Rev. Biol. Trop., 34(2): 247-251, 1986

Seasonal patterns of reproduction of *Norops humilis* (Sauria: Iguanidae) in Costa Rica*

Craig Guyer
Department of Biology, University of Miami, Coral Gables, FL 33124.

(Received: November 8, 1985)

Abstract: Monthly samples of *Norops humilis* were collected from Dec. 1973 through Dec. 1974. Dissection of sacrificed animals revealed that females reach sexual maturity at a body length of 32 mm, whereas males reach maturity at lengths as low as 25 mm. Sexually mature lizards of both sexes were found throughout the year, confirming that reproduction occurs year-round. However, a gap in the occurrence of juveniles occurred during the months of Feb. and Mar. 1974, indicating that recruitment of juveniles was not constant throughout the year. Contrary to previous data on *N. humilis* from Costa Rica, lizards were more abundant during the dry season (Jan. - May) than during the wet season.

Despite the fact that many mainland neotropical anoles are abundant and easily studied, demographic studies lag behind those of north temperate lizard species. Only a few studies have been of sufficient length to describe yearly and seasonal patterns of reproduction and abundance (Sexton, 1967; Sexton *et al.*, 1971; Fleming and Hooker, 1975; Andrews and Rand, 1982; Andrews *et al.*, 1983). Data are beginning to accumulate on another netropical anole, *Norops humilis,* a small leaf-litter species that occurs throughout much of lowland Central America. Talbot (1977; 1979) described and experimented with habitat preference and provided a time budget for this species. Fitch (1970; 1973a; 1973b) reported on population structure and survivorship, and Corn (1981) discussed body size, feeding, reproduction and population structure. All three studies were conducted on sites within 30 km of each other in tropical lowland wet-forest of Costa Rica. Although these studies suggest seasonal patterns of reproduction, they are all limited in that samples were taken of representative wet and dry months rather than as a complete series of samples over a year. Here I add to the available information for this species by reporting sizes at sexual maturity as well as patterns of abundance, reproductive output, and recruitment.

MATERIAL AND METHODS

I studied a sample of *N. humilis* collected at finca La Selva near Puerto Viejo de Sarapiquí, Heredia Province, Costa Rica over a continuous 13-month period (Dec. 1973 - Dec. 1974). Lizards were collected as part of a study of the structure and dynamics of the leaf-litter herpetofauna (Lieberman, 1982) and were captured in one of two ways. Most were captured in 8 x 8 m litter plots. Each plot was staked out and the perimeter outlined. Two to four investigators then carefully sifted through all leaf litter, working from the edge to the center. All lizards were captured, placed in plastic bags, sacrificed, and preserved. Twelve such plots were sampled each month, six in primary forest and six in an abandoned cacao plantation. A few lizards were captured in 1 gal pitfall traps distributed 10 m apart along two 100 m transect lines, one each in primary forest and cacao. Organisms falling into the traps were immediately fixed in picric acid that was placed at the

* Contribution no. 215 from the University of Miami, Departament of Biology Program of Tropical Biology, Ecology and Behavior.

bottom of each trap. Traps were emptied every six to ten hours and were left open for four days each month. All specimens are deposited in the Costa Rica Expeditions herpetological collections at the University of Miami. The physical and biotic environment during the study is described by Lieberman and Dock (1982). Importan patterns include: 1) increased rainfall from June 1974 through Aug. 1974, and Oct. 1974 through Dec. 1974 (greater than 200 mm/mo; wet season); 2) decreased rainfall from Dec. 1973 through May 1974 and Sept. 1974 (less than 200 mm/mo; dry season and *veranillo,* respectively); 3) relatively constant temperatures; 4) lower humidity in the dry season and 5) increased insect abundance late in the dry season. A total of 382 *N. humilis* was collected. Preserved lizards were measured snout-to-vent (SVL) to the nearest mm, sexed by dissection, and categorized as to reproductive status. Reproductive status of females was scored as one of three categories: 1) immature; 2) one or more yolking follicles but no oviductal eggs; 3) one or more oviductal eggs. Reproductive status of males was scored as: 1) immature; 2) testes developing but *vas deferens* thin and weakly convoluted or 3) testes developed and *vas deferens* wide and distinctly convoluted.

