

Estimation of Nesting Female Crocodylian Size from Clutch Characteristics: Correlates of Reproductive Mode, and Harvest Implications

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ABSTRACT.—I used morphometric data from nesting crocodylians and associated clutch characteristics to develop regression models whereby demographic profiles of the female reproductive segment of populations could be reliably estimated on the basis of clutch mass or clutch size alone. Comparisons were made between nesting populations of temperate American alligators (*Alligator mississippiensis*) and tropical New Guinea crocodiles (*Crocodylus novaeguineae*). Alligators exhibited a discrete pulse mode of reproduction in contrast to the near continuous flow pattern of the crocodiles. Reproductively active female alligators from widely disjunct harvested populations were significantly smaller than those in a protected population where larger females may have precluded smaller animals from nesting. Most of the nesting female crocodiles were smaller than the size protected by law and were thus exposed to harvest, which presumably led to a higher turnover rate of the breeding segment and a reduced production of hatchlings.

Although primarily pantropical in distribution (Sill, 1968), the Order Crocodylia has several extant species with ranges that are in part north temperate (*Crocodylus acutus*, *C. moreletii*, *C. niloticus*, *C. palustris*, and *Gavialis gangeticus*) or south temperate (*C. niloticus*, *Caiman latirostris*, and *C. yacare*) (Neill, 1971; Groombridge, 1982). The surviving members of the genus *Alligator* (*A. mississippiensis* and *A. sinensis*) occur only in temperate climates and endure winter weather by constructing earthen dens where they become torpid in response to thermometabolic stress (McIlhenny, 1935; Brisbin et al., 1982).

In this paper, I examine morphometric aspects of nesting crocodylians, their modes of reproduction, and discuss environmental constraints experienced by temperate American alligators (*A. mississippiensis*) and tropical New Guinea crocodiles (*C. novaeguineae*). The former species is endemic to the United States and the latter to the island of New Guinea. References to *C. novaeguineae*, unless otherwise indicated, pertain to those populations south of the New Guinea central highlands, as they compose a taxonomically distinctive form (Hall, 1989).

Biologically meaningful data on reproductive female crocodylians are generally difficult to obtain compared to data on crocodylian nests and nest sites. Therefore, I sought to determine whether the latter data could be used to reconstruct demographic profiles of breeding crocodylian populations given data on small subsets of the nesting female segments. I also briefly

consider the implications of harvesting on the reproductive demography of these populations.

STUDY AREAS

Data on *C. novaeguineae* were collected during 1980–1981 in Lake Murray District, Western Province, Papua New Guinea (PNG; 7°00'S, 141°30'E) (Hall and Johnson, 1987; Hall, unpubl. data). Additional data on nesting animals are from Cox (1985: Appendix 6). The Lake Murray area is primarily tropical moist forest (mean annual precipitation 3200 mm) with pronounced wet (November–May) and dry (June–October) seasons. Habitats important for nesting crocodiles are the fringing mixed swamp/woodland forests, *Echinachloa* grass swamps, and *Saccharum-Phragmites* grass swamps. Further details are provided in CSIRO (1971) and Hall and Johnson (1987).

Observations on nesting alligators were made at Lacassine National Wildlife Refuge (NWR; 30°00'N, 92°50'W), Louisiana, in 1985, and at Lake Griffin (28°50'N, 81°50'W), Lake Okechobee (27°00'N, 81°00'W), Lake Woodruff NWR (29°05'N, 81°25'W), and Orange Lake (29°30'N, 82°10'W), Florida, during 1987. Lacassine NWR (12,860 ha) is within the freshwater coastal marsh region of Louisiana and about one-half of the study site was a shallow (1–2 m) impoundment containing large stands of maidencane (*Panicum hemitomom*) and bulltongue (*Sagittaria falcata*) that supported dense nesting by alligators (an estimated 1 nest per 13 ha). Fruge (1974) provides a full synopsis of the area's veg-

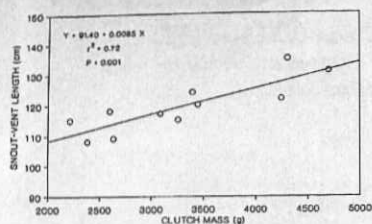


FIG. 1. Regression plot of clutch mass and nesting female alligator snout-vent length.

etiana. Descriptions of the Florida study areas are contained in Deitz and Hines (1980; Orange Lake), Jennings et al. (1987; Lake Griffin, Lake Woodruff NWR), and Millerson (1987; Lake Okechobee).

