Aspects of the Ecology of a Sonoran Desert Population of the Western Banded Gecko, Coleonyx variegatus (Sauria, Eublepharinae)

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ABSTRACT: A population of *Coleonyx variegatus* was studied during 1965-66 at a low-altitude Sonoran Desert mountain range. Seasonal activity extended from April through October, with intermittent activity during winter months. Mean distances between capture points ranged from 10.9 m for immature males to 43.7 m for immature females. Frequency of broken or regenerated tails was positively correlated with body length; in the largest size group 74.1% were broken. Growth rates varied from 9.7 mm/month in immature lizards to no discernible growth for large adults. Gravid females were found from April through September, occurring most frequently in May and June. Two or more clutches of two eggs each are produced annually. Males had enlarged testes from April through August. Hatchlings appeared from July through November. Many individuals of both sexes reached sexual maturity when less than 1 year old, but some did not mature until their 2nd year. Males were captured more frequently than females from January through May, perhaps indicating more extensive wanderings. An estimated 66% of the population was reproductive in May, the height of the breeding season. Among five study areas, abundance was highest on a S-facing slope. Population density in one area was estimated to be 12-25 geckos/ha.

INTRODUCTION

The lizard subfamily Eublepharinae (family Gekkonidae) contains five genera: *Aeluroscalabates* Gunther, an arboreal forest gecko found in Indonesia; *Eublepharis* Gray, a terrestrial desert genus occurring in southwestern Asia, Hainan and Loo-Choo islands; *Hemitheconyx* Stejneger and *Holodactylus* Boettger, ground-dwelling desert genera found in West Africa and Somaliland; and *Coleonyx* Gray, a terrestrial genus distributed from southwestern United States to Central America (Kluge, 1967). Kluge (1962) divided *Coleonyx* into northern (*brevis* and *variegatus*) and southern (*elegans* and *mitratus*) species groups.

Little is known of the life history of any eublepharine gecko. Inger and Greenberg (1966) described aspects of reproduction of *Aeluroscalabates felinus* in Borneo, but knowledge of the other Old World genera is restricted to a few scattered observations. *Coleonyx* has been the most intensively studied genus in the subfamily, but most published life history data are based on captive individuals of *C. variegatus* or miscellaneous field observations. Dixon (1970a, b, c) listed pertinent literature for *Coleonyx, C. brevis* and *C. variegatus.* In spite of the long reference list for eublepharine geckos, there has been no population study of any species; life histories of all members of the subfamily remain relatively unknown.

A field study of the western banded gecko (*Coleonyx variegatus* Baird) was conducted at Phoenix South Mountain Park, Maricopa Co., Ariz., during 1965-66. Turner (1962), Williams (1968, 1970) and Hadley (1970) studied arthropods in the same general vicinity.

STUDY AREAS

Seven areas at the E end of South Mountain, W and S of the town of Guadalupe, were visited from October 1964 through August 1966. Much of the original habitat surrounding the mountains has been modified for agriculture, leaving a remnant of desert at the eastern end. The land surface gradually rises from 336 m at Phoenix to 381 m at Guadalupe. The highest peak is 821 m. Climate is warm and dry with macroclimatic temperatures from -9.4 to 49.4 C, and an annual mean of 21.4 C (U. S. Weather Bureau, 1959). Rainfall at Phoenix averages about 19.8 cm annually (Turnage and Mallery, 1941), but is quite variable. Rainfall during 1965 was 30.5 cm at Phoenix. Seasonally, rainfall was greatest in the cooler months (October through April), with 20.0 cm in 1964-65 and 16.3 cm in 1965-66. Summer rainfall (May through September) was 3.3 cm in 1965 and 7.5 cm in 1966 (U. S. Weather Bureau, 1964-66). Vegetation around the mountains resembles the *Larrea-Franseria* region of the Sonoran Desert (Shreve, 1951) and within South Mountain Park is typical of granitic mountains of the region. Plant names used follow Kearney and Peebles (1960). Elevations were taken from U. S. Geological Survey (1952) Lone Butte and Guadalupe Quadrangles.

The first two areas are located E of the mountains (T1S, R4E, Sec. 5). Areas 3, 4 and 5 are in a line from the top of a N-facing slope to the top of the opposite S-facing slope, 2.5 km W of Guadalupe (T1S, R3E, Sec. 12). Areas 6 (grid area) and 7 (removal area) are about 1 mile S of Guadalupe, SE South Mountain (T1S, R4E, Sec. 8). Williams (1970) has described areas 1, 3, 4 and 5.

Area 1.—This area is 1.0 km W of Guadalupe at an elevation of about 405 m. Vegetation is mostly creosote bush (*Larrea divaricata*) and bur sage (*Franseria deltoidea*), with lesser numbers of little-leaf paloverde (*Cercidium microphyllum*), ironwood (*Olneya tesota*), white bur sage (*Franseria dumosa*), joint fir (*Ephedra* sp.) and saguaro (*Carnegiea gigantea*).