RESULTS AND DISCUSSION

The minimum size at which I observed sexual maturity in females (presence of at least one oviductal egg) was 32 mm SVL, although yolking follicles were occasionally observed in females as small as 30 mm SVL (Table 1). Few females larger than 32 mm were without yolking follicles or oviductal eggs. There was no evidence of seasonal changes in the size at sexual maturity in females. Talbot (1979), Fitch (1970), and Corn (1981) also found sexual maturity in females to occur first in lizards from 32 to 33 mm SVL which suggests that this reproductive factor is relatively unaffected by year or location within tropical lowland Costa Rica. Males showed signs of testicular development in individuales as small as 23 mm SVL and became mature (presence of wide and convoluted *vas deferens*) at sizes as small as 27 mm (Table 2). Once males reached 29 mm SVL nearly all individuals had fully developed reproductive tracts. Although testis size was variable for mature males, there was no evidence of seasonal changes in testis size or variation in development of the *vas deferens* that might suggest seasons of intense reproduction followed by recrudescence. I assume that all males were reproductively active year-round even though I did not sample males for sperm in their reproductive tracts. Corn (1981) found males 26 mm SVL to have abundant sperm in their testes and *epididymi* but suggested that breeding did not occur until males reached 30.5 mm SVL. Talbot (1979) reported maturity in males based on testis size for individuals 29 mm or longer. These data suggest that the size at sexual maturity for males is more variable than for females.

Females reach sexual maturity at a size 3-6 mm longer than males. Average SVL of adult females is also known to be longer than in males (Fitch 1973b; Talbot 1979; Corn 1981). This probably reflects the trade-off between allocation of energy to growth and reproduction with both sexes showing reduced growth once sexual maturity is reached. Sexually mature adults of both sexes were found throughout the year (Tables 1 and 2) as was found by Fitch (1973). However, more adults (as well as juveniles) were found during the drier first half of the year than in the wetter half (Fig. 1). It is not known whether this reflects a real change in population density or a change in activity patterns and threfore catchability as seen in other anoles (Fleming and Hooker 1975). This trend is opposite to that reported by Corn (1981) who found *N. humilis* to be more abundant in the wet season than the dry season.

For both males and females I observed a gap in recruitment of juveniles from Feb. through Mar. 1974 (Tables 3 and 4). Fitch (1973b) and Corn (1981) noted similar depressions in recruitment during this same period. Fitch (1973b) attributed this to reduced egg production. Since gravid females in this study were found throughout the year, although reduced in numbers during the wet season, it may be more likely that shifts in recruitment are due to changes in egg survival rather than or as well as production. Egg mortality in other mainland anoles is known to show variability between sites possibly due to predation (Andrews 1982) or desiccation (Andrews and Sexton 1981) and similar processes may occur for La Selva anoles.

The smallest sizes recorded for both sexes were 16-17 mm SVL. This is assumed to be at or near hatchling size. No growth data were

TABLE 1

Reproductive status of female Norops humilis *at finca La Selva.*
I = immature; F = yolking follicle; M = mature (at least one oviductal egg)

	MONTH												
SVL	D	J	F	M	A	M	J	J	A	S	O	N	D
<30	I	I	I	I	I	I	I	I	I	I	I	I	I
30	I	–	–	–	I	–	F	I	I	–	–	–	–
31	IM	–	I	–	–	–	–	–	–	–	–	–	IF
32	–	M	–	–	–	F	M	M	–	M	F	–	M
33	–	FM	–	FM	M	–	M	–	–	–	M	–	–
34	–	M	–	M	F	M	–	–	F	FM	M	M	FM
35	M	FM	M	F	FM	M	M	M	–	–	–	M	–
36	M	M	–	–	M	FM	M	–	M	–	M	M	M
37	F	M	M	M	–	M	M	–	M	M	–	M	–
38	FM	–	–	M	–	FM	M	–	–	F	–	F	M
39	–	–	–	–	–	–	–	–	–	M	–	–	–
40	M	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 2

