

REPRODUCTIVE CHARACTERISTICS OF A GREEN IGUANA (*IGUANA IGUANA*) POPULATION OF THE WEST COAST OF MEXICO

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By inhabiting major portions of tropical America, the green iguana is exposed to a wide range of climates. It should then be expected to show variability in various aspects of its life history. However, reproductive information is limited to a few populations, mainly from Central America (summaries in Dugan and Wiewandt, 1982; Rand and Greene, 1982; Wiewandt, 1982; Werner, 1991). This paper provides reproductive information on a green iguana population previously unstudied, and also contributes to the understanding of the allocation of energy in the life history of the species.

Iguanas were collected in the vicinity of Maruata Bay in the state of Michoacan on the west coast of Mexico. The area is characterized by a dry tropical climate with an average annual temperature of 25°C and a long annual dry season from November through June. The average annual rainfall is 895 mm. Maruata Bay is situated on a narrow coastal plain near the foothills of the Sierra Madre del Sur. The bay has a 2.5-km-long sandy beach. The dominant vegetation in the Sierra Madre del Sur foothills is tropical deciduous forest and the Maruata plain contains several vegetation types including thornscrub at the beach edge and surrounding a small swamp, and stands of introduced coconut palms and banana trees. Gallery forest is found along the margins of a river of seasonal flow that empties into the bay. Iguanas were most frequently observed in the thornscrub surrounding the swamp and in the gallery forest. From mid-March to mid-April 1992, 60 gravid females were collected by hand. After having identification numbers painted on the sides of their bodies, they were placed in four laying enclosures, each furnished with six artificial nests (Werner and Miller, 1984). At any one time there were no more than six females per enclosure. Fifty-eight of the females oviposited within six days after being placed in the enclosures. The use of the artificial nests allowed identification of spent females and recovery of clutch-

es. In 55 cases, it was possible to attribute clutches to their respective mothers.

After oviposition, mothers were measured to the nearest mm (SVL) and weighed to the nearest g. Clutches were weighed to the nearest 0.5 g, and ten randomly chosen eggs per clutch were individually weighed to the nearest 0.1 mg. Since clutches remained for up to two hours in the artificial nests, eggs may have had a chance to absorb water from the surrounding moist sand. This potential source of weight variation between eggs was not taken into consideration for calculations of the effect of maternal size on egg weight. Relative clutch mass (RCM) was calculated as the weight of the clutch divided by the female weight after laying plus the weight of the clutch. However, for hypothesis testing, RCM was calculated by dividing clutch mass by female mass after laying to avoid statistical problems associated with having clutch mass in both the numerator and denominator (Plummer, 1992).

To obtain hatchlings each clutch was placed in a styrofoam box filled with moist sand, and lowered into the ground providing incubation temperatures similar to those found in natural nests (Werner, 1988). Average nest temperature during incubation was $30.5 \pm 2.6^\circ\text{C}$ (range = 28.4 to 32.4). At this temperature, 80.3% of the eggs hatched in an average of 84 ± 4.1 days (range = 79 to 88). Ten hatchlings per clutch were measured to the nearest 0.1 mm (SVL), and weighed to the nearest 0.1 mg.

Product moment correlation (Parker, 1973) was used to describe the relationship among reproductive characteristics of mothers, clutches, eggs, and hatchlings. For all mean values, a *SD* was estimated. The mean size of gravid females was 315 ± 39 mm (range = 235 to 400, $n = 53$). According to Müller (1972), green iguanas living in semi-arid habitats were smaller in body size than those living in moist habitats. He attributed this to a difference in growth resulting from differences in food availability. Harris (1982) re-

TABLE 1—Product-Moment correlation coefficients among various characteristics of mothers, clutches, eggs and hatchlings in *Iguana iguana*. Significance levels are indicated by * (<0.05), ** (<0.005), *** (<0.001), NS = not significant. SVL = snout-vent length.

