Journal of Herpetology, Vol. 31, No. 4, pp. 514–520, 1997

Monitoring the Distribution, Abundance and Breeding Areas of *Caiman crocodilus crocodilus* and *Melanosuchus niger* in the Anavilhanas Archipelago, Central Amazonia, Brazil

RONIS DA SILVEIRA,[1,3] WILLIAM ERNEST MAGNUSSON,[1] AND ZILCA CAMPOS[2]

[1]*Coordenadoria de Pesquisas em Ecologia, Instituto Nacional de Pesquisas da Amazônia, Caixa Postal 478, 69011-970 Manaus Amazonas, Brazil*, and
[2]*EMBRAPA/CPAP*, Caixa Postal 109, *79320-900 Corumbá Mato Grosso do Sul, Brazil*

ABSTRACT.—*Caiman crocodilus crocodilus* and *Melanosuchus niger* occur throughout most of the Anavilhanas Archipelago, located in the lower Rio Negro, Central Amazonia. The observed densities of these species vary from 0 to 58 per km of shoreline and 0 to 8 per km of shoreline, respectively. Multiple regression analysis indicated that the temperature difference between the water and the air, and water depth affected the observed density of *C. crocodilus* during spotlight surveys in the Archipelago. Percentage illumination by the moon, cloud cover, frequency of occurrence of grass, and food availability did not significantly affect the observed density of *C. crocodilus*.

Nine hatchling groups of *M. niger* that hatched in 1992 were found on islands near the north bank of the Rio Negro, and 15 of 20 hatchlings groups of *C. crocodilus* were found closer to the south bank, indicating a tendency for separation of nesting areas. Discriminant function analysis indicated that water depth and presence of grass were correlated with the occurrence of hatchling groups. *Melanosuchus niger* hatchling groups occurred in areas with deeper water and more grass than those of *C. crocodilus*.

This study showed that surveying hatchling groups in the Anavilhanas Archipelago is more efficient than surveying for subadults and adults, which, by itself, can give false impressions about the suitability of areas for conservation of breeding populations of these species.

The majority of studies of *Caiman crocodilus* (the common caiman) have been in savanna habitats (Gorzula, 1978; Ayarzagüena, 1983; Thorbjarnarson, 1995). Little is known of its ecology in swamps and forests, the most abundant habitats within its distribution (Ouboter and Nanhoe, 1988). *Melanosuchus niger* (the black caiman) is the largest Neotropical crocodilian, reaching a total length of about 6 m (Medem, 1983) and is threatened with extinction due to illegal hunting for its skin (Plotkin et al., 1983; Groombridge, 1987). Little is known of the biology of *M. niger* in the Brazilian Amazon (Vasquez, 1991).

A description of the distribution and abundance of a population of crocodilians is usually the first step in their study and often establishes basic information for their conservation and management (Bayliss, 1987). Estimation of abundance of crocodilians is generally based on indices of density such as the number of individuals seen per km of bank or per hectare. However, the methods used are subject to many problems of interpretation when comparing densities observed in different habitats or with different visibility conditions (Magnusson, 1982a, 1984; Gorzula, 1984, 1987; Bayliss, 1987). The distribution and abundance of crocodilians can also be estimated by counting nests (Chabreck, 1966; McNease and Joanen, 1978), and the occurrence of groups of hatchlings (pods) can also indicate nesting areas, or areas in which the nests had been successful in that reproductive season (Webb and Messel, 1978). Pods are mobile and may include hatchlings from more than one nest, but our observations throughout the year indicate that pods are relatively sedentary and hatchlings generally do not disperse before April in the Anavilhanas Archipelago.

This was the first study of *C. crocodilus* and *M. niger* in a black water system in the Brazilian Amazon, and the overall objective was to develop a standardized methodology of monitoring caiman populations in the Anavilhanas Archipelago. We asked the following questions: (1) Which species of caimans occur in the Anavilhanas Archipelago? (2) What is their distribution, abundance, and size distribution in the Archipelago? (3) Which factors affect observed densities of caimans during spotlight surveys in the Archipelago? (4) What are the characteristics of areas where hatchlings of these species occur?