Reproductive status of male Norops humilis *at finca La Selva.*
I = immature; D = developing gonads; M = mature (wide and convoluted vas deferens)

	MONTH												
SVL	D	J	F	M	A	M	J	J	A	S	O	N	D
<23	I	I	I	I	–	–	I	I	I	I	I	I	I
23	–	I	D	–	I	–	–	I	–	–	–	–	–
24	I	I	–	D	–	–	–	I	–	–	I	–	I
25	ID	–	D	–	ID	–	–	–	–	–	I	I	ID
26	M	–	–	D	D	–	–	D	–	–	I	D	–
27	D	–	D	–	–	D	–	–	–	–	–	D	MD
28	–	–	D	I	–	DM	–	D	–	M	–	–	–
>28	M	M	M	M	M	M	M	M	M	M	M	M	M

TABLE 3

Monthly abundance of male N. humilis *at finca La Selva.*
Data are counts of lizards captured in litter plots and can traps from Dec. 1973 to Dec. 1974

	MONTH												
SVL	D	J	F	M	A	M	J	J	A	S	O	N	D
16-17	1	1	–	–	–	–	1	1	2	–	1	–	1
18-19	1	3	2	–	–	–	–	–	2	1	–	1	1
20-21	2	1	3	2	–	–	–	–	–	–	1	1	3
22-23	–	1	3	1	2	–	1	3	–	–	2	2	1
24-25	3	1	2	1	2	–	–	1	–	–	3	2	4
26-27	2	–	1	1	1	2	–	1	–	–	1	2	2
28-29	2	–	3	2	–	3	1	1	1	3	–	–	–
30-31	3	3	1	7	3	5	–	1	–	–	1	2	1
32-33	5	6	8	3	5	3	1	3	4	2	3	3	2
> 33	5	3	1	1	2	1	1	–	3	–	1	1	1

collected. Therefore, I could not determine the length of time needed to reach sexual maturity. However, the gap in recruitment can presumably be followed as a gap in larger lizards in later months (Tables 3 and 4). This pattern suggests a 4-6 month period of growth