METHODS

The morphometric and reproductive variables recorded, their nearest unit of measure, and their abbreviations, are as follows: body mass (0.1 kg) = BM; clutch mass (g) = CM; clutch size = CS; dorsal cranial length (0.5 cm) [measured from the anterior snout to posterior supraoccipital] = DCL; snout-vent length (cm) = SVL; maximum tail girth (cm) = TG; and total length (cm) = TOT. SVL measurements for crocodiles were taken from the snout tip to the anterior margin of the cloaca, as per Australian convention (Webb and Messel, 1978), whereas data on alligators were recorded to the posterior end of the cloaca, consistent with the North American standard (Chabreck and Joanen, 1979). Morphometric measurements of alligators were from animals captured by short penetration harpoon (modified design of Webb and Messel, 1977a), or from individuals live-trapped at nest sites via an unbaited peddle trip snare (Mazzotti and Brandt, 1988).

Additionally, I examined reproductive tracts of female alligators harvested at Lacassine NWR in August-September 1985 to compare sizes of active breeding animals with those estimated from nest studies. Females were classified as sexually mature based on the color and texture of their ovaries (Graham, 1968; Joanen and McNease, 1980). Reproductive activity was assessed by the presence or absence of postovulatory ovarian follicles (Lance, 1989).

Nesting crocodiles were not captured, although their clutch parameters were recorded. Morphometric measurements were estimated as follows. Data from Cox (1985; Appendix 6) were supplemented with those of Hall and Johnson (1987) to derive a least-squares relationship between CM and CS for nesting female *C. novaeguineae*.

That equation (CM = $-427.27 + 118.94$ CS; $r^2 = 0.84$, $P < 0.001$, $N = 40$) was used to estimate CMs where unknown for individual clutches ($N = 24$). I also regressed CS against nesting female TOT (modified from Hall and Johnson, 1987) to estimate female TOTs for clutches where the adult was unobserved ($N = 55$), whereby: TOT = $119.88 + 3.85$ CS ($r^2 = 0.88$, $P < 0.001$, $N = 9$). Estimated TOTs were then transformed to SVL estimates by using equation 2 of Montague (1984b): SVL = $5.73 + 0.49$ TOT ($r^2 = 0.95$, $N = 150$).

The method for analysis of *C. novaeguineae* oviposition season data is described by Caughley (1977). The dates of nest detection were corrected to the dates of egg deposition through the use of embryonic growth curves (Hall, 1985b).

RESULTS

Alligator mississippiensis.—The morphometric data on female alligators from Florida associated with known clutch data ($N = 11$) were too few to permit meaningful comparisons among study sites; however, regression slopes between areas were similar to each other and the data were thus pooled for analyses. Since among-site resemblances were strong, equations derived from those data were also used to calculate SVL estimates of Florida and Louisiana animals for which only the clutch masses (CM) or clutch sizes (CS) were known. SVL was chosen as a more relevant indicator of adult female size than total length (TOT) due to the high proportion of tail injuries among crocodilians (Webb and Messel, 1977b; Montague, 1984a; Magnusson, 1985).

The best variable for predicting the size of an adult female alligator from a single attribute external to the animal was CM, although the dorsal cranial length (DCL) measurement of an isolated skull was a slightly more sensitive predictor of SVL (Table 1, Fig. 1). The relations between these and other tested factors were essentially isometric, and were not significantly enhanced by the use of logarithmic transformations.

Allometric growth in skull length to body proportions within the Crocodylia has been documented (Källin, 1933; Webb and Messel, 1978; Hall, 1985a), but this was not observed within the size range (97–140 cm SVL) of female alligators in this study. A trend toward allometry of DCL would probably be present in larger animals, but may be sex-specific and outside the body lengths attained by female alligators.