Area 2.—This area is about 0.5 km N of area 1 at a similar elevation. A low-gradient, sandy wash, 1.5-3.0 m wide and incised 0.3-1.0 m into the surrounding terrain, passes from SW to NE. A gravel road 9.0 m wide crosses at right angles to the wash. Abundant plants along the wash include burro bush (*Hymenoclea* sp.) and cocklebur (*Xanthium saccharatum*) with some wolfberry (*Lycium* sp.), paloverde and ironwood. North of the wash vegetation is of the typical *Larrea-Franseria* type, but to the S and along the disturbed margin of the road, burro bush predominates. Debris, including piles of plasterboard, shingles, boxes and old clothing, is abundant on the ground surface.

Area 3.—This area is on a northerly exposure that slopes 25 degrees to an elevation of about 598 m. Predominant plants are bur sage, brittlebush (*Encelia farinosa*), paloverde and staghorn cholla (*Opuntia versicolor*).

Area 4.—Vegetation here shows greatest diversity of any of the

areas. Elevation is about 488 m. Abundant vegetation includes bur sage, brittlebush, creosote bush, paloverde, ironwood, and apricot-mallow (*Sphaeraclea ambigua*). Also present are white bur sage, joint fir, saguaro, barrel cactus (*Ferocactus wislizeni*), ocotillo (*Fouquieria splendens*), staghorn cholla, Christmas cactus (*Opuntia leptocaulis*) and teddybear cholla (*O. bigelovii*).

Area 5.—This area covers part of a southerly exposure with a slope of 25 degrees, up to an elevation of about 528 m. Teddybear cholla is dominant, overshadowing the presence of moderate numbers of brittlebush, creosote bush and barrel cactus. Paloverde, ironwood, wolfberry, ocotillo and saguaro are also present and rock outcrops and boulder piles are conspicuous.

Areas 6-7.—Vegetation in these areas is primarily homogeneous stands of creosote bush and white bur sage at an elevation of about 400 m. A more detailed description was given by Williams (1968).

PROCEDURE

Traps consisted of 1-gal (no. 10) cans buried with rim level to surface, and covered with any suitable object found nearby, including rocks, plasterboard and cardboard. Areas 1-5 had 20 traps each, area 6 had 195 and area 7, 118. Ten 5-gal cans were also used in area 2 and 1 in area 4.

Trap arrangement in areas 1-5 followed a zigzag or oval course depending on terrain. Most traps were placed close to shrubs or boulders. Area 6 (grid) traps were spaced 6-9 m apart in 15 rows of 13 traps each, covering about 1.1 ha. Area 7 (removal) was arranged in two U-shaped lines with 118 traps 7-9 m apart. Areas 6 and 7 were adjacent areas established in early 1966. All traps in area 6 were covered with flat rocks. Positions of traps in each area were determined with a Brunton compass and mapped to scale for calculation of lizard movements. Most distances were paced.

Traps in areas 1-5 were checked twice weekly during summer (May-September) and once weekly at other times. Areas 6 and 7 were checked 2-7 times weekly from February through August 1966. All lizards were removed from areas 1-5 from April through August 1966.

Lizards were marked by toe-clipping, measured for snout-vent and tail lengths to the nearest 0.5 mm, weighed to the nearest 0.1 g, and released at the capture point. Specimens to be preserved were injected with 10% formalin within 3 hr of collection or were refrigerated for a day before preservation. Body and tail lengths were measured before or just after injection. Right testis width was measured with vernier calipers. Ratios to compensate for differences in body size of males were calculated following Asplund and Lowe (1964). It is assumed that maximum relative testis size indicates the peak of the breeding season and that males were capable of inseminating females at least 2 months after the month when maximum size occurred. All

preserved lizards are deposited at Arizona State University (ASU 12178-12357).

I use the following terminology for age groups:

(1) hatchling—less than about 7 days since hatching, 26-31 mm;
(2) juvenile—lizard before first hibernation (includes hatchling), 26-50 mm;
(3) immature—completed one (or more) hibernation(s), and smaller than minimum adult size, males 31-51 mm, females 31-55 mm;
(4) adult—individual of any age, larger than minimum adult size, males 52-66 mm, females 56-70 mm.

Data are based on 262 captures of 201 marked geckos and dissection of 152 preserved specimens. Some data include 99 unmarked geckos which died in traps and were not preserved. The 5% level of significance is used in all statistical tests. Size is expressed as snout-vent length (SVL) unless otherwise stated.

