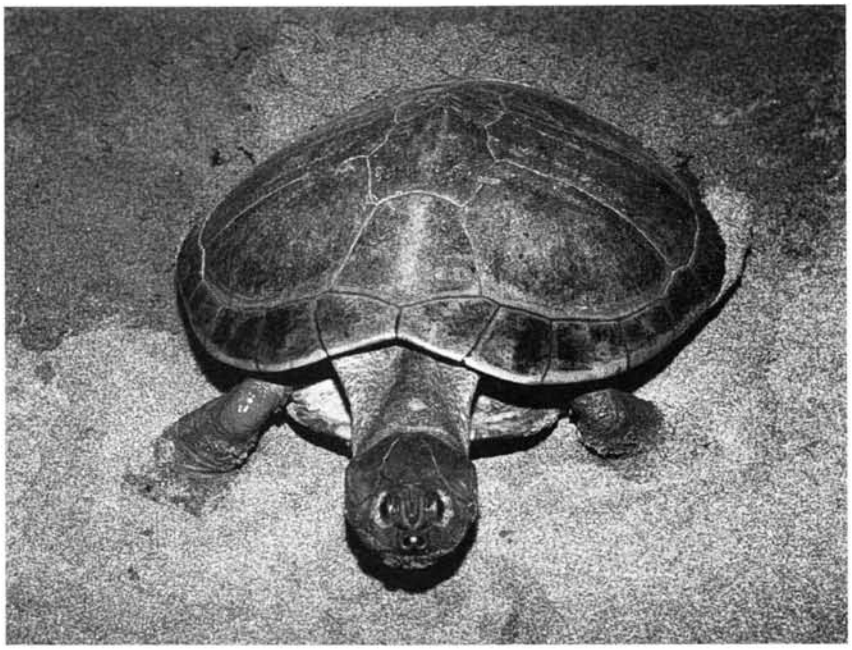

Figure 1. Nesting female *Podocnemis sextuberculata*, Amazonas, Brazil.

Figure 2. Map of Reserva de Desenvolvimento Sustentável Mamirauá, State of Amazonas, Brazil.

On 29 August 1996 we began monitoring the protected area on a daily basis, to detect nests laid the night before. Nests are easily detectable when the soil is recently disturbed and the female tracks are visible. For each nest we registered the day of oviposition, distance from the highest part of the beach, nest depth, and position on the beach. This last characteristic was related to the topography of the beach, and varied from 1 (elevated) to 5 (depression). The location of each nest was marked with a numbered wooden stake. The area was mapped using a grid of 2 m wooden stakes every 50 m. The location of nests was defined by the distance and compass orientation to the nearest stake. Eggs were counted, weighed, and measured in 24 nests. For comparative purposes we randomly selected 180 sites on the beach to measure position and distance to the highest part of the beach.

The status of nests on the unprotected part of Pirapucu beach was monitored three times per week, from 16 August to 21 November 1996. Upon emergence from the egg a sample of 60 hatchlings from 24 nests were weighed to the nearest 0.1 g on a portable electronic balance. In addition, we separated and similarly weighed the residual yolk mass of 40 of these hatchlings. We interviewed local residents about areas of nest concentration, trends in the numbers of nests from year to year, and about the occurrence of *Podocnemis expansa* nests.

We applied a logistic regression model to discriminate between successful and drowned nests using their values of distance and position. In this analysis, the dependent variable was categorized as 0 (flooded nests) and 1 (successful nests). This analysis was done using Systat (Wilkinson, 1990).

RESULTS

We found 220 nests from 16 August to 24 October, 22 of them having been raided before the installation of our camp. We marked and monitored 197 nests in the protected area, 193 *P. sextuberculata* and 4 *P. unifilis*. Only 1 *P. expansa* nest was found, and since it was constructed in the unprotected area, it was raided the same night. Nest densities and relative frequencies for each species at Pirapucu beach are shown in Table 1. Mean *P. sextuberculata* nest depth was 17.5 cm (range 12–23); clutch size was 6–25 eggs (mean 15.8). Information about egg and hatchling biometry are shown in Table 2.