Where morphometric data on the associated females were lacking, I derived SVLs for nesting female alligators from Lake Woodruff NWR, Orange Lake, and Lacassine NWR from their

TABLE 1. Regression equations and standard error of the regression for predicting sizes of nesting female *Alligator mississippiensis* from single source attributes. BM = body mass (kg), CM = clutch mass (g), CS = clutch size, DCL = dorsal cranial length (cm), SVL = snout-vent length (cm), TG = tail girth (cm), TOT = total length (cm).

Equation no. and predictor	Estimated value	Equation	SE	r ²	N	P
X	Y					
1. CM	BM	Y = 7.91 + 0.0125X	10.07	0.54	11	<0.01
2. CM	DCL	Y = 24.77 + 0.0021X	1.14	0.73	11	<0.001
3. CM	SVL	Y = 91.40 + 0.0085X	4.60	0.72	11	<0.001
4. CM	TG	Y = 31.23 + 0.0073X	4.27	0.69	11	<0.001
5. CM	TOT	Y = 181.65 + 0.0159X	9.33	0.69	11	<0.002
6. CS	BM	Y = -13.40 + 1.5185X	10.66	0.56	13	<0.003
7. CS	CM	Y = -1317.6 + 112.9X	412.75	0.78	11	<0.001
8. CS	DCL	Y = 21.01 + 0.2602X	1.74	0.58	13	<0.002
9. CS	SVL	Y = 72.98 + 1.1148X	6.59	0.64	13	<0.001
10. CS	TG	Y = 17.39 + 0.9230X	4.60	0.72	13	<0.001
11. CS	TOT	Y = 144.41 + 2.1512X	12.87	0.64	13	<0.001
12. DCL	SVL	Y = 0.045 + 3.7406X	3.27	0.94	16	<0.001
13. SVL	BM	Y = -121.37 + 1.4443X	5.45	0.93	16	<0.001
14. SVL	TOT	Y = -1.4975 + 1.9804X	3.70	0.98	16	<0.001
15. TG	BM	Y = -68.22 + 2.163X	6.84	0.89	16	<0.001

CMs (equation 3, Table 1). Estimated sizes ($\bar{x} = 119.6$ cm) did not differ ($t = -6.37$, $N = 11$, $P > 0.05$) for animals on which actual sizes ($\bar{x} = 119.5$ cm) were obtained. Thus, estimates were pooled with data from captured nesting females to develop demographic profiles of breeding females from these populations (Fig. 2).

Nesting alligators (pooled values of actual and estimated sizes) at Orange Lake (\bar{x} SVL = 106.0 ± 7.39 SD, $N = 4$) were similar to, but slightly smaller than ($t = 0.71$, $P > 0.05$), animals at Lacassine NWR ($\bar{x} = 110.1 \pm 8.89$, $N = 9$). Both samples were from populations exposed to regulated harvest. However, reproductive females at Orange Lake ($t = 3.01$) and Lacassine NWR ($t = 2.93$) were significantly smaller ($P < 0.01$) than alligators nesting at Lake Woodruff NWR ($\bar{x} = 120.1 \pm 7.49$, $N = 18$), which was a protected population. Furthermore, the sizes of nesting alligators from Lacassine NWR did not differ ($t = 1.43$, $P > 0.05$) from those of harvested females ($\bar{x} = 104.0 \pm 11.95$ SD, $N = 40$) which had nested that year, based on reproductive tract analysis. Thus, those size distributions were included in Fig. 2. Although sample sizes from Orange Lake are small, those estimates are consistent with observations on the mean size of sexually mature female alligators removed from those systems during regulated harvest (A. Woodward, pers. comm.). The Lake Woodruff NWR sample encompassed about one third of the known nesting segment for that season, so those estimates are probably not strongly biased.