RESULTS

ACTIVITY

Adults were active from April through October. Immature geckos were active in every month, but only intermittently from November through March. Trap captures for 1965 indicated greatest activity during July (Fig. 1) in contrast to a May peak in southern California (Klauber, 1945; Banta, 1962). Increasing weekly captures during summer generally paralleled the increase in average weekly temperature up to the July capture peak. After July, captures declined while

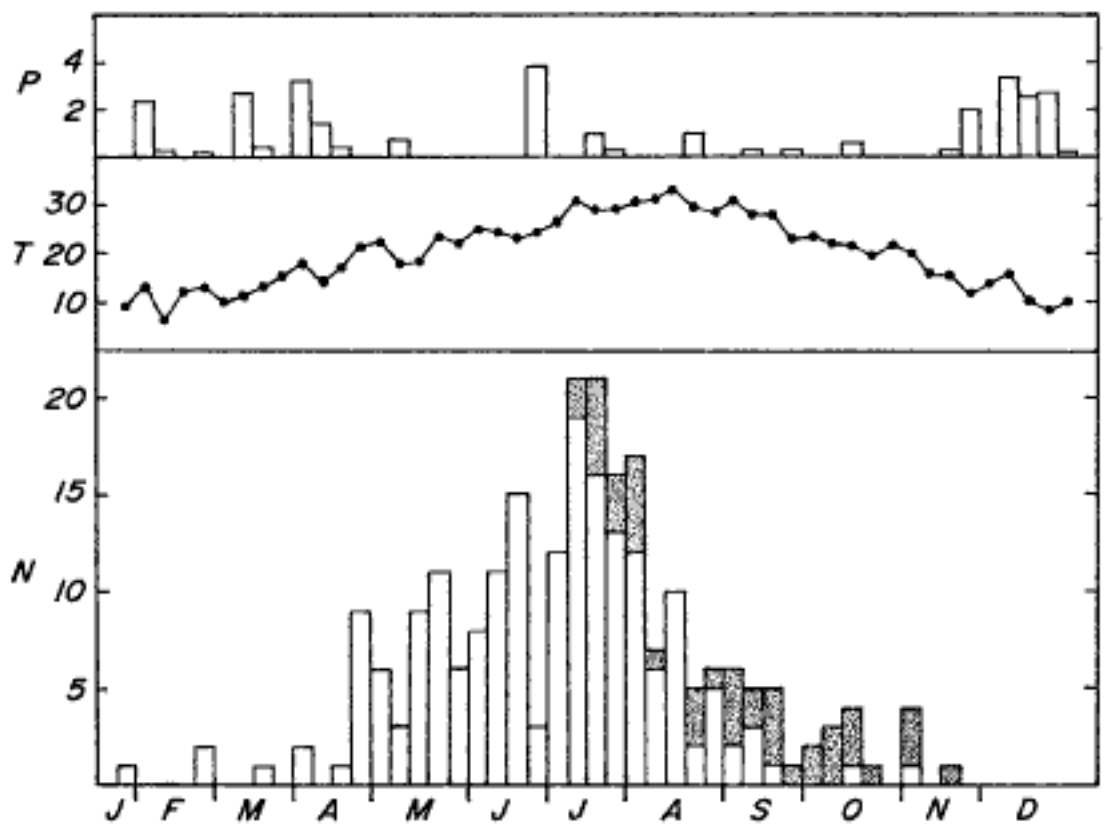

Fig. 1.—Weekly trap captures of *Coleonyx variegatus* (N), average weekly temperature (T) in C and precipitation (P) in cm for 1965. Stippled areas are young-of-the-year

average temperatures remained constant. This may have been partially due to rather high mortality in traps during midsummer. Heavy rainfall in late June appeared to cause reduction of gecko activity (Fig. 1).

Cowles (1941) reported torpid geckos unearthed during February and March in California. Woodbury and Hardy (1948) found geckos in desert tortoise dens during December and January in Utah. Any surface wandering by geckos during winter months (November-March, especially) is probably very limited. Trap captures during this period were minimal (Fig. 1). Small individuals are probably active diurnally on favorable days, emerging beneath rocks warmed by insolation. A 1st-year pair was found together under a rock on a December afternoon. An immature female was found under a rock on a warm January afternoon. Small burrows (presumably the geckos') were present in both cases.

MOVEMENTS

The wanderings of *Coleonyx* were occasionally extensive for such a small, slow-moving terrestrial vertebrate. All but one of the longest movements extended over long time periods. An immature female moved 64 m between 23 and 30 May 1965. She appeared emaciated and had a broken tail when recaptured. Another immature female, marked on 17 October 1965 and recaptured on 22 May 1966, had moved 96 m. However, several other geckos were recaptured in the same trap after periods as long as a year. For example, an adult male was caught in the same trap four times between June 1965 and June 1966.

Only three of 35 marked geckos were recaptured twice and nine once in the grid area (area 6). A combination of four possible factors appeared to influence these results: (1) geckos may have been wary and agile enough to avoid falling into a trap except occasionally; (2) they may have been unfamiliar with the introduced rocks covering the traps thereby failing to go under them readily; (3) the trap area may not have been large enough to encompass the ranges of many individuals so that only a portion of the range of most geckos was covered by trapping; and (4) geckos may limit their activities to a small area, only occasionally moving more than a few meters.

