Effect of translocation on egg viability of the giant Amazon river turtle (Podocnemis expansa)

Article *in* Chelonian Conservation and Biology · January 2003

4 authors, including:

Kelly Bonach
Instituto Chico Mendes de Conservação da Biodiversidade

Luciano Martins Verdade
University of São Paulo

diagnostics: a new technique to obtain template DNA in critical situations. Acta Geneticae Medicae et Gemellologiae 45:301-302.

SAMBROOK, J., FRITSCH, E.F., AND MANIATIS, T. 1989. Molecular Cloning. A Laboratory Manual. 2nd Ed. New York: Cold Spring Harbor Laboratory Press.

SEUTIN, G., WHITE, B.N., AND BOAG, P.T. 1991. Preservation of avian blood and tissue samples for DNA analyses. Canadian Journal of Zoology 69:82-90.

TESSIER, N. AND BERNATCHEZ, L. 1999. Stability of population structure and genetic diversity across generations assessed by microsatellites among sympatric populations of landlocked Atlantic salmon (*Salmo salar* L.). Molecular Ecology 8:169-179.

THOMAS, W.K., PAABO, S., VILLABLANCA, F.X., AND WILSON, A.C. 1990. Spatial and temporal continuity of kangaroo rat populations shown by sequencing mitochondrial DNA from museum specimens. Journal of Molecular Evolution 31:101-112.

Received: 17 September 2001
Revised and Accepted: 22 October 2002

Chelonian Conservation and Biology, 2003, 4(3):712–715

Effect of Translocation on Egg Viability of the Giant Amazon River Turtle, *Podocnemis expansa*

KELLY BONACH[1], MARISTELA P. MIRANDA-VILELA[1], MARCELO C. ALVES[2], AND LUCIANO M. VERDADE[1,3]

[1]*Laboratório de Ecologia Animal, LPA, ESALQ, Universidade de São Paulo, C.P. 09, Piracicaba, São Paulo 13418-900 Brazil;* [2]*Departamento de Ciências Florestais, ESALQ, Universidade de São Paulo, C.P. 09, Piracicaba, São Paulo 13418-900 Brazil;* [3]*Corresponding Author [E-mail: lmv@esalq.usp.br]*

The giant Amazon river turtle (*Podocnemis expansa*) is the largest living South American freshwater turtle. Adult females have a flattened carapace up to 107 cm long (Ernst and Barbour, 1989). Its distribution includes the Orinoco and Essequibo to Amazon river drainages of Colombia, Venezuela, Guyana, eastern Ecuador, northeastern Peru, northern Brazil, and northern Bolivia (Iverson, 1992).

The eggs and meat of the species have been traditionally used by local people in the Brazilian Amazon, being socially important for the upper classes and economically important for the lower classes, which led the species to various levels of population decline in many parts of the Amazon (Pritchard and Trebbau, 1984; Alho, 1985). This decline stimulated the Brazilian government to establish in 1979 a ranching program of the species based on egg collection and captive raising of young for commercial purposes on a biologically sustainable basis (CENAQUA, 1989).

The species has a nesting behavior similar to that of some marine turtles with a markedly concentrated nesting period (Moll, 1979) which has been erroneously assumed to be related to low water levels (Alho and Pádua, 1982a; 1982b) and subsequent formation of sand beaches, known locally as *tabuleiros* (Alfinito, 1976). Average nesting female body mass can vary from 15.7 to 33.0 kg even in the same population and as many as some thousands may nest simultaneously (Ojasti, 1967) which is locally called an *arribada* in Spanish (Carr, 1967) or *arribação* in Portuguese (Alfinito, 1976). Females may possibly store sperm after copulation (van Tienhoven, 1983) and multiple paternity has been described (Valenzuela, 2000).

Although successfully used for caiman in Brazil (Verdade, 1985; Verdade et al., 1992) artificial incubation has been discarded as a management tool for the *P. expansa* ranching program because of the immense number of nests that would have to be housed (CENAQUA, 1989). However, a high rate of unhatched eggs have been reported in some *tabuleiros*, and the usual occurrence of unseasonal short-term flooding in the middle of the nesting period — known locally as *repiquete* (Pádua and Alho, 1984) — generally causes massive egg mortality (CENAQUA, 1985).