MATERIALS AND METHODS

The Anavilhanas Ecological Station (02°00′ to 03°02′ S and 60°27′ to 61°07′ W) is located in the

[3] Present Address: Projeto Mamirauá, Caixa Postal 38, 69470-000 Tefé Amazonas, Brazil.

lower Rio Negro, between the cities of Manaus and Novo Airão, Amazonas, Brazil. The Reserve contains 250,000 ha of terra firme forest (forest not subject to inundation) and thousands of islands (100,000 ha) (Brasil, 1984).

The Rio Negro is the largest tributary of the Rio Amazonas and has an annual fluctuation of 9 to 12 m (Goulding et al., 1988). During this study in 1991, the water level of the Rio Negro varied by 12 m. At the peak of the wet season (June–July) the river flooded all islands, connecting all water bodies in the Archipelago. The lowest river levels occurred between October and December. The islands are elongated and encompass thousands of lakes and canals (Leenher and Santos, 1980). The majority of the lakes remain connected with other water bodies throughout year. Canals remain connected to other water bodies at both ends throughout the year and have continuous flow.

The climate of the study area, based on data for the Manaus region, is classified as Afi of Köpen, with a mean monthly temperature higher than 18 C, and a monthly rainfall greater than 60 mm (Ribeiro, 1976). The islands are covered by igapo forest, a low forest that occurs in flooded areas of black and clear water rivers (Pires and Prance, 1985). Lower parts of the islands are covered by shrub vegetation and are subject to longer periods of inundation. Higher areas have forest up to 35 m in height.

Distribution and Abundance.—Caimans were counted in 0.5, 1.0, or 2.0 km segments in 81 different sites in the Archipelago (54 lakes and 27 canals), between June 1991 and March 1992. Each site was surveyed only once. Densities are expressed as the number of caimans observed per km of bank. Densities of caimans in the same body of water, but outside the census segment, were not estimated but the presence or absence of each species was noted.

Sites were surveyed between 1930 h and 2030 h, using a 5 m aluminum boat with a 15 Hp motor, or by paddling a wooden canoe. The Reserve has been protected for 16 yr, the caimans do not respond to observers until approached closely, and we believe that both modes of transport give similar results. Caimans were located by their eyeshine using a hand-held spotlight. In this paper, "caiman" refers to the three genera of Amazonian crocodilians.

Size Distribution.—Snout–vent lengths (SVL) of caimans were estimated at distances <5 m and a sample of caimans was subsequently captured for measurement of SVL. Regression equations relating measured SVL (MSVL, cm) to estimated SVL (ESVL, cm) by Da Silveria before capture were used to correct estimated SVL of caimans seen in surveys but not captured (Magnusson, 1983). The regression lines for *C. crocodilus* (MSVL = 16.3 ± 0.76ESVL, $F_{1,128} = 309.6$, $P = 0.000$) and *M. niger* (MSVL = 14.8 ± 0.69 ESVL, $F_{1,13} = 15.8$, $P = 0.002$) have reasonable predictive value up to 120 cm SVL both species ($r^2 = 0.70$ and $r^2 = 0.55$, respectively) but adult *M. niger* were not captured.

Environmental Factors.—Data on environmental factors were collected from 500 m sections of 46 survey sites. The number of *C. crocodilus* observed in each 500 m section was related by multiple regression analyses to the differences in temperature between the water and the air, the percentage illumination by the moon, cloud cover, water depth, water level of the Rio Negro, velocity of the current, frequency of occurrence of grass, and food availability.

Water depth was measured 5 m from the bank, at the beginning, middle, and end of each 500 m section. The majority of caimans occur between 1 and 2 m from the bank and obstacles and shallow water make it difficult to travel closer to the bank than 5 m in the Anavilhanas Archipelago. The average of the three depth measurements at each site was used in analyses. The percentage illumination by the moon was estimated using the program "Almanac," developed by R. Alford (pers. comm.). The occurrence of cloud cover was registered as present or absent. The presence or absence of grass was registered at intervals of 10 m along the section. Thus, the index of frequency of occurrence of grass varied from 0 to 50 for each section.