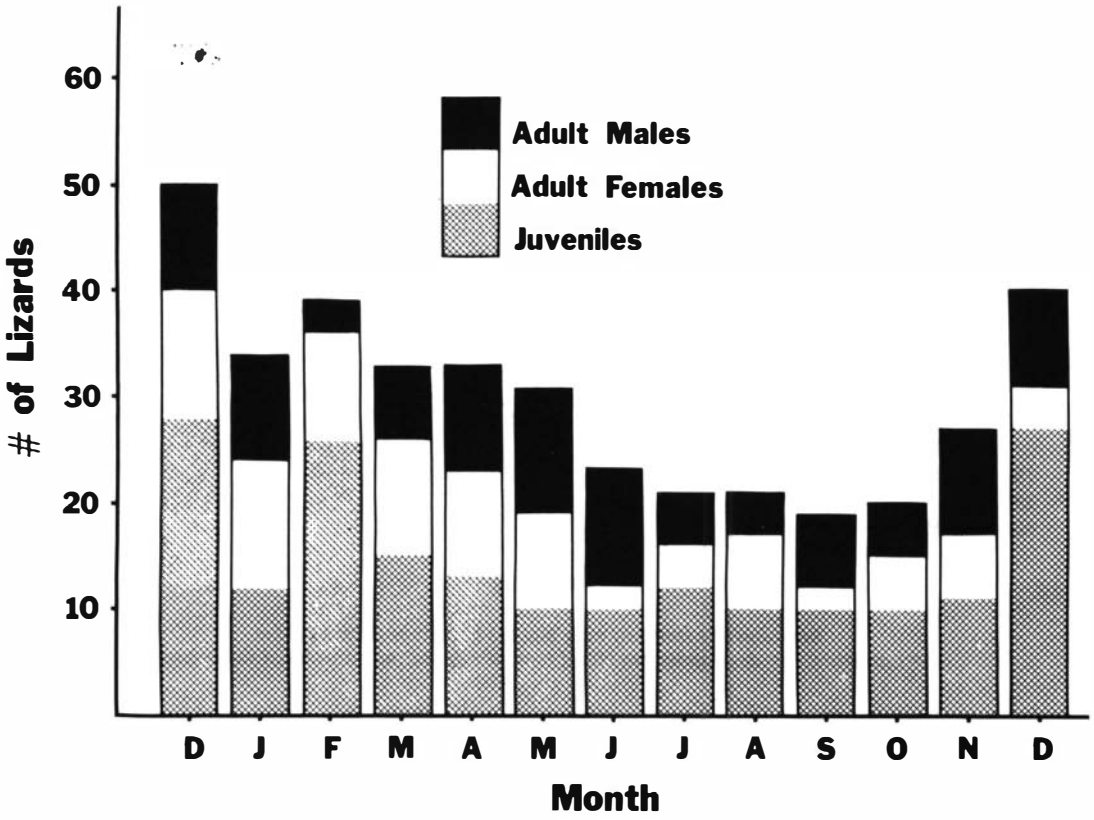

Fig. 1. Frequency distribution of adult male, adult female, and juvenile *Norops humilis* over a 13 month study period at finca La Selva (Dec. 1973 – Dec. 1974)

TABLE 4

Monthly abundance of female N. humilis *at finca La Selva.*
Data are counts of lizards captured in litter plots and can traps from Dec. 1973 to Dec. 1974

	MONTH												
SVL	D	J	F	M	A	M	J	J	A	S	O	N	D
16-17	3	–	1	–	–	1	1	1	1	1	1	–	3
18-19	4	–	–	2	–	1	1	1	1	2	1	1	2
20-21	2	1	–	1	–	–	1	–	–	–	–	1	1
22-23	1	1	4	–	–	–	–	2	1	1	–	1	–
24-25	–	2	3	2	–	1	–	–	1	–	–	–	–
26-27	3	1	1	1	3	–	1	–	–	1	1	–	6
28-29	1	–	2	2	3	2	2	–	–	1	–	–	1
30-31	3	–	1	–	2	–	1	1	1	–	–	–	2
32-33	–	3	–	3	1	2	3	2	–	1	2	–	3
34-35	4	3	1	2	4	3	1	3	1	2	1	4	3
36-37	5	4	2	1	5	5	7	–	3	3	2	5	1
> 37	2	–	–	1	–	2	1	–	–	1	–	1	2

from hatchling to adult sizes. Fitch (1973b) suggested a similar growth period.

In summary these data suggest the following reproductive pattern for *N. humilis* in lowland wet-forests of Costa Rica. Males reach sexual maturity between 26 and 29 mm SVL and females at 32 mm SVL; both sexes probably are sexually active continuously once maturity is

reached. Size at sexual maturity appears to be relatively constant throughout the year, between years, and between sites. Although eggs are produced year-round, the rate of production may be slower during the dry season (Fitch 1973a; Corn 1981) and environmental factors may lower egg survivorship. This study substantiates the general pattern of population dynamics for *N. humilis* present in earlier works (Fitch 1973 a,b; Talbot 1979; Corn 1981), although observed seasonal abundance contradicts Corn (1981). In addition I establish the year-round presence of gravid females and suggest that environmental factors in addition to reduced egg production account for gaps in population recruitment.