I converted estimated SVL measurements for Louisiana alligators to TOT estimates by using

equation 14 of Table 1, which was developed from Florida data. The same SVL values were then compared with transformed TOT estimates derived from Louisiana observations, whereby female SVL = $-2.24 + 0.5035$ TOT and body mass (BM) = $1.35 - 0.0378$ TOT + 0.0000046 TOT³ (Chabreck and Joanen, 1979). Those results indicated that female alligators from Louisiana display longer TOTs than do Florida animals of an equivalent SVL; hence, with corresponding SVL, alligators from Louisiana had a greater BM than Florida specimens. Consequently, the relative clutch mass (expressed as the ratio of $[(CM/1000)/BM] \times 100$) was depressed in Louisiana females ($\bar{x} = 5.12 \pm 0.41$ SD, range = 4.7–5.8) when contrasted with Florida alligators ($\bar{x} = 6.82 \pm 1.14$, range = 5.1–8.7). This difference ($t = 4.01$, $P < 0.001$) might seem to be an artifact of the larger mean SVL (119 cm) of females composing the Florida sample. However, the comparable relative clutch mass for a Louisiana individual with an SVL of 121 cm was only 5.6, suggesting that the difference is real.

Crocodylus novaeguineae.—The estimated mean SVL for 60 individuals (excluding four captives) was 104.1 cm ± 10.89 SD (Fig. 3). Estimated CM and BM (equation 83 of Montague, 1984b) for a crocodile of this size were 2001 g and 38.2 kg, respectively. Relative clutch mass was 5.2, which lies within the interval of 4–7% previously reported for the species (Hall and Johnson, 1987).

The lower mean SVL of *C. novaeguineae* compared to alligators was a reflection of smaller adult size. Maximum recorded size (TOT) for female *C. novaeguineae* is 2.65 m (Hall and John-

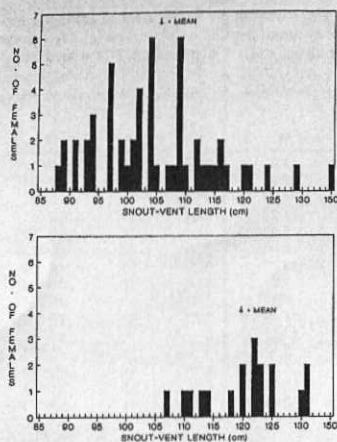


FIG. 2. Size structures of nesting female *Alligator mississippiensis* from harvested (Orange Lake and Lacassine National Wildlife Refuge—top) and protected (Lake Woodruff National Wildlife Refuge—bottom) populations.

son, 1987), whereas female alligators can attain 2.87 m (Joanen and McNease, 1989).

The sizes (SVL) of nesting crocodiles reported here encompassed the minimum and maximum known range of reproduction by the species. Since data representing the upper, but not the lower, limit of the reproductive curve were available for alligators, I hypothesized that an estimate of the minimum size at reproduction in alligators would be proportional to the maximum adult female size ratio between these species (0.92). To test this assumption, I took the lowest observed SVL value for *C. novaeguineae* (80 cm), added 3 cm to make the measurement equivalent to that for alligators (see Methods), and obtained a predicted SVL estimate of 90 cm (83/0.92) for alligators. This value closely approximated that observed (88 cm) for the smallest reproductively active female alligator that I observed during reproductive tract analysis of harvested animals from Lacassine NWR, and is similar to that for a 1.71 m TOT female observed during incubation (Joanen and McNease, 1989). Thus, in these two crocodilians, females appear capable of nesting once they have attained about 55–60% of maximum TOT.

Existing legislation designed to safeguard breeding population segments protects PNG crocodiles above 51 cm commercial belly width from harvest. This measurement is the equiv-

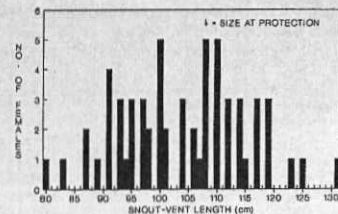


FIG. 3. Size structure of nesting female *Crocodylus novaeguineae* in Lake Murray District, Papua New Guinea.

alent of an animal with an SVL of 108 cm (209 cm TOT) (equation 12 of Montague, 1984b). However, based on the analysis presented here, 57% (95% confidence intervals = 40–73%) of nesting *C. novaeguineae* were below that size. A previous estimate of 74% (Hall and Johnson, 1987) was based on visual estimates of nest-attending females. The discrepancy among these estimates is due to the clustering around the minimum size at protection (see Fig. 3). Elsewhere, Cox (1985) found that 86% of female *C. novaeguineae* from northern Papua New Guinea killed at their nest sites were below the size protected by law.