The availability of fish, shrimps, insects, and spiders was estimated along each 500 m section on the same nights as surveys. Fish were sampled with three gill nets at the beginning, middle, and end of each section. Gill nets were set between 1800 and 1830 h and fish removed at 2100 and at 0000 h. Fish were weighed the following morning. The 10 m nets were of 3 mm nylon, with a 20 mm stretch mesh, at 2.0 m deep, 30 mm stretch mesh, at 3.0 m deep, and 30 mm stretch mesh, at 1.5 m deep. The nets captured fish with standard length > 9 cm and < 80 cm, and these were weighed to the nearest 1 g the following morning.

Shrimp, small fish (standard length <8 cm), spiders and insects were sampled with a dipnet. The dipnet (45 × 45 × 45 cm with 2 mm diameter nylon mesh) was swept 50 times in the water, each 10 m, through the flooded vegetation and/or along the banks, between 2200 and 2300 h. Samples were separated the following morning and preserved in 70% alcohol. Samples were weighed to the nearest 0.01 g, after draining off excess alcohol. The index of food availability used in analyses was the total mass of fish, shrimp, insects, and spiders captured in each 500 m section.

Extensive Survey and Occurrence of Pods.—Four pods of *C. crocodilus* and one of *M. niger* were found during the spotlight surveys in February 1992. Other pods were found during an extensive spotlight survey between March and April 1992. The extensive survey covered 1500 km of the Archipelago and 22 km along three forest stream tributaries on the north bank, and two on the south bank of the Rio Negro. Distances traveled during the surveys are based on measurements from the RADAMBRASIL map SA.20/Z-B-V/MI5-6, with a 1:100000 scale.

Discriminant function analysis was used to differentiate site characteristics of 17 pods of *C. crocodilus* and eight pods of *M. niger* that hatched in 1992. The type of water body was categorized as lake or canal. Zero depth was attributed to pods that were on dry land. A depth of 0.1 m was recorded for pods in water, but adjacent to the bank. Conductivity was measured to the nearest μScm^{-1} and temperature of the water was measured to the nearest of 0.1 C with a Yokogawa model SC82 conductivity meter. Bank was recorded as absent (0), if more than 1 km from the site, or present (1). The substrate was recorded as grass (1) or non-grass (0).

All statistical analyses were done with the program SYSTAT (Wilkinson, 1990).

RESULTS

We counted 478 caimans in the 81 survey sites along 82 km of bank. Of these total, 88 were hatchling *Caiman crocodilus* and four were hatchling *Melanosuchus niger* from the 1991 nesting season. Of the remainder, 221 were *C. crocodilus*, eight were *M. niger*, and 157 were unidentified. Caimans that could not be identified to species during the surveys were assumed to be *C. crocodilus* due to the low density of *M. niger* in the Archipelago. Estimates of observed densities did not include hatchlings (SVL < 20 cm).

Caiman crocodilus densities within survey sections in lakes (N = 54) varied from 0 to 58 per km of shoreline (Fig. 1A), and from 0 to 7 per km of shoreline in canals (N = 27) (Fig. 1B). Densities higher than 15 per km were observed only in October–November 1991. Zero counts of *C. crocodilus* occurred in 10 of the 81 survey sections (Fig. 1A, B). However, the species was present around the survey sections in all 81 sites. *Melanosuchus niger* was present in 12 of the 81 sites, but only occurred in five of the survey sections. Its density varied from 0.5 to eight per km of shoreline in the five sections.

Excluding hatchlings (SVL < 20 cm), 67% of *C. crocodilus* were subadults (SVL <70 cm) and 5% were probably adult males (SVL > 90 cm). (Fig. 2A). The majority of *M. niger* observed during these surveys were subadults (SVL < 120 cm), and only two *M. niger* larger than 150 cm SVL were observed (Fig. 2B).