ACKNOWLEDGEMENTS

The specimens examined in this study were collected by C.F. Dock, C.S. Leib, J.J. Talbot, and R.W. Van Devender as part of the leaf-litter herpetofauna study funded by NSF grant BMS 7301619A01 to J.M. Savage and I.R. Straughan. Thanks go to the organization for Tropical Studies, San José office for logistic support during my stay in Costa Rica and to M.A. Donnelly, M.P. Hayes, S.M. Hermann, and an anonymous reviewer for suggestions on improving the manuscript.

RESUMEN

Muestras mensuales de *Norops humilis* fueron colectadas durante un período de 13 meses desde diciembre 1973 hasta diciembre 1974. La disección reveló que las hembras alcanzaron la madurez sexual a los 32 mm de longitud y que en los machos es a los 25 mm. Durante todo el año se encontró lagartijas sexualmente maduras de ambos sexos aunque no así juveniles durante los meses de febrero y marzo de 1974, indicando que su reclutamiento no fue constante durante el año. Contrario a datos previos sobre *N. humilis* de Costa Rica, las lagartijas fueron más abundantes durante la estación seca (enero-mayo) que durante la temporada húmeda.

REFERENCES

Andrews, R.M. 1982. Spatial variation in egg mortality of the lizard *Anolis limifrons*. Herpetologica 38: 165-171.

Andrews, R.M. & O.J. Sexton. 1981. Water relations of the eggs of *Anolis auratus* and *Anolis limifrons*. Ecology 62: 556-562

Andrews, R.M., & A.S. Rand. 1982. Seasonal breeding and long-term population fluctuations in the lizards *Anolis limifrons*. *In* E.G. Leigh, Jr., A.S. Rand & D.W. Windsor (eds.). The ecology of a tropical forest, long-term changes. Smithsonian Institution Press.

Andrews, R.M., A.S. Rand & S. Guerrero. 1982. Seasonal and spacial variation in the annual cycle of a tropical lizard. *In* G.J. Rhodin & K. Miyata (eds.). Advances in herpetology and evolutionary biology: essays in honor of E.E. Williams. Harvard University, Cambridge, Mass.

Corn, M.J. 1981. Ecological separation of *Anolis* lizards in a Costa Rican rain forest. Ph.D. dissertation, Univ. of Florida, Gainesville.

Fitch, H.S. 1970. Reproductive cycles in lizards and snakes. Misc. Publ. Mus. Nat. Hist. Univ. Kansas 52: 1-247.

Fitch, H.S. 1973a. A field study of Costa Rican lizards. Univ. Kansas Sci. Bull. 50: 39-126.

Fitch, H.S. 1973b. Population structure and survivorship in some Costa Rican lizards. Occas. Papers Univ. Kansas Mus. Nat. Hist. 18: 1-41.

Fleming, T.H. & R.S. Hooker. 1975. *Anolis cupreus*: the response of a lizard to tropical seasonality. Ecology 56: 1243-1261.

Lieberman, S.S. 1982. The ecology of the leaf litter herpetofauna of a neotropical rainforest: La Selva, Costa Rica. Ph.D. dissertation, Univ. of Southern California, Los Angeles.

Lieberman, S.S. & C.F. Dock. 1982. Analysis of the leaf litter arthropod fauna of a lowland tropical evergreen forest site (La Selva, Costa Rica). Rev. Biol. Trop. 30: 27-34.

Sexton, O.J. 1967. Population changes in a tropical lizard, *Anolis limifrons* on Barro Colorado Island, Panama Canal Zone. Copeia 1967: 219-222.

Sexton, O.J., E.P. Ortleb, L.M. Hathaway, R.E. Ballinger & P. Licht. 1971. Reproductive cycles of three species of anoline lizards from the Isthmus of Panama. Ecology 52: 201-215.

Talbot, J.J. 1977. Habitat selection in two tropical anoline lizards. Herpetologica 33: 114-123.

Talbot, J.J. 1979. Time budget, niche, overlap, inter- and intraspecific aggression in *Anolis humilis* and *Anolis limifrons* in Costa Rica. Copeia 1979: 472-481.