Mean distance between capture points was higher for the grid than for the irregular trap arrangement (areas 1-5) (Table 1). Adult males moved farther than adult females and young males. The high mean value for young females resulted from two exceptionally long distance records mentioned previously. Because the trap arrangement in any one

TABLE 1.—Mean distances (m) between capture points for *Coleonyx variegatus*. Numbers in parentheses are sample size

Trap Arrangement	Males		Females		Hatchlings
	Adult	Immature	Adult	Immature	
Irregular	17.3(12)	10.9(2)	12.9(8)	43.7(5)	17.5(3)
Grid	31.9(6)	....	23.5(5)	....	....

area was sufficient to capture geckos moving only up to about 122 m, these are all minimum estimates.

TAIL BREAKAGE AND REGENERATION

Intact tails of the banded gecko are usually equal to or slightly shorter than the snout-vent length. They break readily when only slight pressure is applied and regenerate at a rate depending upon the amount of original tail lost. A regenerated part is easily distinguished by its coloration of dark flecks and bars on a light ground color. Dark rings are characteristic of an original tail.

Geckos which received broken tails during handling are not included below. For those with tail regenerations, I assumed the break had occurred at about the point where the base met the regeneration.

Several geckos with tail regenerations were recaptured after several months. Rate of regeneration was most rapid when breaks occurred close to the tail base (Table 2: Nos. 1, 2 and 8), with a maximum of 0.82 mm/day. Mulaik (1935) reported regeneration of about 0.38 mm/day in a captive *C. brevis*. Few breaks occurred in the distal half of the tail. Most were near the base or in the middle. Regeneration proceeds rather slowly or stops completely when the tail has regained about 60-75% of its original length (what the normal length would have been if the tail was complete) (Table 2: Nos. 3, 4, 5 and 7).

TABLE 2.—Selected records of growth and tail regeneration in *Coleonyx variegatus*

Sex		Capture dates	SVL (mm)	Tail length (mm) Base	Regeneration
♂	1	4 Jul 65	57	15	10
		11 Jul 65	57	15	13
	2	19 May 65	58	22	3
		30 May 65	60	24	12
		18 Aug 65	63	25	23
	3	18 Jul 65	55	20	27
		8 May 66	60	20	31
	4	18 Jul 65	52	11	31
		8 May 66	60	12	32
	5	29 Aug 65	54	5	31
		20 Jun 66	56	5	36
	6	19 Sep 65	44	23	13
		30 May 66	58	29	18
♀	7	7 Jul 65	58	22	21
		26 Jun 66	61	22	25
	8	1 Sep 65	31	9	5
		8 May 66	51	15	25
	9	25 Apr 65	48	5	30
		27 Jun 65	59 (gravid)	5	38
	10	25 Jul 65	35	35	....
		8 May 66	56	29	20
	11	17 Oct 65	30	28	....
		22 May 66	49	4	29
	12	10 Apr 66	51	....	....
		8 May 66	58 (gravid)	....	....

Some tail breakage in males may result from territorial encounters as male geckos are intrasexually aggressive (Greenberg, 1943). Contrary to expectation, frequency of tail breakage in males was not significantly higher than in females (Table 3). In the largest size group, females had a higher frequency than males. Breakage frequencies in all size groups were considerably higher than in comparable groups of six other lizard species found at the study location (pers. observ.). Tail autotomy thus appears to have considerable survival value for this species.

Werner (1968) reviewed literature on regeneration frequencies in geckos and summarized the anatomical and ecological factors responsible for the frequencies observed in four Israeli species. The climbing geckos *Hemidactylus turcicus* and *Pytodactylus hasselquistii* had regeneration frequencies of 61.2% and 50.5%, respectively. Although these included breaks incurred during capture or museum handling, the percentages are similar to those for *Coleonyx variegatus*. Werner (1968) stated that ground-dwelling geckos, particularly psammophilous forms, generally show low regeneration frequencies, but *Coleonyx* is an exception.

GROWTH

Many hatchlings reached minimum adult size during the spring following hatching (Table 2). July and August hatchlings reach adult size by mid-May (No. 10) while September and October hatchlings attain it in late May, June or July (Nos. 8 and 11).