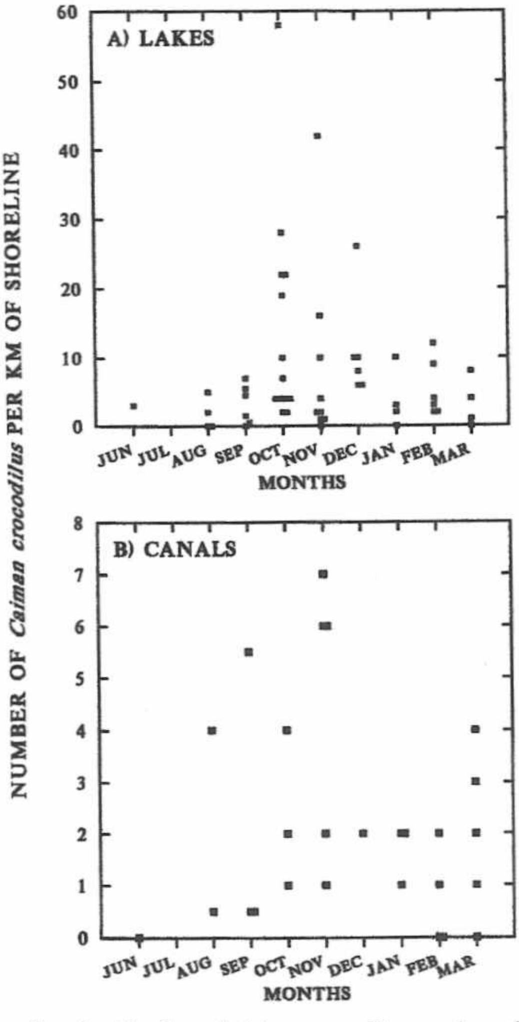

FIG. 1. Number of *Caiman crocodilus* per km of shoreline seen during spotlight surveys between June 1991 and March 1992 in (A) lakes and (B) canals. Each point represent a different survey site.

The multiple regression analysis was used only to investigate the density of *C. crocodilus*, because the density of *M. niger* in the area was too low for analysis. The multiple regression, using all variables except food availability, explained only 40% of the variance in observed numbers of *C. crocodilus* during spotlight surveys (R^2 = 0.40, $F_{6,39}$ = 4.292, P = 0.002). The temperature difference between the water and the air (P = 0.002), and water depth (P = 0.029), were the only factors that had partial regressions that contributed significantly (Fig. 3A and B, respectively). The relationship between observed numbers of *C. crocodilus* and water depth was nonlinear, and was modeled as a quadratic function (Fig. 3B). The water level of the Rio Ne-

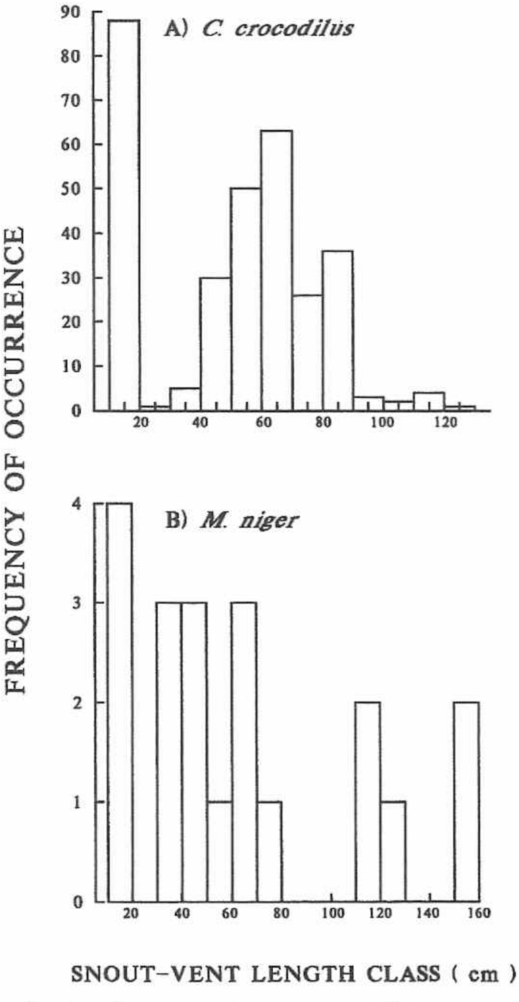

FIG. 2. Frequency of occurrence of *Caiman crocodilus* (A) and *Melanosuchus niger* (B) in 10 cm snout–vent length size classes estimated. Data include 8 *M. niger* found outside the survey sections.