Mother ¹	Egg weight	Clutch		Neonate	
		Size	Mass	SVL	Mass
SVL	0.148 NS	0.944***	0.814***	0.546***	0.650***
Mass	0.406*	0.895***	0.784***	0.573***	0.661***

¹ Correlation between mother's SVL and mass was 0.926 ($P < 0.001$).

ported that juvenile iguanas from a dry habitat (Santa Marta in northeastern Colombia) grew half as rapidly as those from a moist habitat (Isla de Salamanca in northern Colombia) and matured at a smaller size. The study site in Michoacan is strongly seasonal with a long dry season and low rainfall. Adult females were smaller than those living in less seasonal habitats in Panama ($\bar{X} = 373$ mm, range = 340 to 410, $n = 11$; Miller, 1987) and Nicaragua ($\bar{X} = 324$ mm; Fitch, 1985). Therefore, these results strengthen the conclusion of Müller that in arid habitats *Iguana iguana* is smaller than in moist habitats.

The smallest gravid female was 235 mm, which is similar to the size of 22-month-old first-nesters of the same population raised in captivity ($\bar{X} = 239$ mm, range = 215 to 260, $n = 6$) as part of the Green Iguana Management Program in Michoacan.

Average clutch size was 29.7 ± 9.4 (range = 13 to 47, $n = 53$). Previous studies indicated that clutch size increased with body size in green iguanas (Rand, 1984; Werner, 1991). Following this pattern, iguanas in the Michoacan population laid larger clutches than the smaller iguanas of Curacao ($\bar{X} = 17$ eggs, range = 10 to 31, $n = 23$; Fitch, 1985), and smaller clutches than the larger iguanas of Panama ($\bar{X} = 39.5$ eggs, range = 23 to 60, $n = 21$; Miller, 1987) and Nicaragua ($\bar{X} = 30.5$ eggs, range = 11 to 54, $n = 31$; Fitch, 1985). According to Rand (1984), the factor that set an upper limit to clutch size was the space available within the female for eggs, suggesting that clutch size is not limited by food availability.

Clutch size is an important parameter in a reproductive strategy. However, clutch weight or calorific content was a better measure of reproductive effort (Vitt and Congdon, 1978; Rand, 1984). Although there are no calorific data for iguanas, Vitt (1978) has shown that for some lizards, the ratio of calorific content of clutch to

calorific content of female was similar to the ratio of clutch weight to female weight. Average female weight after laying was 808 ± 307 g (range = 181 to 1606, $n = 53$) and mean clutch weight was 445.8 ± 164.6 g (range = 187.4 to 885.8, $n = 53$). The percentage of clutch to the combined weight of female and clutch (relative clutch mass of Vitt and Congdon, 1978) ranged from 28.1 to 44.9% ($\bar{X} = 35.6 \pm 0.033$, $n = 54$). Rand (1984) reported a RCM mean of 30.3% (range = 19.7 to 39.9, $n = 28$) for an iguana population of central Panama.

Williams (1966) predicted that within a species, relative reproductive effort should increase with age because as an animal ages there would be less cost to future reproduction from a high effort at the present age. Rand (1984) reported that for iguanas of central Panama and Nicaragua the RCM was higher in large females than in small ones. In these iguanas, the greatest difference in RCM was between very small females and all the rest. These data suggested that *Iguana iguana* behaved in accord with Williams' prediction. In Michoacan, however, there did not seem to be a correlation between female size and RCM ($r = 0.023$, $P > 0.1$, $n = 55$). Medium sized iguanas had the highest RCM values and the lowest size extremes. Reproductive information of more green iguana populations is needed to evaluate the relevance of William's suggestion.

Egg weight varied between females. The smallest egg weighed 12.1 g, whereas the largest weighed 17.7 g ($\bar{X} = 15.2 \pm 1.6$). The percentage that a single egg represented of the RCM (expenditure per egg of Rand, 1984) varied from 0.7 to 2.6% ($\bar{X} = 1.3 \pm 0.47$, $n = 54$ clutches). The mean hatchling length was 71.8 ± 3.2 mm (range = 61 to 85, $n = 327$). The weight ranged from 6.3 to 17.7 g ($\bar{X} = 12.3 \pm 1.5$, $n = 327$). The size of Michoacan hatchlings was higher than that reported for Curacao ($\bar{X} = 65.6$ mm, range