Growth rate was expectedly much faster in younger geckos (Table

TABLE 3.—Frequency of tail breakage in different size classes of *Coleonyx variegatus*

SVL group (mm)	Sex	N	Percentage with broken or regenerated tails
26-30	....	22	15.8
31-40	....	50	24.0
41-50	♂	30	43.3
41-50	♀	23	47.8
51-60	♂	103	57.3
51-60	♀	48	50.0
61-66	♂	38	55.3
61-70	♀	39	74.1

TABLE 4.—Mean growth rates in different size classes of *Coleonyx variegatus*

SVL group (mm)	Sex	N	Growth per month (mm)	
			$\bar{x}$	range
27-44	....	4	8.64	4.29-9.69
30-50	♂	2	4.83	2.30-6.99
30-50	♀	3	4.77	4.23-7.50
50-60	♂	10	0.71	0.00-5.46
50-60	♀	3	2.28	0.87-7.50
58-64	♂	8	0.63	0.00-2.13
58-69	♀	8	0.59	0.00-2.22

4). Growth of individuals larger than 55 mm was highly irregular, but females appeared to grow more rapidly than males, especially in the 50-60 mm range. Five adult males and one adult female showed no growth over periods of 20-133 days ($\bar{x}$ = 63 days).

REPRODUCTION

Females.—Reproductive condition of mark-release females was easily determined as eggs were visible through the ventral body wall. Individuals with enlarged ova were found from May through September 1965 and April through August 1966 (Table 5). Two eggs were present in all gravid females, one in each ovary or oviduct. One female laid two eggs in a trap between 12 and 15 August 1965. Another contained eggs on 24 June and none on 11 July 1965. A third had large eggs on 30 June and again on 28 July 1965.

Mean size of 54 gravid females was 62.4 mm, range 52-70 mm. Mean size of nine with oviducal eggs or corpora lutea was 65.8 mm. Frequencies of gravid females were highest during May and June in both years, but sample sizes in other months were too small to be reliable.

Most females probably lay at least two clutches a year. A 69 mm female contained large, apparently oviducal eggs on 8 May 1966, small ovarian follicles (5 mm diam, measured externally) on 20 May, and large oviducal eggs again on 20 June. Three females (70, 65 and 68 mm) collected on 8 and 18 May and 5 June 1966 contained both oviducal eggs and yolked follicles.

Eggs may be laid one at a time. A captive gecko from Pima Co., Ariz., laid a single egg while retaining a second (Ortenburger and Ortenburger, 1926). W. L. Minckley (pers. comm.) kept a captive female from Graham Co., Ariz., that laid its eggs 1 day apart (12 and 13 July) but buried them side by side.

Incubation period (time between oviposition and hatching) is about 6 weeks as the first females with presumably oviducal eggs were trapped on 20 May 1965 and 1 May 1966 and hatchlings were first caught on 7 July 1965 and 12 June 1966. A captive *C. brevis* from

TABLE 5.—Size and monthly frequency of gravid and nongravid female *Coleonyx variegatus* in 1965 and 1966. Numbers in parentheses are sample size

	SVL (mm)						Percentage with enlarged eggs	
	gravid			nongravid				
Month	N	$\bar{x}$	Range	N	$\bar{x}$	Range	1965	1966
March	0	....	....	1	59.0	....	....	0.0(1)
April	1	61.0	....	3	55.7	52-62	0.0(2)	50.0(2)
May	18	63.1	52-70	12	55.8	52-67	44.4(9)	63.2(21)
June	15	63.5	58-69	9	58.4	53-69	50.0(10)	71.4(14)
July	11	63.1	57-67	19	57.8	53-65	35.0(20)	40.0(10)
August	8	62.0	60-64	8	58.6	53-63	50.0(6)	50.0(10)
September	1	60.0	....	1	68.0	....	50.0(2)	....
October	0	....	....	2	55.0	53-57	0.0(2)	....
November	0	....	....	1	57.0	....	0.0(1)	....

Texas laid two eggs which hatched after 30 days (Werler, 1970).

Corpora lutea apparently degenerate rapidly after ovulation. The only female with well-defined corpora lutea was the one with the smallest oviducal eggs. This individual had probably recently ovulated. Other females with oviducal eggs had remnants of corpora lutea visible macroscopically as small, dark yellow bodies without the distinctive mushroom shape of recently formed corpora lutea.

Some females attain sexual maturity at less than 1 year of age. Two young females were captured as immatures and recaptured gravid a few months later (Table 2: Nos. 9 and 12). Growth records of these and other females indicate that many (mainly the earliest hatchlings from the previous year) first reproduce during the spring after hatching. This is in sharp contrast to another small, nocturnal desert lizard, *Xantusia vigilis,* in which females reach maturity at 3 years (Zweifel and Lowe, 1966).

Size at maturity varied considerably. The smallest females with enlarged eggs were 52 and 56 mm. Maturity may thus be attained anywhere in this range, probably depending partially upon the time of year at which mature size is reached. Greater percentages of females $>$ 56 mm were gravid in any 1 month (Table 5), further demonstrating a large number of immature individuals in the 52-56 mm range.

Males.—Male geckos emerged in April with testes at nearly maximum size. Mean relative size gradually declined from a peak in May to successively smaller sizes in June, July and August (Table 6). Development of the epididymis and vas deferens followed a similar cycle.