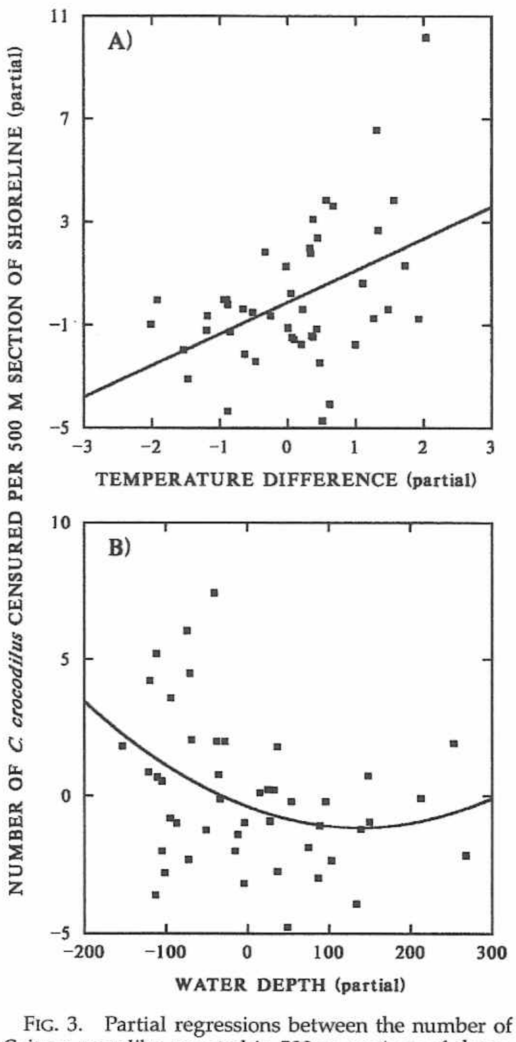

FIG. 3. Partial regressions between the number of *Caiman crocodilus* counted in 500 m sections of shoreline and (A) the temperature difference between water and air in °C, (B) water depth in meters. Some numbers of axes are negative because the partial regressions represent deviations from the expected result if all others variables were held constant at their observed means.

gro and current velocity were excluded from the multiple regression, because they were correlated with the frequency of occurrence of grass (r = 0.56) and water depth (r = 0.52). It was not feasible to test all possible combinations of factors, but the majority of combinations produced qualitatively similar results, so the model does not appear to be sensitive to the inclusion or exclusion of variables.

Inclusion of the indices of food availability in the regression in addition to habitat characteristics did not significantly increase the capacity of the regression to estimate the number of *C. crocodilus* observed in the surveys ($R^2 = 0.44$, $F_{6,39} = 5.177$, $P = 0.001$). Successive permutations of these factors produced qualitative results similar indicating that the model is robust to the inclusion or exclusion of variables.

We grouped the indices of availability of shrimp and small fish in the same category because, when considered separately, their contributions to the regression model were qualitatively similar. Insect and spider availability were grouped for the same reason.

Extensive Survey and Occurrence of Pods.—Between March and April 1992 we traveled 1500 km through the Archipelago and in five forest streams searching for caimans. Excluding hatchlings, 1180 caimans were counted. Of these, 313 were *C. crocodilus*, 51 *M. niger*, one *Paleosuchus palpebrosus*, and 815 were not identified to species. *Caiman crocodilus* occurred in all water bodies visited during the surveys. *Melanosuchus niger* was not found in all water bodies, but this species occurred throughout most of the Archipelago. *Caiman crocodilus* was found in all of the water bodies in which *M. niger* was found.

We found 178 hatchling *C. crocodilus* in 20 pods and 77 hatchling *M. niger* in nine pods. One *C. crocodilus* hatchling was dead and was being eaten by a fish (probably *Hoplias* sp.). Two pods of *C. crocodilus* and three pods of *M. niger* contained only one or two hatchlings, but these were counted as distinct because of their great distances from other pods. The nine pods of *M. niger* were found in islands near the north bank of the Rio Negro, and 15 of the 20 pods of *C. crocodilus* were closer to the south bank. Although we encountered one *C. crocodilus*, one *Paleosuchus palpebrosus* and one *P. trigonatus* in forest streams, no hatchlings were found.