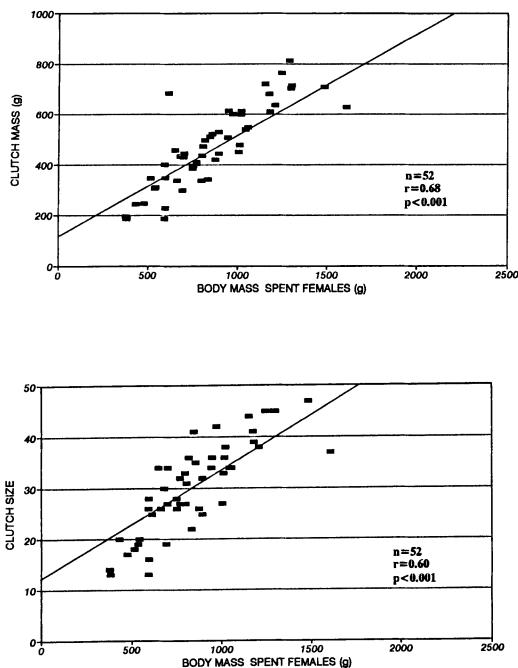


FIG. 1—Top: Relation between clutch mass and body mass of spent females. Bottom: Relation between clutch size and body mass of spent females.

= 62 to 68, $n = 23$; Bakhuis, 1982) and north-eastern Colombia ($\bar{X} = 68$; Müller, 1972) and smaller than that reported for northern Colombia (range = 70 to 86; Harris, 1982).

As has been reported for other populations of green iguana (Fitch and Henderson, 1977; Rand, 1984; Werner, 1991), maternal size had significant effects on the size and weight of clutches and hatchlings (Table 1). The relationship between body mass of spent females and mass and size of clutches is illustrated in Fig. 1. Mean egg weight was not correlated to female size ($r = 0.148$, $P > 0.1$, $n = 30$) and weakly correlated to female weight ($r = 0.406$, $P < 0.05$, $n = 30$; Table 1). This suggested that, as the clutch increased in size as the female grew larger, the egg mass varied little.

Se presentan las características reproductivas de una población de iguana verde *Iguana iguana* en la costa de Michoacán, México. El tamaño promedio de nidada fue de 29.7 huevos y este valor fue intermedio a valores mayores reportados para poblaciones con hembras de mayor tamaño y valores menores reportados para poblaciones

con hembras de tamaño menor. La relación del porcentaje del peso de nidada con el valor del peso de la hembra más el peso de nidada varió de 28.1% a 44.9%. A diferencia de otras poblaciones de iguana verde, en Michoacán no se encontró una correlación entre el tamaño de la hembra y la masa relativa de nidada. El promedio de peso del huevo fue de 15.2 g y el promedio de peso de las crías fue de 12.3 g. El tamaño y peso de la madre tuvo efectos significativos sobre el tamaño y peso de las nidadas y las crías.

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LITERATURE CITED

- BAKHUIS, W. L. 1982. Size and sexual differentiation in the lizard *Iguana iguana* on a semi-arid island. *J. Herpetol.*, 3:322-325.
- DUGAN, B., AND T. V. WIEWANDT. 1982. Socio-ecological determinants of mating strategies in iguanine lizards. Pp. 303-319, in *Iguanas of the world: behavior, ecology and conservation* (G. M. Burghardt and S. Rand, eds.). Noyes Publ., Park Ridge, New Jersey.
- FITCH, H. S. 1985. Variations in clutch and litter size in New World reptiles. *Misc. Publ. Mus. Nat. Hist., Univ. Kansas*, 76:17-21.
- FITCH, H. S., AND R. HENDERSON. 1977. Age and sex differences, reproduction and conservation of *Iguana iguana*. *Contrib. Biol. Geol., Milwaukee Public Museum, Wisconsin*, 13:1-21.
- HARRIS, D. M. 1982. The phenology, growth, and survival of the green iguana *Iguana iguana*, in Northern Colombia. Pp. 150-161, in *Iguanas of the world: behavior, ecology and conservation* (G. M. Burghardt and S. Rand, eds.). Noyes Publ., Park Ridge, New Jersey.
- MILLER, T. J. 1987. Artificial incubation of eggs of the green iguana (*Iguana iguana*). *Zoo Biol.*, 6:225-236.
- MÜLLER, H. 1972. Ukologische und ethologische studien an *Iguana iguana* (Reptilia: Iguanidae) in Kolumbien. *Zoologische Bertrage N. F.*, 18:109-131.
- PARKER, R. E. 1973. *Introductory statistics for biology*. Edward Arnold Ltd, London.