We marked the first nests 3 September 1996 and the last ones 30 September, with only one nest later than this (on 24 October). The number of females arriving on the beach and number of nests laid each night are shown in Fig. 3. Nearly 78% of the nests are from the first two weeks of September. Mean incubation duration (time from nesting to pipping) was 64 days (range 56–72).

All the nests mapped on Pirapucu beach are represented in Fig. 4. The highest nest concentrations were situated in a

Table 1. Number and relative frequency of nests from Pirapucu beach, Mamirauá, September – October 1996.

Species	n	%	Density (nests/ha)
P. sextuberculata	193	97.5	3.47
P. unifilis	4	2.0	0.07
P. expansa	1	0.5	0.01
Total (known species)	198	100.0	3.55
Not identified	22		0.36
Total	220		3.91

Table 2. *Podocnemis sextuberculata* egg and hatchling morphometrics obtained at Pirapucu beach, September – November 1996.

	n	Mean	Min	Max	S.D.
Clutch size	24	15.8	6	25	4.99
Clutch mass (g)	24	308.0	107.0	476.0	117.22
Egg length (mm)	379	41.4	20.1	58.7	2.92
Egg width (mm)	379	28.9	15.3	39.0	2.55
Egg mass (g)	379	19.6	12.0	29.0	3.25
Hatchling mass (g)	60	14.7	8.7	24.0	3.64
Yolk mass (g)	45	2.3	1.1	5.1	0.75

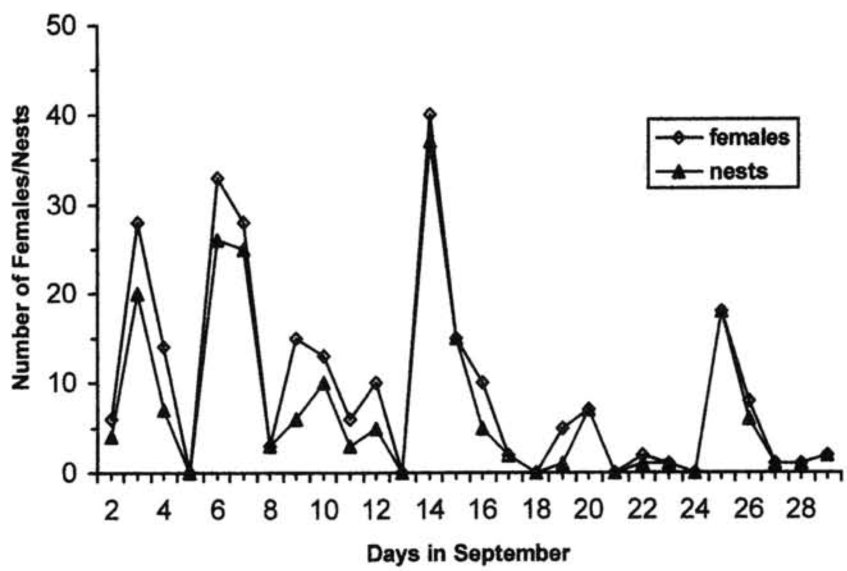

Figure 3. Number of females arriving and of nests laid each night on Pirapucu beach during September 1996.

central region, relatively distant from the water. In the unprotected area of the beach, nearly 100% of the nests were collected: we found only one intact nest, some moments before dawn, which most probably was collected later the same day. Flooding destroyed 111 nests in the protected area, approximately 56% of the total monitored. Nest distance to the highest place on the beach and date of laying contributed strongly to discriminate between flooded and successful nests ($p = 0.00011$ and 0.00059, respectively; Table 3). We found 80% of the successful nests during the first week of monitoring.