We used discriminant function to try to differentiate the sites with *C. crocodilus* hatchlings from sites with *M. niger* hatchlings. Only water depth had a high loading on the discriminant function (0.94). Grass (0.48) and type of bank (−0.36) were intermediate, and the other variables contributed negligibly to discrimination (conductivity 0.17, type of water body 0.06 and water temperature, −0.08). The analysis erred only in the prediction of one *C. crocodilus* and one *M. niger* pod. This occurred because that *C. crocodilus* pod was found in water 4.6 m deep, whilst all other pods of this species were found in water less than of 2.5 m deep. Only one *M. niger* pod was found in water less than 3 m deep and away from grass.

Discussion

Caiman crocodilus and *Melanosuchus niger* occur throughout the Anavilhanas Archipelago but we found only one *Paleosuchus palpebrosus* in the Archipelago. *Caiman crocodilus*, *P. palpebrosus*, and *P. trigonatus* occur in forest streams that flank the Archipelago. Further studies should be extented to forest streams to evaluate the status of these species in the Reserve. The size distributions indicate that the Anavilhanas Archipelago contains suitable habitat for all size classes of *C. crocodilus* and *M. niger*. It has been postulated that the occurrence of *M. niger* may affect the abundance of *C. crocodilus* (Magnusson, 1982b; Magnusson and Rebelo, 1983). However, the low density of *M. niger* apparently does not appear to have a large effect on the distribution of *C. crocodilus* in the Anavilhanas Archipelago.

Variations in numbers counted in response to environmental temperature has direct implications for monitoring and hence management of crocodilians (Lang, 1987). In the Anavilhanas, the difference between water and air temperatures was the factor that had the largest correlation with the number of *C. crocodilus* seen. These results are in agreement with those of Murphy and Brisbin (1974) and Woodward and Marion (1978), who also found positive correlations between water temperature and the observed numbers of *Alligator mississippiensis*. During this study, observed numbers of *C. crocodilus* were generally negatively correlated to water depth and/or current velocity, factors that were positively correlated. The greater water depth and current velocity in the canals may account for the lower density of *C. crocodilus* found there relative to lakes.

Caiman crocodilus is generally more common in grassy areas (Magnusson, 1985; Ouboter and Nanhoe, 1988). However, the frequency of occurrence of grass was not related to the observed number of *C. crocodilus* in the Anavilhanas. Possibly, an increase in real density that occurred with increase in grass cover was offset by decreases in the visibility of caimans, or the behavior of *C. crocodilus* in the Anavilhanas may be different from that in others areas.

Woodward and Marion (1978) found a positive correlation between moon phase and observed density of *Alligator mississippiensis*. However, no relationship was found between the percentage illumination by the moon and observed densities of *C. crocodilus* in this study.

Many authors have suggested that the abundance of crocodilians is related to food availability (e.g., Webb et al., 1982; Ouboter and Nanhoe, 1988). However, we found no relationship between food availability and the abundance of *C. crocodilus*. It may be that caimans do not respond to the absolute density of prey, but seek conditions where prey are more easily captured, or it may be that other factors are more important.

Pods of *M. niger*, indicating successful nesting, occurred only on islands next to the north bank of the Rio Negro. This bank suffers greater influence from the Rio Branco, which enriches the water with nutrients (S. Filoso, pers. comm.). The possible effect of the Rio Branco on the occurrence of nesting areas, and on the distribution and abundance of both species, should be evaluated in future studies. Overall, *M. niger* pods occurred in sites with deeper water, indicating that the species nests on the more low lying islands or parts of islands in the Archipelago. The occurrence of eight of the nine pods of *M. niger* on grass reinforces this notion. Beginning in March, the islands are gradually inundated by the Rio Negro and grass is the only substrate on which the hatchlings can rest.

Further surveys of the distributions of pods need to be undertaken in consecutive years to see if the separation of caiman species is maintained. Searches for caiman nests by land or by aerial survey (McNease and Joanen 1978), are generally not efficient in the Archipelago because nests occur in low densities in the dense "igapó" forest. However, searches for nests by land could be concentrated in areas where pods are known to occur.