Mean testis width/snout-vent ratios were low in males $<$51-52 mm; most males smaller than 52 mm exhibited no enlargement of epididymis or vas deferens. Males thus attain sexual maturity at smaller sizes than females, and some are probably reproductively active at less than 1 year of age as shown by the growth record in Table 2 (No. 6).

Mating.—Coitus and mating stimuli were described in detail for *C. variegatus* by Greenberg (1943). Maximum relative testis size occurred concurrently with first ovulations, suggesting that most mating takes place in May and June. Males evidently move extensively, or more frequently, in May, judging from the high numbers trapped

TABLE 6.—Ranges and means for testes (testis width/SVL) and SVL in *Coleonyx variegatus*

	Relative testis size		SVL (mm)		
Month	$\bar{x}$	Range	$\bar{x}$	Range	N
April	0.050	0.042-0.056	57.3	51-62	7
May	0.052	0.040-0.072	57.5	51-65	36
June	0.048	0.036-0.055	57.5	52-66	15
July	0.043	0.036-0.049	58.1	53-63	9
August	0.044	0.038-0.054	57.7	52-66	12
October	0.031	....	61.0	....	1

(Fig. 2), thus possibly enhancing the likelihood of successful matings. Whether mating continued into July and August could not be determined. The number of reproductively active males decreased in these months as did the frequency of gravid females, but part of the population apparently continued to mate since hatchlings continued to appear through November. Sperm storage by females mated in May and June may explain continued egg laying into September (*see* Cuellar, 1966).

Hatchlings.—Three hatchling *C. brevis* from Texas were 23.8, 24.4 and 25.1 mm (Werler, 1970). Hatchling *C. variegatus* measured 26 to about 31 mm. No month in 1965 showed a peak number of hatchlings, a few being recorded from 7 July through November. Emergence in 1966 was obscured by high mortality of adults in traps during 1965 and to removal of adults from areas 1-5 in 1966.

Other geckos.—Little is known of reproduction in any desert-dwelling eublepharine. *Coleonyx elegans nemoralis* (Davis and Dixon, 1961) and *C. e. elegans* (Duellman, 1965), as well as other species of eublepharines, generally lay two eggs, but Mulaik (1935) reported two *C. brevis* which each laid only one. Reproductive data on one captive *Eublepharis macularius* in West Pakistan suggest a long reproductive cycle, multiple clutches and sperm storage by females (Minton, 1966). The reproductive biology of *E. macularius* may thus be quite similar to that of *C. variegatus.* The genus *Coleonyx* was presumably derived from a *Eublepharis*-like ancestor (Kluge, 1962).

Reproductive cycles of Gekkoninae have been studied primarily in tropical regions where reproduction is essentially acyclic (Church, 1962; Inger and Greenberg, 1966). However, Sanyal and Prasad (1967) described cyclic reproduction of *Hemidactylus flaviviridis* in India. The male active phase extended over an 8-month period. In Louisiana, males of the introduced gecko, *Hemidactylus turcicus,* are sexually active from April through July and females from May through early August (Rose and Barbour, 1968). In the tropics sexual maturity is attained at less than 1 year of age, while the introduced temperate species matures in its 2nd year. Females of the Israeli desert gecko (*Ptyodactylus hasselquistii*) lay 3-5 clutches of eggs during May-August (Werner, 1965), a period similar to that of *Coleonyx variegatus.*

Other lizards at the study location.—The gross reproductive cycle of the banded gecko is generally similar to cycles of *Cnemidophorus tigris, Callisaurus draconoides* and *Urosaurus ornatus* at South Mountain (pers. observ.). The gecko cycle of testicular enlargement is most similar to that of *C. tigris* in that adult males emerge from hibernation with enlarged testes. All four species have enlarged testes from March or April through July or August, but enlargement does not begin in *Callisaurus* or *Urosaurus* until after they have emerged. Oviposition and hatching are also distributed over a 5- to 6-month period for all four species. Attainment of sexual maturity, however, varies in *Coleonyx* and *Cnemidophorus* from 1 to 2 years, whereas all individuals of *Callisaurus* and *Urosaurus* mature in less than 1 year (pers. observ.).

POPULATION STRUCTURE

Size.—Female geckos attain slightly larger sizes than males. The largest female was 70 mm; the largest male, 66 mm. Hardy (1944) found similar size maxima in Utah populations, and Klauber (1945) reported females of 77 mm and males of 69 mm from California. *C. elegans* and *C. mitratus* of Mexico reach sizes exceeding 90 mm, but *C. brevis* is the smallest member of the genus with maxima shorter than 60 mm (Klauber, 1945).

Weights of *C. variegatus* in my study were as follows: mature males, 2.5-3.9 g; gravid females, 3.0-4.5 g; nongravid mature females, 2.2-3.9 g; and hatchlings, 0.3-0.6 g.