Diptera fly larvae (Sarcophagidae) were found predating hatchlings in 4 nests. Causes of mortality in 198 nests in the protected area were flooding ($n = 111$, 56%) and fly larvae ($n = 4$, 2%), with 83 nests (44%) showing survivorship. Harvesting occurred in 22 of 220 nests (10%) before we protected the beach, but was 100% on the unprotected beach.

DISCUSSION

Early September was the most important period for *P. sextuberculata* nesting. These results are in accord with the information given by local inhabitants, who report that the peak of egg laying of this species occurs 7 September. Most probably females start their nesting activity when water levels fall sufficiently to expose the first and higher river beaches, in contrast to that of *P. expansa*, which is initiated only when the river reaches its lowest level of the year (Alho and Padua, 1982). Nesting is influenced by when the river level begins to fall in any given year. In Pacaya-Samíria, Peru, according to Soini (1995), more than 90% of the nests are collected, and nests constructed in the sand beaches are the most susceptible. In Manu Biosphere Reserve, Peru, and in the Caquetá River, Colombia, 100% of nests on sand beaches are taken on non-protected beaches (Hildebrand et al., 1988; Mitchell and Quiñones, 1994).

Table 3. Logistic regression with the independent variables of (1) day of oviposition, (2) position, and (3) height, and the dependent variable categorized as 0 (flooded nests) or 1 (hatched). Coeff. = coefficients, Prob. = probabilities.

Variables	Estimate	S.D.	Coeff.	Prob.
Constant	4.83966	0.87143	5.55371	0.00000
Day of oviposition	- 0.19592	0.05701	- 3.43648	0.00059
Height	- 0.41698	0.23083	- 1.80646	0.07085
Position	- 0.01321	0.00341	- 3.87352	0.00011

Podocnemis expansa and *P. sextuberculata*, which specifically nest only on exposed river sand beaches, have serious conservation problems. Nests are easily detectable and nesting beaches are accessible; and these rivers have heavy boat traffic. Nests in these areas are collected and consumed by a much larger population than that which lives in the area. In the future, continuous protection and monitoring of nest densities from beaches with different harvesting and flooding characteristics will be essential to understand these phenomena and their annual variation. Residents reported that nest densities on the same beaches were formerly much higher, and they recalled capturing more than a hundred nesting turtles per night 30–40 years ago. Eggs of *P. sextuberculata* still constitute a valuable food resource in Mamirauá, although it is evident that nest numbers are declining from year to year.