Estimates of the distribution and abundance of crocodilians are generally based on surveys of subadults and adults. However, these surveys are usually based on indices of relative density that cannot currently be corrected for visibility biases (Magnusson, 1982a, 1984; Gorzula, 1984, 1987; Bayliss, 1987). Moreover, subadults and adults may occur at relatively high densities in areas that are inadequate for nesting, and hence the overall maintenance of the population (Van Horne, 1983). The results of this study demonstrate the need to identify actual nesting areas, since this is important information for the design of reserves. With degradation of surrounding areas, maintenance of the population by immigration may no longer be viable.

Areas with highest densities of nests also had high densities of adults and subadults caimans. This indicates that annual searches for hatchling pods, in the period March to April, would be the most efficient method for monitoring caiman populations in the Anavilhanas Archipelago. Although river levels are high, surveys of subadults and adults at this time of the year are probably just as useful for long term monitoring of population trends as surveys at low water (September to November) when a larger, but unknown, proportion is seen and hatchlings groups are dispersed. If the bias is consistent, then the resulting index of relative density would be stable and just as useful for monitoring changes in adult and subadult densities as surveys at low water when more individuals are seen.

Acknowledgments.—This study is part of a Master of Science thesis by Ronis da Silveira presented to the Ecology Course of the Instituto Nacional de Pesquisas da Amazonia (INPA). We thank the thesis evaluation committee: Grahame Webb, Augusto Shinya Abe, José Marcio Ayres, Kent Redford and John Thorbjarnarson. Peter Bayliss criticized the manuscript. Marivaldo Pontes participated in data collection. The values for the daily level of the Rio Negro were furnished by Portobrás, Manaus. This study was funded by World Wildlife Fund (WWF/Brazil), fundação Vitória Amazônica (FVA/Brazil), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq/Brazil, grant 401118/87-8/PQ/FV to W. Magnusson) and the First World Congress of Herpetology. The Brazilian Institute of the Environment and Renewable Natural Resoruces (IBAMA) gave access to the floating and ground bases in the Anavilhanas. CNPq provided a masters scholarship to Ronis Da Silveria (grant 133259/90).

Literature Cited

Ayarzagüena, J. S. 1983. Ecologia del caiman de anteojos o baba (*Caiman crocodilus* L.) en los llanos de Apure (Venezuela). Doñana Acta Vert. 10:7–136.

Bayliss, P. 1987. Survey methods and monitoring within crocodile management programes. *In* G. J. W. Webb, S. C. Manolis, and P. J. Whitehead (eds.), Wildlife Management: Crocodiles and Alligators, pp. 157–175. Surrey Beatty & Sons, Chipping Norton, Australia.

Brasil. 1984. Estacão Ecológica de Anavilhanas. Ministério do Interior/Secretaria Especial do Meio Ambiente, Brasília.

Chabreck, R. H. 1966. Methods of determining the size and composition of alligator populations in Louisiana. Proc. Ann. Conf. S. E. Assoc. Game and Fish Comm. 20:105–112.

Gorzula, S. J. 1978. An ecological study of *Caiman crocodilus crocodilus* inhabiting savanna lagoons in the Venezuelan Guayana. Oecologia 35:21–34.

———. 1984. Request for interchange of ideas on standardization of terminology used to express densities of crocodilians. IUCN/SSC Crocodile Specialist Group Newsletter 3:23.

———. 1987. The management of crocodilians in Venezuela. *In* G. J. W. Webb, S. C. Manolis, and P. J. Whitehead (eds.), Wildlife Management: Crocodiles and Alligators, pp. 91–101. Surrey Beatty Pty. Ltd., Chipping Norton, Australia.

Goulding, A., M. L. Carvalho, and E. G. Ferreira. 1988. Rio Negro: Rich Life in Poor Water. SPB Academic Publishing.

Groombridge, B. 1987. The distribution and status of world crocodilians. *In* G. J. W. Webb, S. C. Manolis, and P. J. Whitehead (eds.), Wildlife and Management: Crocodiles and Alligators, pp. 9–21. Surrey Beatty Pty. Ltd., Chipping Norton, Australia.

Lang, J. W. 1987. Crocodilian behaviour: implications for management. *In* G. J. W. Webb, S. C. Manolis, and P. J. Whitehead (eds.). Wildlife and Management: Crocodiles and Alligators, pp. 273–293. Surrey Beatty Pty. Ltd., Chipping Norton, Australia.