The nesting season for *C. novaeguineae* from Lake Murray is almost exclusively coincidental with the wet season (Hall, 1985b). Unlike American alligator populations that confine egg laying activities to a period of approximately three weeks during June or early July (Joanen and McNease, 1979), Lake Murray crocodiles oviposit during an interval more than ten times as long (Fig. 4). The mean oviposition date was February 6 \pm 345 days SD, far in excess of a 30 day SD characteristic of populations that follow birth flow models (Dittus, 1981). Clutch size remained nearly constant throughout the oviposition period.

DISCUSSION

This study demonstrates clearly that demographic interpretations of the nesting female segments of crocodilian populations are possible on the basis of associated clutch parameters. Although nesting densities have been used as an index of crocodilian populations (McNease and Joanen, 1978; Hollands, 1987), monitoring of the reproductive cohorts per se has not been possible until now due to the paucity of data on breeding females associated with specific nests. The methods I use circumvent that difficulty and permit a reliable determination of the size of nesting females among populations from existing data sets composed of CM or CS

alone. These results indicate that CM is a better predictor of adult female size than is CS for both alligators and crocodiles. They lend further support to the use of SVL measurements as the most biologically meaningful criterion of crocodilian size, since female alligators with equivalent SVLs from geographically disjunct populations are not equivalent in TOTs. This phenomenon was also reported for *Crocodylus porosus*, in which Bornean crocodiles possessed longer tails than did Australian animals (Webb and Messel, 1978).

Temperate alligators and tropical crocodiles share similar behavioral repertoires (Garrick and Lang, 1977). However, the timing and duration of reproductive seasonality differs strongly among *A. mississippiensis* and southern-form *C. novaeguineae*.

The full complement of reproductive activities (courtship through hatching) occurs between mid-March and mid-September in *A. mississippiensis* (Ferguson, 1985), whereas reproduction in *C. novaeguineae* is circa-annual (Hall and Johnson, 1987). In addition, subsets of the reproductive cycle are temporally compressed in alligators—incubation requires 9–10 weeks to completion (Joanen, 1969) versus 12–13 weeks for New Guinea crocodiles (Hall and Johnson, 1987). Consequently, the genitalia of hatchling alligators are morphologically undifferentiated compared to hatchling crocodiles. Thus, neonate alligators cannot be sexed reliably by cloacal examination (Joanen and McNease, 1978), although gender determination of hatchling crocodiles by that method is possible (Webb et al., 1984). Clearly, the narrow time interval for egg laying within alligator populations characterizes the species as having a pulse reproductive mode (Caughley, 1977), contrasted with the flow model of *C. novaeguineae*. Why these species differ in this respect, and what some of the probable consequences of each mode on population recruitment are, remain to be answered.

The timing of oviposition by American alligators is negatively correlated with ambient temperatures during the spring months of March to May ($P < 0.01$; i.e., years of colder mean spring temperatures result in later mean dates of egg laying). Egg deposition also coincides with the maximal photoperiod interval. Although rainfall does not affect the time of nesting, it does influence the degree of nesting (Joanen and McNease, 1979; Kushlan and Jacobsen, 1990). This agrees with what one should expect of a poikilothermic species in temperate habitat where marked seasonal fluctuations in incident sunlight and temperature greatly constrict the period of primary and secondary productivity compared to tropical environments. It