In order to minimize egg loss caused by this flooding without having to invest in artificial incubators, translocation of eggs has been proposed (Alho, 1985). However, its possible influence on egg viability has never been determined. This was the main goal of the present study.

Methods. — Eggs of *P. expansa* were collected from September to December 2000 in the following *tabuleiros* of Rio Araguaia: 04GO (Praia 04 GO: 13°21'57.6"S; 50°39'05.7"W) and 06 MT (13°23'32.3"S; 50°40'12.8"W), on the border between Goiás (GO) and Mato Grosso (MT) states, central Brazil. We tested four different translocation periods for the eggs, moving them at age 1, 14, 28, and 42 days since egg-laying.

We used eight nests per treatment (i.e., translocation period) with a total of 32 nests. The eggs were collected early in the morning (0700 to 0930 hrs) or late in the afternoon (1600 to 1830 hrs). Clutch size and the number of unviable eggs (damaged, decomposing, or no embryonic development) were recorded for each nest. Clutches were transported in separate sand-filled plastic boxes with the eggs placed in layers, reversed in relation to their original position in the nest (i.e., top layers placed in the bottom and vice-versa). The top of each egg was pencil-marked and eggs positions were maintained unaltered (i.e., eggs were not turned, so as to prevent egg mortality by respiratory or excretory dysfunction as suggested by Webb et al., 1987, for crocodile eggs).

All clutches were transported to a sand beach (18GO: 13°30'12.4"S; 50°44'12.4"W), a few kilometers from the *tabuleiros* of origin and less likely to be flooded. Careful transportation was by boat with the egg boxes eggs placed on a thick layer of foam and shaded by a layer of local soft weed (usually "*macela*", *Gnaphalium purpureum*) to prevent desiccation and overheating.

Artificial nests 50 cm deep and 25 cm wide were manually excavated one meter apart. The eggs were placed in the artificial nests in their original layer relationship. Local sand was gently spread over the eggs in order to fill up the nest without harming the eggs. Nests were individually identified by numbered stakes. A plastic fence (100 cm high, 15 cm buried in sand) was placed around the nests forming

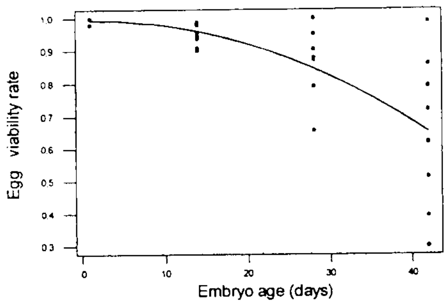

Figure 1. The relationship between egg viability rate on the day of translocation (y_1) and the age of embryos in days (x).

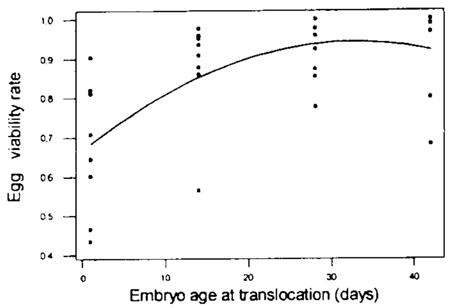

Figure 2. The relationship between egg viability rate at the end of incubation (y_2) and the age of embryos in days at translocation (x).

a "nursery" of 56 m^2 (8 x 7 m) in order to prevent egg predation and hatchling escape.

Nests were manually opened at day 45 of incubation (counting from laying date, not translocation date). The number of viable and unviable eggs (damaged, decomposing, or no embryonic development) was then recorded.

We used Analysis of Variance (ANOVA) to evaluate the effect of translocation on egg viability and Tukey Test to compare treatments. We also established regression models in order to assess embryo losses related to embryo age and egg translocation.

Results. — There was a significant relationship between egg viability rate and both age of embryo (Fig. 1) and age of embryo at translocation (Fig. 2). Translocation at day 1 of the incubation period resulted in a significantly higher embryo mortality than at days 14, 28, and 42 (Tukey Test, $\alpha = 0.05$), but there was no significant difference among these later three periods of translocation.