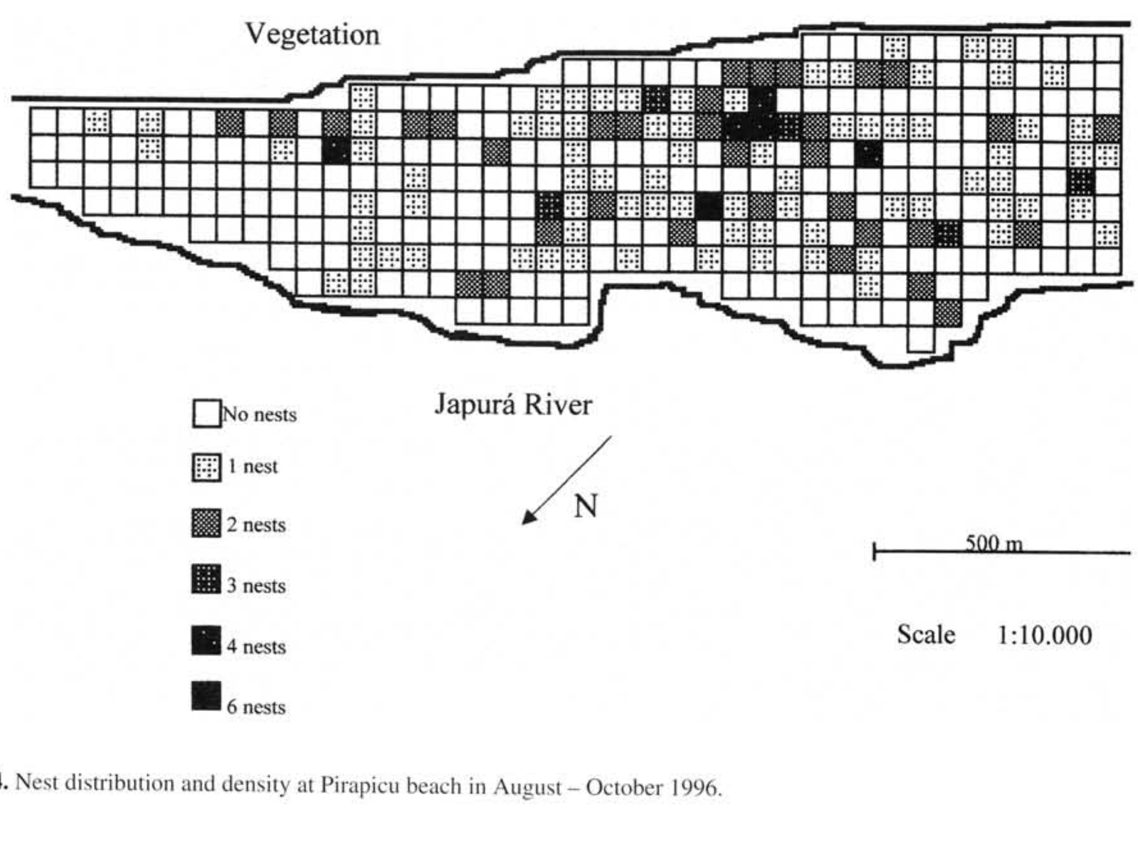

Figure 4. Nest distribution and density at Pirapicu beach in August – October 1996.

There are two possible models of rational use of chelonian eggs in Mamirauá, both based on the idea of harvesting eggs with higher probability of flooding before hatching and emergence of hatchlings. One would be allowing egg harvest of fresh nests at the end of the laying season, temporally close to the beginning of rising water levels. The other would protect the highests beaches or the highest parts of the beaches, leaving the nests constructed at lower positions (and thus more susceptible to flooding) destined for harvest and consumption throughout the nesting seson. It will be interesting to test these different strategies and evaluate their effectiveness and advantages. For the management of nests in the Manu Bioshpere Reserve, Peru, Mitchell and Quiñones (1994) also suggested protection of beaches where nest success probabilities are greater, and harvesting where flooding probabilities are higher. These authors also pointed to the fact that harvesting would be allowed only to the population resident within the reserve.

However, there is no reasonable justification for the fact that nearly all chelonian conservation efforts around the world are concentrated only on the protection of nesting areas. It has been suggested by Crouse et al. (1987) that nests and hatchling protection represent the stage where increasing survivorship provides proportionately less possibility of demonstrable long term results. They developed a population matrix model based on stage/class specific information of survivorship and fecundity for *Caretta caretta*, testing the sensibility of the model to variations on the parameters included and comparing predictions and possible effects of different management strategies of the species. It was found that age classes corresponding to juveniles and subadults were the most susceptible to changes of survivorship levels. Simulations clearly showed that only nest protection at the beaches will not guarantee the preservation of populations, if strategies to protect young and adult individuals are not taken. Their study analyzed one species of sea turtle, but their results may apply to other species of turtles as well, at least they should be taken into consideration when management practices are being developed.

The severe losses caused by flooding probably do not occur every year. Rising of the river in 1996 was abrupt and started early. However, losses of turtle nests by flooding can be significant, depending on the annual variation of the flooding season. It is necessary to continue monitoring nests in the area to understand these phenomena. Soini (1995) registered a variation from 1% (1979) to 100% (1985) in annual losses of *Podocnemis* nests caused by flooding in Samíria River, Peru. In the Manu Reserve, Peru, except for egg harvesting, the greatest cause of nest mortality is flooding (Mitchell and Quiñones, 1994), and in Caquetá, Colombia, Hildebrand et al. (1988) described a similar situation with an annual variation from 0 to 100% mortality caused by nest flooding.