- PLUMMER, M. V. 1992. Relationships among mothers, litters, and neonates in diamondback water snakes (*Nerodia rhombifer*). *Copeia*, 1992:1096-1098.
- RAND, A. S. 1984. Clutch size in *Iguana iguana* in Central Panama. Pp. 115-122, in *Vertebrate ecology and systematics—a tribute to Henry S. Fitch* (R. A. Seigel, L., E. Hunt, J. L. Knight, L. Malarct, and N. L. Zuschlag, eds.). *Mus. Nat. Hist., Univ. Kansas*, Lawrence.
- RAND, A. S., AND H. W. GREENE. 1982. Latitude and climate in the phenology of reproduction in the green iguana, *Iguana iguana*. Pp. 142-149, in *Iguanas of the world: behavior, ecology and conservation* (G. M. Burghardt and S. Rand, eds.). Noyes Publ., New Jersey.
- Vitt, L. J. 1978. Caloric content of lizard and snake (Reptilia) eggs and bodies and the conversion of weight to caloric data. *J. Herpetol.*, 12:65-72.
- VITT, L. J., AND J. D. CONGDON. 1978. Body shape, reproductive effort, and relative clutch mass in lizards; resolution of a paradox. *Amer. Nat.*, 112:595-608.
- WERNER, D. I. 1988. The effect of varying water potential on body weight, yolk and fat bodies in neonate green iguanas. *Copeia*, 1988:406-11.
- . 1991. The rational use of green iguanas. Pp. 181-201, in *Neotropical wildlife use and conservation* (J. G. Robinson and K. H. Redford, eds.). Univ. Chicago Press, Chicago, Illinois.
- WERNER, D. I., AND T. J. MILLER. 1984. Artificial nests for female green iguanas. *Herpetol. Rev.*, 15: 57-58.
- WIEWANDT, T. A. 1982. Evolution of nesting patterns in iguanine lizards. Pp. 119-141, in *Iguanas of the world: behavior, ecology and conservation* (G. M. Burghardt and S. Rand, eds.). Noyes Publ., New Jersey.
- WILLIAMS, G. C. 1966. *Adaptation and natural selection*. Princeton Univ. Press, Princeton, New Jersey.

REPRODUCTIVE BIOLOGY OF THE RIO GRANDE SUCKER,
CATOSTOMUS PLEBEIUS (CYPRINIFORMES), IN A
MONTANE STREAM, NEW MEXICO

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Although the Rio Grande sucker, *Catostomus plebeius*, was first described almost a century and a half ago by Baird and Girard (1854), Koster (1957) first presented the meager known life history information for the species. It is currently distributed in tributaries of the Rio Grande, primarily north of the 36th parallel (Sublette et al., 1990). It has been introduced into the headwaters of the Gila River. Although substantial populations are extant in New Mexico, only one occurs in Colorado. The species also currently inhabits a half dozen river basins encompassing three states of Mexico (Smith, 1966; Hendrickson et al., 1980; Sublette et al., 1990).

Larger individuals feed on filamentous algae and other microscopic and macroscopic organisms such as diatoms and benthic invertebrates inhabiting fast, rocky riffles (Sublette et al., 1990). Koster (1957) reported that Rio Grande sucker

spawns in spring and, in some areas, in the fall. Although adults may grow to a large size (>40 cm), most individuals are small and some mature when only "a few inches long." Rausch (1963) examined age, growth and maturity of this sucker. Koster (1957) suggested this species to be a good bait or forage fish and that trout can and commonly do feed on this largely primary consumer.

The Rio Grande sucker was encountered in large numbers during research investigating the effects of grazing on nearstream and instream habitat and biota in the Rio de las Vacas in northern New Mexico (Rinne, 1988). Because there is a lack of ecological and life history information for Rio Grande sucker, specimens were collected between 1985 and 1987, preserved, and aspects of their reproductive biology were examined. This paper reports information on aspects of the re-