The relationship between egg viability rate on the day of translocation (y_1) and the age of embryos in days (x) can be expressed by the following regression equation (Fig. 1): $y_1 = 0.993647 + 0.0004611x - 0.0002050x^2$; ($p < 0.0001$; $r^2 = 0.542$).

The relationship between egg viability rate at the end of incubation (y_2) and the age of embryos in days at translocation (x) can be expressed by the following regression equation (Fig. 2): $y_2 = 0.666665 + 0.0168995x - 0.0002581x^2$; ($p < 0.001$; $r^2 = 0.403$).

Discussion. — Natural mortality of embryos during the incubation period can be associated with intrinsic (both genetic and phenotypic) characteristics of eggs and embryos as well as with the physical conditions of incubation. Low fertility rate of females may be the main cause for infertile eggs in crocodilians (Cardeilhac, 1989, 1990; Verdade et al., 1993) as well as in turtles (CENAQUA, 1985). Egg size (Gutzke and Packard, 1985), nesting site (Campos, 1993), and clutch volume (Schulte and Chabreck, 1990) may be associated with embryonic mortality in reptiles. However, temperature (Yntema, 1960; Ewert, 1985; Plummer et al., 1994), humidity (Grigg, 1987; Kam, 1994) and their interaction (Bustard, 1971) are possibly the main physical conditions related to embryonic mortality in reptiles.

Malvásio (2001) reported a temperature range in *P. expansa* nests in the northern Rio Araguaia from 25.8 to 39.1°C, with the upper limit, if sustained, possibly causing significant embryonic mortality. Although Malvásio worked at a lower latitude, a similar pattern can be expected for the *tabuleiros* in the present study. Eventual exposure to temperatures above or below a certain level usually causes embryonic mortality (Ewert, 1985; Plummer et al., 1994; Tucker and Warner, 1999). However, in such cases, a high embryonic mortality usually occurs at early stages of incubation, which did not occur in the present study.

Humidity can influence clutch size in turtles in that smaller clutches are usually associated with drier substrates (Zug, 1993). A dry substrate can cause embryonic death by desiccation, whereas a soaked substrate can result in suffocation of the embryos (Fenwick, 1992). Even a brief submergence of nests can result in high embryonic mortality (Plummer, 1976; Joanen et al., 1977; Magnusson, 1982). The distribution of nests on a *tabuleiro* can possibly result in significantly different humidity among the nests (Zwinck and Young, 1990) because humidity in sand can vary significantly even on a small temporal-spatial scale (Sánchez, 1981). This would result in a cumulative downward curve of mortality along the incubation period (Zwinck and Young, 1990). The curve of egg viability found in the present study (Fig. 1) can possibly be explained by these reasons.

Parasitism can also result in high embryonic mortality. Lopes (1982) identified *Eumacronychia sternalis* (Diptera, Sarcophagidae) larvae living on eggs and hatchlings of the east Pacific green turtle (*Chelonia mydas*). Broderick and Hancock (1997) report insect (four species of fly and one species of wasp) infestation on eggs of Mediterranean marine turtles (*Chelonia mydas* and *Caretta caretta*). Vogt (1981) reported a low eclosion rate in 39 out of 236 nests of *Graptemys* spp. and *Chrysemys picta* in Wisconsin, USA, due to phorid fly larvae infestation. In the present study, some nests contained fly larvae, that may have contributed to embryo mortality.

The temperature of incubation determines sex in *P. expansa* (Valenzuela, 2001) and other turtles (Bull, 1980; Mrosovsky and Yntema, 1980; Ewert et al., 1994; Shine, 1999). Embryonic development (Packard et al., 1981; McGehee, 1990; Whitehead et al., 1990), post-hatching growth (Joanen et al., 1987, Webb and Cooper-Preston, 1989), and skin pigmentation (Deeming and Ferguson, 1989) are also influenced by the incubation environment in reptiles. These factors are possibly related to individual fitness, and their careless manipulation for management purposes, even when well intentioned, might result in deleterious consequences for the species. For these reasons, they should be carefully considered by ranching program managers.