There are opposite extreme situations that present different conditions resulting in advantages or disadvantages for nest survivorship. Local people explained that in drier years nests are more difficult to be found by collectors, but the distance hatchlings must travel to find the water are also increased so that their survivorship could be affected by greater susceptibility to desiccation or predation. Aquatic predation might also be greater in low water years, because predators are more concentrated.

Soini (1995) identified the following nest predators of *P. expansa*, *P. unifilis*, and *P. sextuberculata* on Pacaya-Samíria National Reserve, Peru: ants, lizards (*Tupinambis teguixin*), birds (*Daptrius ater*, *Coragyps atratus*, *Buteogallus urubitinga*, *Mivalgo chimachima*), and mammals (*Didelphis marsupialis*). *Tupinambis* was the most important and had a great ability to detect nests, even older ones. However, it was suggested that *P. sextuberculata* nests are less vulnerable to this predation because large expansive sandy beaches are not the preferred habitat of this *Tupinambis*. There were no signs of *Tupinambis* on Pirapucu beach during our study period. Nest predation is probably a density-dependent phenomenon, with predator populations not building up unless there are high nest concentrations. Actual nest density in the area is lower than it was some decades ago, and could be sufficiently low as not to stimulate predator congregations.

The impact of sarcophagid fly larvae on survival was reduced because nests with pipped hatchlings were removed before total absorption of yolk mass, thus reducing possibility of infestation. In the Trombetas Reserve, Para, Brazil, a high mortality of *Peltocephalus dumerilianus* hatchlings (60.5%) was caused by fly larvae predation after pipping (Vogt et al., 1994). It would also be interesting to investigate how and when flies insert their larvae into turtle nests.

By involving the local people, the main predators of the turtles and their eggs, in an effort to protect at least part of some of the nesting beaches from exploitation, and allowing them to harvest part of the annual production of eggs, those that would be normally lost to flooding, we hope to maintain this viable population of *Podocnemis sextuberculata*.

Resumen

Este estudo foi desenvolvido em várias praias do rio Japurá na Reserva de Desenvolvimento Sustentado Mamirauá, Estado do Amazonas, Brasil, entre agosto e novembro de 1996. Investigamos a distribuição espacial e a densidade de ninhos de *Podocnemis sextuberculata* (iaçá) e as causas de perda dos mesmos. Metade de uma praia foi protegida contra a coleta de ovos pelos moradores e monitorada diariamente, outras 2 praias foram monitoradas a cada 2–3 dias, e outras foram vivitadas em 3 ocasioes. Ninhos eclodidos e ninhos atingidos pelo repiquete do rio foram comparados através de regressão logística. Foram identificados 193 ninhos (3.47 ninhos/ha). Na área não protegida, a coleta de ovos pelos moradores foi próxima de 100% na área protegida, o repiquete do rio foi responsável pela perda de 111 (56%) ninhos. A data de oviposição e a posição dos ninhos influíram significativamente na diferenciação entre ninhos eclodidos e afogados ($p = 0.0006$ e $p = 0.00011$, respectivamente). Filhotes de 4 ninhos foram

predados por larvas de um díptero pertencente à família Sarcophagidae. A avaliação do impacto causado pelo repiquete e por outras é necessária para que se possa compreender melhor estes fenômenos e suas variações anuais.

ACKNOWLEDGMENTS

This project was financed by the Wildlife Conservation Society and the European Economic Community through the Sociedade Civil Mamiraua and J. Thorbjarnarson. Pezzuti thanks Conselho Nacional de Pesquisa (CNPq) for a financial support during the project in the form of a MS scholorship. The Instituto Nacional Pesquisas Amazonas Department of Ecology and Postgraduation in Tropical Studies is thanked for logistical support. The staff of Mamiraua facilitated the completion of this research. Vogt was supported by a CNPq fellowship during the writing of the paper. Statistical analysis was aided by the critical eye of W.E. Magnusson. Augusto Fachin helped Pezzuti manage the rigors of long lonely nights on turtle nesting beaches.