Sex ratio.—Males outnumber females significantly in samples from January through May (Fig. 2). Three factors may account for this ratio: (1) May is the height of the breeding season and males may move more extensively or more frequently in search of mates and/or in defense of territories; (2) males may outnumber females in the population; (3) trapping method may have introduced a bias against females. The first possibility is here considered the most likely even though the sex ratio of immature lizards was similarly biased toward males during the same period. Other spring samples with preponderance of males were reported in *Ophisaurus attenuatus* (Fitch, 1967) and *Cnemidophorus tigris* (Turner *et al.*, 1969). Sex ratio of adult geckos marked in the grid area (18 ♂♂, 12 ♀♀) indicates that males do not significantly outnumber females. The third possibility is considered remote, although pitfall traps were found to be biased against females in samples of terrestrial isopods (Hayes, 1970).

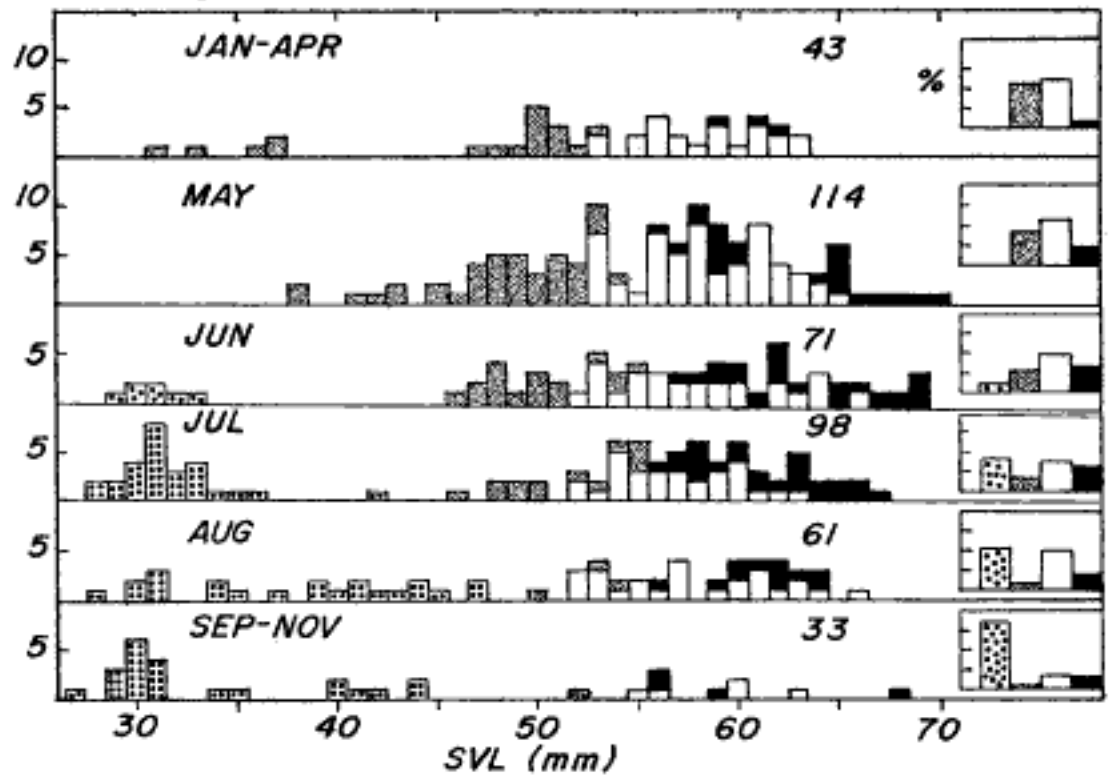

Fig. 2.—Seasonal snout-vent length (SVL) distribution and seasonal frequencies of different age and sex groups of *Coleonyx variegatus*. Left ordinate is number of lizards. Each mark on ordinate of percentage histogram is 20%. Numbers indicate sample size. Shading: unshaded, adult male; darkened, adult female; small spots, immature; large spots, juvenile

Seasonal changes in population composition.—Ratios of immature and adult geckos in early spring and autumn were obscured by small sample sizes and greater activity by immatures. From May through August, however, relative numbers of immatures and adults in the population appeared to be reasonably well represented by the samples. Each seasonal or monthly sample was arbitrarily divided into the size groups defined in Procedure.

About 66% of the population was potentially reproductive in May. Only a few lizards hatched late in the previous year were still of immature size at the beginning of their 2nd winter. Therefore, all surviving geckos of both sexes that did not mature the 1st spring after hatching would surely be capable of reproduction by the 2nd spring.

The degree of annual population turnover could not be determined accurately from available data. Although the physiological longevity of this species is at least 14 years (Moehn, 1962), a fairly rapid turnover is indicated by recapture in 1966 of only seven (5.8%) of 120 immature and adult geckos marked in 1965.