In the present study, early (first third of incubation) translocation was associated with higher embryonic mortality, similar to the pattern found in sea turtles, unless eggs are moved during the first six hours after laying (Frazer, 1994). This period does not coincide with the thermosensitive period for sex determination in turtles, which occurs in the middle third of incubation (Mrosovsky and Yntema, 1980; Bull and Vogt, 1979; Gutzke and Chymiy, 1988; Wibbles et al., 1991, Pieau et al., 1994).

Although the factors above should be considered, egg translocation after the first third of the incubation period can be an effective tool for ranching programs of *P. expansa* in regions where short-term flooding (i.e., *repiquete*) is common during the incubation period. Although there are good ranching programs based on egg collection and captive rearing of crocodilians (Joanen and McNease, 1987; Larriera et al., 1996; Velasco and De Sola, 1997), freshwater turtles (CENAQUA, 1989), and sea turtles (Reichart, 1982), its effectiveness for the conservation of those species is controversial (Frazer, 1992; Meylan and Ehrenfeld, 2000). However, either for conservation or management purposes, further research on the possible influences of egg translocation on sex determination of embryos and fitness of young is urged. In particular, the shape of the translocation mortality curve during the first third (1 to 14 days) of the incubation period should be determined.

Acknowledgments. — This study was partially supported by Fundação de Amparo à Pesquisa do Estado de São Paulo (Processes No. 00/00215-7, 00/00443-0, and 00/00597-7). Vítor Hugo Cantarelli and Yeda L. Bataus from Centro Nacional dos Quelônios da Amazônia / IBAMA, and Paulo Souza Neto and José de Paula Moraes Filho, from Agência Ambiental de Goiás, provided invaluable logistics for the field studies. Paulo Bezerra e Silva Neto, from Pró-Fauna Assessoria e Comércio Ltda, introduced us to the problems faced by turtle ranchers in Goiás, Brazil.

LITERATURE CITED

ALFINITO, J. 1976. Migração de tartarugas. Brasil Florestal 7:55-58.

ALHO, C.J.R. 1985. Conservation and management strategies for commonly exploited Amazon turtles. Biological Conservation 32:291-298.

ALHO, C.J.R. AND PADUA, L.F.M. 1982a. Reproductive parameters and nesting behavior of the Amazon turtle *Podocnemis expansa* (Testudinata: Pelomedusidae) in Brazil. Canadian Journal of Zoology 60:97-103.

ALHO, C.J.R. AND PADUA, L.F.M. 1982b. Sincronia entre o regime de vazante do rio e comportamento de nidificação de *Podocnemis expansa* (Testudinata, Pelomedusidae) Acta Amazônica 12:323-326.

BRODERICK, A.C. AND HANCOCK, E.G. 1997. Insect infestation of Mediterranean marine turtle eggs. Herpetological Review 28 (4):190-191.

BULL, J.J. 1980. Sex determination in reptiles. Quarterly Review of Biology 55(1):3-21.

BULL, J.J. AND VOGT, R.C. 1979. Temperature-dependent sex determination in turtles. Science 206:1186-1188.

BUSTARD, H.R. 1971. Temperature and water tolerances of incubating crocodiles eggs. British Journal of Herpetology 4:198-200.

CAMPOS, Z. 1993. Effect of habitat on survival of eggs and sex ratio of hatchlings of *Caiman crocodiles yacare* in the Pantanal, Brazil. Journal of Herpetology 27(2):127-132.

CARDEILHAC, P. 1989. Husbandry and preventative medicine practices that increase reproductive efficiency of breeding colonies of alligators. Gainesville, FL: Aquaculture Market Development Aid Program.

CARDEILHAC, P. 1990. Husbandry and preventative medicine practices that increase reproductive efficiency of breeding colonies of alligators. II. Gainesville, FL: Aquaculture Market Development Aid Program.

CARR, A. 1967. So Excellent a Fishe: A Natural History of Sea Turtles. Garden City, NY: Natural History Press, 248 pp.