LITERATURE CITED

ALHO, C.J.R., AND PADUA, L.F.M. 1982. Sincronia entre o regime de vazante do rio e o comportamento de nidifição da tartaruga da amazônia *Podocnemis expansa* (Testudinata: Pelomedusidae). Acta Amazonica 12(2):323-326.

BATES, H.W. 1892. The Naturalist on the River Amazons. London, Murray, 395 pp.

CARR, A., CARR, M.H., AND MEYLAN, A.B. 1978. The ecology and migrations of sea turtles, 7. The west Caribbean green turtle colony. Bull. Amer. Mus. Nat. Hist. 162:1-46.

CORNELIUS, S.E. 1982. Status of sea turtles along the Pacific coast of Middle America. In: Bjorndal, K.A. (Ed.). Biology and Conservation of Sea Turtles. Washington, DC: Smithson. Inst. Press, pp. 211-219.

CROUSE, D.T., CROWDER, L.B., AND CASWELL, H. 1987. A stage-based population model for loggerhead sea turtles and implications for conservation. Ecology 68:1412-1423.

FACHIN, A. 1992. Desove y uso do playas para nidificaión de taricaya (*Podocnemis unifilis*) en el río Samiria, Loreto-Perú. Boletin de Lima 84:79-88.

HILDEBRAND, P.V., SAENZ, C., PENUELA, M.C., AND CARO, C. 1988. Biologia reproductiva de la tortuga charapa (*Podocnemis expansa*) en el bajo rio Caqueta. Colombia Amazonica 3(1):89-112.

JOHNS, A.D. 1987. Continuing problems for Amazon river turtles. Oryx 21:25-28.

LAGUEUX, C.J. 1991. Economic analysis of sea turtle eggs in a coastal community on the Pacific coast of Honduras. In: Robinson, J.G., and Redford, K.H. (Eds.). Neotropical Wildlife Use and Conservation. Chicago: Chicago University Press, pp. 136-144.

MITCHELL, C., AND QUIÑONES, L. 1994. Manejo y conservacion de la taricaya (*Podocnemis unifilis*) en la Reserva de Biosfera del Manu, Madre de Dios. Boletin de Lima 16:425-436.

MITTERMEIER, R.A. 1978. South America´s river turtles: saving them by use. Oryx 14:222-230.

ROBINSON, J.G., AND REDFORD, K. 1991. The use and conservation of wildlife. In: Robinson, J.G., and Redford, K.H. (Eds.). Neotropical Wildlife Use and Conservation. Chicago: Chicago University Press, 520 pp.

SILVA COUTINHO, J.M.d. 1868. Sur les tortues de l'Amazone. Bull. Soc. Impér. Zool. Acclim. (2)5:147-166.

SMITH, N.J.H. 1979. Quelônios aquáticos da amazônia: um recurso ameaçado. Acta Amazonica 9:87-97.

SOINI, P. 1995. Investigaciones en la Estación Biológica Cahuana. Reporte Pacaya-samiria, Universidad Nacional Agraria La Molina, 435 pp.

VOGT, R.C. 1994. Temperature controlled sex determination as a tool for turtle conservation. Chelonian Conservation and Biology.1:159-163.

VOGT, R.C., CANTARELLI, V.H., AND CARVALHO, A.G.d. 1994. Reproduction of the cabeçudo, *Peltocephalus dumerilianus*, in the Biological Reserve of Rio Trombetas, Pará, Brazil. Chelonian Conservation and Biology 1:145-148.

WILKINSON, L. 1990. Systat: the system for statistics. Systat Inc., Evanston, Illinois, 822 pp.

WOODY, J.B. 1986. On the dollar value of the Oaxacan ridley fishery. Marine Turtle Newsletter 36:6-7.

Received: 30 March 1998
Reviewed: 27 October 1998
Revised and Accepted: 30 January 1999