ECOLOGICAL DISTRIBUTION AND POPULATION DENSITY

It is difficult to compare gecko abundance between areas 1-5 because of differences in trap arrangement. Each study area had a different shape and each sampled a different surface area. The following adjustments were made assuming the number of geckos captured increased with increasing size and/or length of the trap area. The size of the trap area was estimated by constructing a convex polygon of outermost trap positions, and determining the area enclosed. The number of individuals captured in each study area was divided by the corresponding surface area (m^2) and by the study area's maximum length (m) to obtain adjusted values. These were then converted to percentages for direct comparisons (Table 7).

The surface area adjustment values indicate a likelihood of greater abundance on the rocky slopes and valley than in the relatively level desert E of the mountains. The length adjustment lowers the relative abundance in areas 3 and 4 to the same level as areas 1 and 2, but slightly enhances the value for area 5. In both techniques, the S-facing slope was apparently optimum habitat.

Twenty males, 14 females and 15 hatchlings were captured in the grid area. As only 12 adults were recaptured, an accurate density calculation is speculative. If all geckos (excluding hatchlings) caught

TABLE 7.—Per cent of 265 individual *Coleonyx variegatus* captured during 22 months in five distinct study areas with 20 traps each

Study area	Actual	Adjusted by surface area	Adjusted by area length
1 Shrub	21.5	13.9	17.6
2 Disturbed wash	16.9	13.1	15.8
3 N-facing slope	18.5	20.5	13.5
4 Valley	20.8	19.7	18.5
5 S-facing slope	22.3	32.8	34.5

only in the outermost trap row are excluded as transients, and those caught only in the first inner row are divided in half (a modification of Stickel's, 1960, "buffer" area), the calculated density is 12 geckos/ha. A crude biomass estimate on this basis is about 32 g/ha. Density using Stickel's (1950) method was 25 geckos/ha, a higher figure because 16 of the 34 adults were captured only in the outer row.

PREDATION

Predation on geckos was not observed, but several known and probable vertebrate and invertebrate predators were present at the study areas. Known predators include the giant hairy scorpion *Hadrurus arizonensis* (Hadley and Williams, 1968), zebra-tailed lizard *Callisaurus draconoides,* spotted leaf-nosed snake *Phyllorhynchus decurtatus,* western patch-nosed snake *Salvadora hexalepis,* western diamondback rattlesnake *Crotalus atrox* (Stebbins, 1954), sidewinder *Crotalus cerastes* (Funk, 1965) and night snake *Hypsiglena torquata* (R. M. Winokur, pers. comm.). Night snakes were frequently encountered under rocks or trash in spring and autumn in situations identical to those where geckos were collected. Other snake predators probably include *Crotalus mitchelli, C. molossus, C. tigris* and *Micruroides euryxanthus.* Probable mammalian predators are *Canis latrans, Vulpes macrotis, Urocyon cinereoargenteus* and *Pecari angulatus.* Tarantulas, giant centipedes and large solpugids may prey on small geckos.

DISCUSSION

Kluge (1967) postulated that multiple parallelism in habitat preference has evolved in four of the five genera of Eublepharinae. If this is true, it might be expected that parallelism has also occurred in various additional aspects of the life histories of these genera as is the case when Old World desert Agamidae and New World desert Iguanidae are compared (Pianka, 1971). Reproductive similarities between *C. variegatus* and *Eublepharis macularius* indicate the likelihood of such parallelism, but more extensive research will be required before life history studies can substantiate this.

My preliminary observations on reproduction in *C. variegatus* conform to Tinkle's (1969) prediction that in "areas with long periods favorable to reproduction, multiple clutches each breeding season will be the rule." The banded gecko fits into one of the categories of Tinkle *et al.* (1970) of relatively early maturing species of lizards having multiple broods and small clutches. Since, however, *Coleonyx* probably reaches maturity and reproduces in either its 1st or 2nd year, it is also like *Cnemidophorus tigris* in being intermediate between the early-maturing and late-maturing groups of lizard species. It could therefore be categorized into either.

Possibilities for future ecological work on the genus *Coleonyx* and other eublepharines are numerous. Of particular importance is the compilation of detailed life history data for all four desert genera of Eublepharinae to amplify the knowledge of their evolutionary rela-

tionships. Life history data for Kluge's (1962) southern species group of *Coleonyx* would be useful for comparison with the northern group.

Acknowledgments.—For their assistance during various stages of this study special thanks are due William S. Brown, Gregory Fernald, Henry S. Fitch, M. J. Fouquette, Jr., W. L. Minckley, Terry Parker, Walter K. Taylor and Stanley C. Williams. A portion of this paper was part of a Master's thesis submitted at Arizona State University.

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SUBMITTED 6 JULY 1971 ACCEPTED 13 SEPTEMBER 1971