CENAQUA. 1985. Preservação de Quelônios no Rio Guaporé: Atividades em 1984/1985. Brasília: Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis.

CENAQUA. 1989. Projeto Quelonios da Amazonia - 10 Anos. Brasilia: Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, 119 pp.

DEEMING, D.C. AND FERGUSON, M.W.J. 1989. The mechanism of temperature-dependent sex determination in crocodilians: a hypothesis. American Zoologist 29(3):973-989.

ERNST, C.H. AND BARBOUR, R.W. 1989. Turtles of the World. Washington, DC: Smithsonian Institution Press, 313 pp.

EWERT, M.A. 1985. Embryology of turtles. In: Gans, C., Billett, F., and Maderson, P.F.A. (Eds.). Biology of the Reptilia, Vol. 14, Development A. New York: John Wiley and Sons, pp. 75-267.

EWERT, M.A., JACKSON, D.R., AND NELSON, C.E. 1994. Patterns of temperature-dependent sex determination in turtles. Journal of Experimental Zoology 270:3-15.

FENWICK, H. 1992. Breeding Tortoises in Captivity. Bristol: British Chelonia Group Testudo.

FRAZER, N.B. 1992. Sea turtle conservation and halfway technology. Conservation Biology 6(2):179-184.

FRAZER, N.B. 1994. Sea turtle headstarting and hatchery programs. In: Meffe, G.K. and Carroll, C.R. (Eds.). Principles of Conservation Biology. Sunderland, MA: Sinauer Associates, pp. 374-380.

GRIGG, G.C. 1987. Water relations of crocodile eggs. In: Webb, G.J.W., Manolis, S.C., and Whitehead, P.J. (Eds.). Wildlife Management: Crocodiles and Alligators. Chipping Norton, Australia: Surrey Beatty, pp. 499-502.

GUTZKE, W.H.N. AND CHYMIY, D.B. 1988. Sensitive periods during embryogeny for hormonally induced sex determination in turtles. General and Comparative Endocrinology 71(2):265-267.

GUTZKE, W.H.N. AND PACKARD, G.C. 1985. Hatching success in relation to egg size in painted turtles (*Chrysemys picta*). Canadian Journal of Zoology 63(1): 67-70.

IVERSON, J.B. 1992. A Revised Checklist with Distribution Maps of the Turtles of the World. Richmond, IN: Privately printed, 363 pp.

JOANEN, T. AND MCNEASE, L.M. 1987. The management of alligators in Louisiana. In: Webb, G.J.W., Manolis, S.C., and Whitehead, P.J. (Eds.). Wildlife Management: Crocodiles and Alligators. Chipping Norton, Australia: Surrey Beatty, pp. 33-42.

JOANEN, T., MCNEASE, L.M., AND PERRY, G. 1977. Effects of simulated flooding on alligator eggs. Proceedings of the Southeastern Association of the Fish and Game Commission 31:33-35.

JOANEN, T., MCNEASE, L.M., AND FERGUSON, M.W.J. 1987. The effects of egg incubation temperature on post-hatching growth of American alligators. In: Webb, G.J.W., Manolis, S.C., and Whitehead, P.J. (Eds.). Wildlife Management: Crocodiles and Alligators. Chipping Norton, Australia: Surrey Beatty, pp. 533-537.

KAM, Y.-C. 1994. Effects of simulated flooding on metabolism and water balance of turtle eggs and embryos. Journal of Herpetology 28(2):173-178.

LARRIERA, A., IMHOF, A., AND VON FINK, C. 1996. The experimental ranching program of broad-snouted caiman in Santa Fe, Argentina. In: Crocodile Specialist Group. Crocodiles: Proceedings of the 13th Working Meeting of the Crocodiles Specialist Group. Gland, Switzerland: IUCN - The World Conservation Union, pp. 1-6.

LOPES, H.S. 1982. On *Eumacronychia sternalis* Allen (Diptera, Sarcophagidae) with larvae living on eggs and hatchlings of the east Pacific green turtle. Revista Brasileira de Biologia 42(2):425-429.

MAGNUSSON, W.E. 1982. Mortality of eggs of the crocodile *Crocodylus porosus* in northern Australia. Journal of Herpetology 16:121-130.