Leenher, J. A., and H. Santos. 1980. Considerações sobre os processos de sedimentação na água preta ácida do Rio Negro (Amazônia Central). Acta Amazonica, 10:343–355.

Magnusson, W. E. 1982a. Techniques of surveying for crocodilians. *In* Crocodiles. Proc. of the 5th Working Meeting of the Crocodile Specialist Group, pp. 389–403. IUCN Publ. N. S., Gland, Switzerland.

———. 1982b. Biological aspects of the conservation of Amazonian crocodilians in Brazil. *In* Crocodiles. Proc. of the 5th Working Meeting of the Crocodile Specialist Group, pp. 108–116. IUCN Publ. N. S., Gland, Switzerland.

———. 1983. Size estimates of crocodilians. J. Herpetol. 17:86–88.

———. 1984. Response to request for exchange of ideas on standardization of terminology on crocodilian densities. IUCN/SSC Crocodile Specialist Group Newsletter 3:14–15.

———. 1985. Habitat selection, parasites and injuries in Amazonian crocodilians. Amazoniana 9:193–204.

———, AND G. H. REBELO. 1983. Brazilian crocodiles: problems of conservation in a multispecies system. Zimbabwe Science News 17:56–57.

MCNEASE, L., AND T. JOANEN. 1978. Distribution and relative abundance of the alligator in Louisiana coastal marshes. Proc. Ann. Conf. S. E. Assoc. Fish and Widl. Agencies 3:182–186.

MEDEM, F. 1983. Los Crocodylia de Sur America, Vol. 2. Carrera, Bogota.

MURPHY, T. M., AND I. L. BRISBIN. 1974. Distribution of alligators in response to thermal gradients in a reactor cooling reservoir. *In* J. W. Gibbons, and R. R. Sharitz (eds.), Thermal Ecology, pp. 313–321. U.S. Atomic Energy Commission, Oak Ridge.

OUBOTER, P. E., AND L. M. R. NANHOE. 1988. Habitat selection and migration of *Caiman crocodilus crocodilus* in a swamp and swamp-forest habitat in Northern Suriname. J. Herpetol. 2:283–294.

PIRES, J. M., AND G. T. PRANCE. 1985. The vegetation types of the Brazilian Amazon. *In* G. T. Prance and T. E. Lovejoy (eds.), Amazonia, pp. 109–145. Pergamon Press, Oxford.

PLOTKIN, M. J., F. MEDEM, R. A. MITTERMEIER, AND I. A. CONSTABLE. 1983. Distribution and conservation of the black caiman (*Melanosuchus niger*). *In* A. Rhodin and K. Mitaya (eds.) Advances in Herpetology and Evolutionary Biology, pp. 695–705. Museum of Comparative Zoology, Cambridge, Massachusetts.

RIBEIRO, M. N. G. 1976. Aspectos climatológicos de Manaus. Acta Amazonica 6:229–233.

THORBJARNARSON, J. B. 1995. Dry season diel activity patterns of the spectacled caiman (*Caiman crocodilus*) in the Venezuelan llanos. Amphibia-Reptilia 16:415–421.

VAN HORNE, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47:893–901.

VASQUES, P. G. 1991. *Melanosuchus* Gray. Cat. Amer. Amphib. Rept. 1991:530.1–530.4.

WEBB, G. J. W., AND H. MESSEL. 1978. Movements and dispersal patterns of *Crocodylus porosus* in some rivers of Arnhen Land, Northern Australia. Aust. Wildl. Res. 5:263–283.

———, S. C. MANOLIS, AND R. BUCKWORTH. 1982. *Crocodylus johnstoni* in the McKinlay River area, N. T.: variation in the diet, and a new method of assessing the relative importance of prey. Aust. J. Zool. 30:877–899.

WILKINSON, L. 1990. Systat: The System for Statistics. Systat Inc., Evanston, Illinois.

WOODWARD, A. R., AND W. R. MARION. 1978. An evaluation of factors affecting night-light counts of alligators. Proc. Ann. Conf. S. E. Assoc. Fish and Widl. Agencies 32:291–302.

Accepted: 20 July 1997.