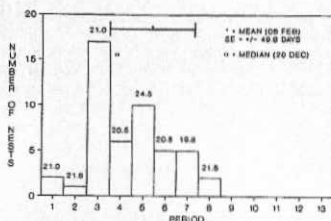


FIG. 4. Nesting seasonality, adjusted to reflect oviposition dates, for wild New Guinea crocodiles (*Crocodylus novaeguineae*) from Lake Murray, Papua New Guinea. Mean clutch sizes indicated above period bars. Period dates: 1 = 23 Sept.–20 Oct.; 2 = 21 Oct.–17 Nov.; 3 = 18 Nov.–15 Dec.; 4 = 16 Dec.–12 Jan.; 5 = 13 Jan.–09 Feb.; 6 = 10 Feb.–09 Mar.; 7 = 10 Mar.–06 Apr.; 8 = 07 Apr.–04 May; 9 = 05 May–01 Jun.; 10 = 02 Jun.–29 Jun.; 11 = 30 Jun.–27 Jul.; 12 = 28 Jul.–24 Aug.; 13 = 25 Aug.–22 Sept.

is also not surprising that alligators have a size-specific dominance breeding hierarchy whereby larger males and females copulate earlier and more frequently within a season than do smaller conspecifics (Ferguson, 1985; Vliet, 1987), given the limited temporal framework within which mating must occur (two months annually). Accordingly, model simulations for alligator populations are largely deterministic since the proximate factors affecting recruitment are essentially stable and predictable, whereas stochastic events (such as hurricanes) are relatively rare (Nichols et al., 1976). However, the impact of stochasticity on alligator populations can be devastating. For instance, the early arrival of 1985 hurricanes in Louisiana resulted in the loss of about 80–90% of the coastal alligator egg crop due to flooding (T. Joanen, pers. comm.). The long-term effects of such occurrences on the population are undoubtedly lessened because the potential longevity of alligators (and other crocodilians) may exceed 50 years (Graham, 1968; Chabreck and Joanen, 1979). Thus, breeding segments of crocodilian populations may be composed of 20 or more active age cohorts. Some female crocodilians, though, eventually become reproductively senescent (Graham, 1968; Joanen and McNease, 1980). For further discussion on the consequences of "one-year wipeouts," see comments by Abercrombie (1989).

In contrast, the proximate factor apparently governing the reproductive cycle of *C. novaeguineae* is annual precipitation, as photoperiod and temperature are fairly uniform throughout the year. Pronounced variation in rainfall occurs both within and among years, with most

of the variance accounted for by patterns of dry season precipitation (Hall, 1990). Although the reproductive hormonal cycle has yet to be studied in this species, courtship behavior seems to be synchronous with the onset of the wet season rains as egg deposition spans the duration of the wet season. Crocodiles seem to cue on the high water mark of the previous year, since their nests are constructed on land above that point or are built on mounds of floating herbaceous vegetation that rise and fall with water levels (Hall and Johnson, 1987). The prolonged seasonality of nesting makes it unlikely that catastrophic stochastic events (e.g., earthquakes, fires, storms) will eliminate an entire cohort as can happen in alligator populations. Whether or not a size-specific dominance breeding hierarchy exists in wild *C. novaeguineae* is also unknown, although such behavior is exhibited by captive animals (Lang, pers. comm.; Hall, pers. obs.). I suspect that if that behavior occurs in the wild, the intensity of interactions should be relaxed compared to alligators since the interval in which spermatogenesis and vitellogenesis can occur is potentially four times as long in *C. novaeguineae*.

Although techniques for aging crocodilians and other long-lived reptiles have been developed (Graham, 1968; Hutton, 1986; Zug et al., 1986; Zug and Rand, 1987), they produce estimates that suffer from low precision and accuracy for all but very young cohorts. It is partly for this reason that Nichols (1987) argued for the use of size, rather than age-specific, cohort analysis of crocodilian populations. In addition, a population with a flow mode of reproduction like southern-form *C. novaeguineae* would further obfuscate such interpretations, especially if making interpopulation comparisons with northern-form *C. novaeguineae*, which has a much shortened reproductive season (Cox, 1985). Since reproductive mode may differ among populations within a species, these generalizations should not be assumed to apply uniformly to other crocodilians on the basis of latitudinal gradients.