MALVÁSIO, A. 2001. Aspectos do mecanismo alimentar e da biologia reprodutiva em *Podocnemis expansa* (Schweigger, 1812), *P. unifilis* (Troschel, 1848) e *P. sextuberculata* (Cornalia, 1849) (Testudines, Pelomedusidae). Ph.D. Thesis, Universidade de São Paulo, Brasil.

MCGEHEE, M.A. 1990. Effects of moisture on eggs and hatchlings of loggerhead sea turtles (*Caretta caretta*). Herpetologica 46:251-258.

MEYLAN, A.B. AND EHRENFELD, D. 2000. Conservation of marine turtles. In: Klemens, M.W. (Ed.). Turtle Conservation. Washington, DC: Smithsonian Institution Press, pp. 96-125.

MOLL, E.O. 1979. Reproductive cycles and adaptations. In: Harless, M. and Morlock, H. (Eds.). Turtles: Perspectives and Research. New York: Wiley and Sons, pp. 305-331.

MROSOVSKY, N. AND YNTEMA, C.L. 1980. Temperature dependence of sexual differentiation in sea turtles: implications for conservation practices. Biological Conservation 18:271-280.

OJASTI, J. 1967. Consideraciones sobre la ecología y conservación de la tortuga *Podocnemis expansa* (Chelonia, Pelomedusidae). Atas do Simpósio sobre a Biota Amazônica 7:201-206.

PACKARD, G.C., BOARDMAN, T.J., PACKARD, M.J., AND ASHEN, M.D. 1981. Possible adaptive value of water exchanges in flexible-shelled eggs of turtles. Science 213:471-473.

PADUA, L.F.M. AND ALHO, C.J.R. 1984. Avaliação do comportamento de nidificação em *Podocnemis expansa* (Testudinata, Pelomedusidae) durante cinco anos em área de proteção. Brasil Florestal 59:59-61.

PIEAU, C., GIRONDOT, M., RICHARDMERCIER, N., DESCAGES, G., DORIZZI, M., AND ZABORSKI, P. 1994. Temperature sensitivity of sexual differentiation of gonads in the European pond turtle: hormonal involvement. Journal of Experimental Zoology 270:86-94.

PLUMMER, M.V. 1976. Some aspects in the nest success in the tutrtle, *Trinyx muticus*. Herpetologica 32:353-359.

PLUMMER, M.V., SHADRIX, C.E., AND COX, R.C. 1994. Thermal limits of incubation in embryos of softshell turtles (*Apalone mutica*). Chelonian Conservation and Biology 1(2):141-144.

PRITCHARD, P.C.H. AND TREBBAU, P. 1984. The Turtles of Venezuela. Society for the Study of Amphibians and Reptiles, Contributions in Herpetology No. 2, 403 pp.

REICHART, H.A. 1982. Farming and ranching as a strategy for sea turtle conservation. In: Bjorndal, K. (Ed.). Biology and Conservation of Sea Turtles. Washington, DC: Smithsonian Institution Press, pp. 465-471.

SANCHEZ, P.A. 1981. Suelos del Trópico: Características y Manejo. San José, Costa Rica: Instituto Interamericano de Cooperación para la Agricultura.

SHINE, R. 1999. Why is sex determined by nest temperature in many reptiles? TREE 14(5):186-189.

SCHULTE, D.M. AND CHABRECK, R.H. 1990. Effects of nest and egg characteristics on size and early development of American alligators. In: Crocodile Specialist Group. Crocodiles: Proceedings of the 10th Working Meeting. Gland, Switzerland: IUCN – The World Conservation Union, pp. 177-187.

TUCKER, J.K. AND WARNER, D.A. 1999. Microgeographic variation in response of red-eared slider (*Trachemys scripta elegans*) embryos to similar incubation environments. Journal of Herpetology 33(4):549-557.

VALENZUELA, N. 2000. Multiple paternity in side-neck turtles *Podocnemis expansa*: evidence from microsatellite DNA data. Molecular Ecology 9:99-105.

VALENZUELA, N. 2001. The effects of constant, shift and naturally-fluctuating temperature on sex-determination in *Podocnemis expansa* turtles. Ecology 82(11):3010-3024.

VAN TIENHOVEN, A. 1983. Reproductive Physiology of Vertebrates. 2nd Ed. Ithaca, NY: Cornell University Press.

VELASCO, A. AND DE SOLA, R. 1997. Programa de manejo de la baba (*Caiman crocodilus*) de Venezuela. In: Arriaga-Weiss, S.L and Contreras, S.W. (Eds.). Memórias de la 4a Reunión Regional del Grupo de Especialistas en Cocodrilos de América Latina y el Caribe. Tabasco, México: Centro Regional de Innovación Agroindustrial S.C. Villahermosa, pp. 235-246.

VERDADE, L.M. 1985. Biologia reprodutiva do Jacaré-de-Papo-Amarelo (*Caiman latirostris*) em São Paulo, Brasil. In: Larriera, A. and Verdade, L.M. (Eds.). La Conservación y el Manejo de Caimanes y Cocodrilos de América Latina. Vol. 1. Santa Fe, Argentina: Fundación Banco Bica. Santo Tomé, pp. 57-79.

VERDADE, L.M., MICHELOTTI, F., RANGEL, M.C., CULLEN L., JR., HERNANDEZ, M.M., AND LAVORENTI, A. 1992. Manejo dos ovos de jacarés-de-papo-amarelo (*Caiman latirostris*) no CIZBAS/ESALQ/USP. In: Verdade, L.M. and Lavorenti, A. (Eds.). Anais do II Workshop sobre Conservação e Manejo do Jacaré-de-Papo-Amarelo (*Caiman latirostris*). Piracicaba, Brazil: CIZBAS / ESALQ / USP, pp. 92-99.

VERDADE, L.M., LAVORENTI, A., AND PACKER, I.U. 1993. Manejo reprodutivo do jacaré-de-papo-amarelo (*Caiman latirostris*) em cativeiro. In: Verdade, L.M., Packer, I.U., Rocha, M.B., Molina, F.B., Duarte, P.G., and Lula, L.A.B.M. (Eds.). Anais do III Workshop sobre Conservação e Manejo do Jacaré-de-Papo-Amarelo (*Caiman latirostris*). Piracicaba, Brazil: ESALQ / USP, pp. 143-151.

VOGT, R.C. 1981. Turtle egg (*Graptemys*: Emydidae) infestation by fly larvae. Copeia 1981(2):457-459.

WEBB, G.J.W. AND COOPER-PRESTON, H. 1989. Effects of incubation temperature and the evolution of reptilian oviparity. American Zoologist 29(3):953-971.

WEBB, G.J.W., MANOLIS, S.C., DEMPSEY, K.E., AND WHITEHEAD, P.J. 1987. Crocodilian eggs: a functional overview. In: Webb, G.J.W., Manolis, S.C., and Whitehead, P.J. (Eds.). Wildlife Management: Crocodiles and Alligators. Chipping Norton, Australia: Surrey Beatty, pp. 417-422.

WIBBELS, T., BULL, J.J., AND CREWS, D. 1991. Chronology and morphology of temperature-dependent sex determination. Journal of Experimental Zoology 260:371-381.

WHITEHEAD, P.J., WEBB, G.J.W., AND SEYMOUR, R.S. 1990. Effect of incubation temperature on development of *Crocodylus johnstoni* embryos. Physiological Zoology 63(5):949-964.

YNTEMA, C.L. 1960. Effects of various temperatures on the embryonic development of *Chelydra serpentina*. Anatomical Record 136:305-306.

ZUG, G.R. 1993. Herpetology: An Introductory Biology of Amphibians and Reptiles. San Diego, CA: Academic Press, 527 pp.

ZWINK, W. AND YOUNG, P.S. 1990. Desova e eclosão de *Podocnemis expansa* (Schweigger 1812) (Chelonia: Pelomedusidae) no Rio Trombetas, Pará, Brasil. Forest'90 (1):34-35.

Received: 26 September 2001
Revised and Accepted: 14 August 2002