I believe that the effects of controlled harvests may have operated differentially on the breeding female segments of these populations of *A. mississippiensis* and *C. novaeguineae*. The similarity of mean sizes of nesting female alligators in populations exposed to harvest (Lacassine NWR and Orange Lake), and the significantly larger mean size of animals nesting in an unharmed population (Lake Woodruff NWR) suggests: (1) the existence of a reservoir of sexually mature, but socially subordinate, animals in recovered, protected alligator populations; (2) that such animals fail to nest because they are exploitatively or behaviorally inferior to larger, dominant fe-

males; and, (3) that they will not achieve active reproductive status until either attaining larger size or until a socially mature female is removed through natural mortality or managed harvest, thus producing a reproductive vacancy. The mean size of nesting females in the protected population was 14% longer, but 72% heavier, than that of females in harvested populations. Thus, even relatively small differences in length can place smaller sexually mature females at a great competitive disadvantage with larger conspecifics.

A caveat of the preceding paragraph is the implicit assumption that competition among females is occurring due to some strongly limiting factor, presumably access to nesting habitat. Habitat quality differs greatly throughout the range of these species, where nesting densities are generally low in riverine areas, intermediate in lake habitats, and highest in grassland marshes. Among the latter, *Panicum hemitomon* marsh is considered qualitatively inferior to coastal brackish and intermediate marshes in Louisiana (T. Joanen, pers. comm.). Nesting habitat appears not to be a limiting factor in these marshes and they support the highest nesting density of alligators in the United States. The percent of annual nesting by adult female alligators in these marshes is over twice as high (68%; Joanen and McNease, 1980) than reported in Florida (29%; Kushlan and Jacobsen, 1990) or South Carolina (27.5%; Wilkinson, 1984). Accordingly, management harvest quotas in Louisiana are based on habitat type (Joanen and McNease, 1987).

These results also suggest that selective culling of larger nesting female alligators may lead to accelerated population growth through the creation of higher nesting densities and incremented egg and hatchling production (see Hines and Abercrombie, 1987; Abercrombie, 1989). Clutch size increases with female size in *A. mississippiensis* (Ferguson, 1985) and *C. novaeguineae* (Hall and Johnson, 1987). A decrease in mean clutch size resulting from the prudent removal of large nesting female alligators should be offset by an increase of smaller females that nest in the absence of more dominant females.

The relatively short, clearly demarcated nesting season of alligators (in addition to differential seasonal habitat use by adult males and females) favors management practices that selectively cull adult animals following the completion of reproduction. Such measures would not be feasible for the management of southern-form *C. novaeguineae* due to its very extended reproductive period. Harvest regulations target alligators larger than 1.2 m TOT, whereas harvests of crocodiles are restricted to animals less than 2.1 m. Although the life history traits of

crocodilian species generally support the removal of juvenile and subadult size classes (Messel et al., 1981; Magnusson, 1986), most reproductively active *C. novaeguineae* were nesting at sizes smaller than that protected by law and were thus also exposed to harvest. Consequently, the estimated annual turnover in the female breeding segment was high (>60%) and population growth was retarded (Hall and Johnson, 1987).

Additional studies of this nature are needed to more fully evaluate whether or not site-specific differences exist among slopes for the regression models presented herein, and to assess their predictive ability for constructing demographic profiles of breeding female crocodilian populations. Although based on small sample sizes, these models are practical because they provide a fair to excellent accounting of the associated variances (r^2 values) for each model. Preliminary tests indicate that they provide excellent agreement of estimated with actual sizes of nesting female alligators subsequently captured (H. F. Percival, unpubl. data). The use of multiple regression analysis did not enhance those values since predictors were highly correlated with each other.

In conclusion, accurate and precise estimates of nesting adult female crocodilians are feasible in the course of activities normally conducted by ecologists and management authorities, with little expenditure and justifiable effort. This has proven effective with both hole nesting *Crocodylus acutus* (Mazzotti and Brandt, 1988) and mound nesting species (this study). Data of these type, hitherto rarely obtained, are of demonstrable value to biologists and agency personnel concerned with crocodilian conservation. An initial understanding of the sizes of reproductive females provides a mechanism for the long-term monitoring of crocodilian populations in response to protection or induced harvest strategies, as well as affording a practical manner in which unanswered questions pertaining to the reproductive longevity and success of individual animals may be addressed.

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